The Estero Americano Watershed Management Plan

A Project of the Gold Ridge Resource Conservation District with funding from the State Water Resources Control Board

The Estero Americano Watershed Management Plan

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List of Abbreviations

BMP	Best Management Practice
CAFO	Confined Animal Feeding Operation
CCRC	Central Coast Rangeland Coalition
CDQAP	California Dairy Quality Assurance Program
CDFG	California Department of Fish & Game
CNDDB	California Natural Diversity Data Base
CWA	Federal Clean Water Act
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
GIS	Geographical Information System
NCRWQCB	North Coast Regional Water Quality Control Board
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint Source Pollution
NRCS	Natural Resources Conservation Service
RCD	Resource Conservation District
RDM	Residual Dry Matter
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
UCCE	University of California Cooperative Extension
USDA	United States Department of Agriculture
USGS	U.S. Geological Survey
WDR	Waste Discharge Requirement
WUD	Western United Dairymen

Executive Summary

The Estero Americano and its main tributary Americano Creek drain into Bodega Bay and the Gulf of the Farallones National Marine Sanctuary. The Estero Americano is a fjord-like estuary that extends from the Pacific Ocean, just south of Bodega Harbor, to the town of Valley Ford 4.0 miles inland. Americano Creek is roughly 7.6 miles in length and drains the upper third of the Estero Americano Watershed before flowing into the tidal estuary at Valley Ford. The 2002 California Water Quality Assessment Report published by the State Water Resources Control Board (SWRCB) listed 199 acres of the Estero Americano and the entire length of Americano Creek as impaired waterbodies due to nutrient pollution from agricultural sources. The Estero Americano is also listed as impaired due to sedimentation/siltation.

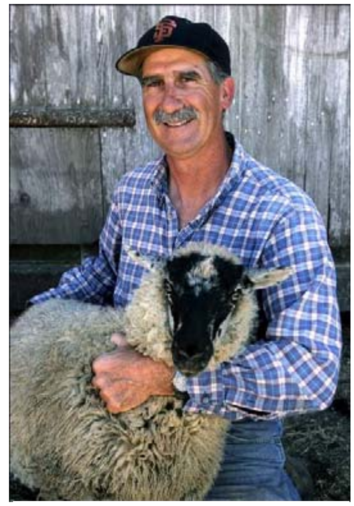
The Estero Americano Watershed Management Plan was funded through the SWRCB as part of a Clean Water Act, Section 205(j) planning grant to focus efforts on identifying the potential sources of these water quality impairments and to identify land management solutions through a voluntary, cooperative planning process. The Gold Ridge Resource Conservation District (RCD) applied for and received funding to produce this document in the spring of 2004. The purpose of this watershed management plan is to characterize and assess the ecological processes and conditions of the Estero Americano Watershed, and to provide economically viable and agreed upon recommendations for improving water quality and the natural resource base through conservation-oriented land management practices.

The Estero Americano Watershed Management Plan was developed over the course of two-and-a-half years of planning efforts involving numerous resource agency staff, watershed landowners, and other interested parties. A technical advisory committee (TAC) was organized early in the planning process and met two or three times a year to oversee technical planning elements and to provide guidance on the writing of the plan. Numerous interviews were conducted with watershed residents over the course of this planning study to gain valuable on-the-ground information about changes in the watershed, the value of its resources, along with any problems and issues encountered in the management of these resources. Two large public meetings were sponsored by the RCD to facilitate landowner participation in the planning process and to create a venue for public comment on the results of planning studies.

The *Agricultural Best Management Practices* and *Action Plan* chapters of this document attempt to synthesize landowner identified objectives and strategies with the water quality objectives of the North Coast Regional Water Quality Control Board (NCRWQCB), the best management practices promoted by USDA’s Natural Resources Conservation Service (NRCS) and University of California Cooperative Extension (UCCE), and the habitat enhancement objectives of the California Department of Fish & Game (CDFG) and the National Marine Fisheries Service (NOAA Fisheries Service). In addition, the U.S. Environmental Protection Agency’s (EPA) *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (2005) was used as a guidance document in the development of the Estero Americano Watershed Management Plan. The plan incorporates the nine minimum elements of an effective watershed management plan outlined in EPA’s guidance document.

The Estero Americano Watershed Management Plan should be viewed as a “living document.” The goals and management strategies outlined in this plan are based on our current level of understanding of the ecological processes and health of the watershed. It is expected that management issues and priorities in the watershed will change through time as will the goals and objectives of the management plan.

CHAPTER 1


Jeff Kan Lee/Press Democrat

INTRODUCTION:

The Estero Americano and its main tributary Americano Creek drain into Bodega Bay and the Gulf of the Farallones National Marine Sanctuary. The Estero Americano is a fjord-like estuary that extends from the Pacific Ocean, just south of Bodega Harbor, to the town of Valley Ford 4.0 miles inland. The open water surface width of the Estero Americano averages about 300 feet in the lower 1.5 miles; it then widens to 1000 feet before narrowing down to less than 10 feet at the town of Valley Ford. Americano Creek is roughly 7.6 miles in length and drains the upper third of the Estero Americano Watershed before flowing into the tidal estuary at Valley Ford.

In total, there are approximately 31 miles of USGS ephemeral streams in the watershed, and an additional 56 miles of smaller seasonal streams draining into these larger tributaries. The watershed area of the Estero Americano and its main tributary is 39 square miles in size. The Estero Americano forms the boundary between Marin and Sonoma counties, and its watershed is located within both the Marin Resource Conservation District boundary and the Gold Ridge Resource Conservation District boundary (Figure 1-1).

Unlike many coastal wetlands in the State, the Estero Americano is relatively undisturbed. This is due, in large measure, to the unique continuity of land ownership and land use patterns in the watershed. Small, multigenerational family run dairies and livestock ranches are the mainstay of the local economy, and account for over 80 percent of land use in the watershed. While historical land ownership patterns have preserved large tracts of open space and critical habitat for wildlife, there is concern that erosion and agricultural run-off are impacting the natural resources and habitat values of the Estero and its tributaries.

The 2002 California Water Quality Assessment Report published by the State Water Resources Control Board (SWRCB) listed 199 acres of the Estero Americano and the entire length of Americano Creek as impaired waterbodies due to nutrient pollution from agricultural sources. The Estero Americano is also listed as impaired due to sedimentation/siltation. The Estero Americano Watershed Management Plan was funded through the SWRCB as part of a Clean Water Act, Section 205(j) planning grant to focus efforts on identifying the potential sources of these water quality impairments and to identify land management solutions through a voluntary, cooperative planning process. The Gold Ridge Resource Conservation District (RCD) applied for and received funding to produce this document in the spring of 2004.

The purpose of this watershed management plan is to 1) characterize and assess the ecological processes and conditions of the Estero Americano Watershed within the context of current land uses, and 2) to provide economically viable and agreed upon recommendations for improving water quality and the natural resource base through conservation-oriented land management practices.

The Watershed Management Planning Process:

Since the 1940s, the RCD has sponsored numerous conservation-oriented projects and programs to enhance and protect the natural resource base of the District. Over the years, the RCD has formed productive, long standing relationships with the agricultural community in the Estero Americano Watershed. Given the RCD's commitment to valuing both the ecological integrity and economic productivity of the natural resource base of the Gold Ridge Resource Conservation District, we at the RCD felt well positioned to produce this document and to oversee the cooperative planning process on which it is based. The primary goal of this watershed management plan is to provide a "plan of action" for improving the ecological health of soils, water, vegetation and habitat that will also improve the quality and economic sustainability of agricultural production in the watershed.

Figure 1-1. Map of RCD Boundaries

The Estero Americano Watershed Management Plan was developed over the course of two-and-a-half years of planning efforts involving numerous resource agency staff, watershed landowners, and other interested parties. A Technical Advisory Committee (TAC) was organized early in the planning process and met two or three times a year to oversee technical planning elements and to provide guidance on the writing of the plan. The TAC was comprised of agency representatives from the Marin Resource Conservation District, the North Coast Regional Water Quality Control Board, USDA's Natural Resources Conservation Service, UC Cooperative Extension, and the California Department of Fish & Game. Other organizational staff involved in the TAC included representatives from Western United Dairymen, The Gulf of the Farallones Marine Sanctuary, Friends of the Esteros, the Sonoma Land Trust, and a local area paddling club. The TAC also included numerous members of the watershed's agricultural community.

A large part of the work that went into developing this document involved characterizing and assessing the ecological processes and conditions of the watershed based on a compilation and synthesis of existing studies as well as the creation of new information derived from environmental map data such as soils, vegetation, water resources, land uses, and high resolution aerial photography. Numerous interviews were conducted with watershed residents over the course of this planning study to gain valuable on-the-ground information about changes in the watershed, the value of its resources, along with any problems and issues encountered in the management of these resources. Two large public meetings were sponsored by the RCD for watershed residents. The first meeting took place at the start of the process to encourage landowner participation and to provide an overview of the watershed management planning grant received by the RCD. The second public meeting was held in the winter of 2006 to present technical results of the watershed assessment and to develop landowner driven action plans and strategies.

The *Agricultural Best Management Practices* and *Action Plan* chapters of this document attempt to synthesize these landowner identified objectives and strategies with the water quality objectives of the North Coast Regional Water Quality Control Board (NCRWQCB), the best management practices promoted by USDA's Natural Resources Conservation Service (NRCS) and UC Cooperative Extension (UCCE), and the habitat enhancement objectives of the California Department of Fish & Game (CDF&G) and the National Marine Fisheries Service (NOAA Fisheries Service). In addition, the U.S. Environmental Protection Agency's (EPA) *Handbook for Developing Watershed Plans to Restore and Protect Our Waters (2005)* was used as a guidance document in the development of the Estero Americano Watershed Management Plan. The plan incorporates the nine minimum elements of an effective watershed management plan outlined in EPA's guidance document.

The nine minimum elements are:

a) An identification of causes of impairment and pollutant sources.

b) An estimate of load reductions expected from management measures.

c) A description of the nonpoint source management measures that will be implemented to achieve load reductions.

d) An estimate of the amounts of technical and financial assistance needed to implement those management measures.

e) An information and education component used to enhance public understanding of the project and to encourage their early and continued participation in selecting, designing, and implementing nonpoint source management measures.

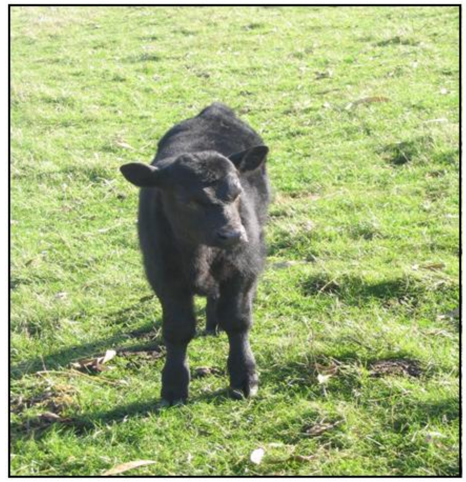
f) A schedule for implementing nonpoint source management measures identified in the plan.

g) A description of interim measurable milestones for project implementation efforts.

h) A set of criteria that can be used to determine whether load reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

i) A monitoring component to evaluate the effectiveness of implementation efforts over time.

Fostering Sustainable Agriculture in the Estero Americano Watershed:



Although this first edition of the Estero Americano Watershed Management Plan does not explicitly develop a "plan of action" for fostering innovative and sustainable agricultural markets and businesses in the watershed, many of the recommended "agricultural best management practices" presented in this document do lay the groundwork for such a strategy. Further, many of the agricultural producers in the Estero Americano Watershed are already working proactively with resource agencies and organizations such as NRCS, the Marin RCD and Gold Ridge RCD, UCCE California Dairy Quality Assurance Program (CDQAP), Western United Dairymen, and the California Certified Organic Program, to name a few, in adopting innovative and conservation-oriented management practices and business models. Table 5.1 provides a more complete listing of existing conservation programs in the watershed.

The RCD, along with its partners, understand that agricultural producers in our coastal watersheds are under the dual pressures of increasing regulatory oversight and the increasingly competitive demands of the marketplace. We believe that sustainable ranching and livestock production can increase profits while at the same time improve the overall conditions of soil, water, grassland and riparian resources. The financial benefits of sustainable ranching include reductions in property loss due to soil erosion, improved forage production, improved livestock health, higher product values, market diversification, and greater market accessibility.

For example, ranchers and dairy operators in Marin and Sonoma counties are finding that the adoption of sustainable practices such as reductions in hormone and antibiotic use can substantially increase the marketability of livestock products through increased access to lucrative niche markets within the natural foods industry in the Bay Area. Close to half of the dairies in the Estero Americano Watershed are currently certified organic or are working towards organic certification. In addition, half of the dairies in the watershed are working towards environmental certification through the CDQAP. Many of these dairies, along with a number of livestock ranches in the watershed, are also receiving conservation planning assistance through NRCS's Environmental Quality Incentives Program (EQIP).

A primary goal of the planning strategy outlined in this document is to continue to support the conservation efforts already underway in the watershed. We believe working in partnership with the agricultural community is the best strategy for improving the health of the watershed and the long-term preservation of its habitats and natural capital. Table 1.1 provides a basic overview of the watershed goals and management objectives developed over the course of the Estero Americano Watershed planning process. A more in depth discussion of watershed goals and objectives is presented in *Chapter 6: Action Plans to Improve Natural Resources and Agricultural Sustainability.*

Table 1.1 Estero Americano Watershed Management Plan Goals & Objectives

Goal	Indicator	Potential Source of Impact	Management Objective
Meet water quality standards for nitrogen	Total Ammonia; Unionized Ammonia; Dissolved Oxygen; Temperature	Agricultural runoff from farm fields, dairy facilities, and livestock heavy use areas.	Reduce nitrogen loads from land application of manure; improve stormwater controls around livestock heavy use areas and dairy facilities.
Meet water quality standards for sediment/siltation	Turbidity; Temperature	Unmanaged livestock grazing; destabilized streambanks; removal of riparian vegetation; modified drainage pathways; gully erosion; and ranch roads.	Reduce streambank, sheet and rill, and gully erosion through grazing management practices; stabilize and revegetate stream corridors; mitigate erosion from gullies and ranch roads.
Support designated uses for aquatic life; eliminate anoxic conditions and fish kills	Unionized Ammonia; Dissolved Oxygen; Temperature; Turbidity	Elevated levels of nitrogen causing algal blooms which decreases dissolved oxygen levels; high turbidity levels and aggradation of stream channels and the estuary bottom raises water temperatures; nutrient and sediment loads from dairy and livestock operations.	Improve agricultural management practices to reduce runoff to the estuary and its tributaries; restore hydrologic conditions in the watershed through sediment reduction and better designed drainage ways and stormwater conveyance structures.
Restore aquatic habitat	Riparian vegetation; instream habitat structure; fish passage to upper watershed in Ebabias Creek	Removal of riparian vegetation; streambank and upland erosion and delivery; fish passage barriers.	Improve aquatic habitat through streambank stabilization and stream corridor revegetation; conduct stream habitat typing; remove fish passage barriers; and increase instream habitat structure and complexity.
Assess, protect & enhance riparian and wetland habitat	Extent & condition of wetland plant communities; wetland functional assessments; habitat connectivity; bird species diversity and richness	Streambank and upland erosion; unmanaged livestock grazing.	Map and assess wetland functions and conditions; improve agricultural management and grazing practices in sensitive areas; identify areas for conservation easements or restoration.
Promote native biodiversity in upland habitats	Extent and condition of native plant communities	Historic potato farming; range management practices; invasive species.	Map remnant populations of coastal prairie; establish rangeland health indicators; map highly invasive species such as gorse and develop eradication plans.
Reduce flood levels	Peak flow volume and velocity	Hydromodification; stream aggradation; streambank and upland erosion; inadequate stormwater controls and public road maintenance.	Restore hydrologic conditions in the watershed through sediment reduction and better drainage ways and stormwater conveyance structures.
Support Agricultural Sustainability Efforts	Innovative production methods; niche markets; local production facilities; agricultural cooperatives; agricultural diversification	Competitive markets; environmental regulations.	Provide technical and funding assistance.

How this document is organized:

Chapter 2 of this document presents an overview of the biological resources of the estuary and its watershed. Most of the information in this section was compiled from a series of biological resources studies conducted in the watershed in the late 1980s. Chapter 3 presents baseline water quality data, and discusses various nutrient sources and the results of modeling conducted for this plan. Chapter 4 presents an overview of sediment sources and impacts in the watershed, and discusses results of sediment load modeling conducted for this plan. Chapters 5 and 6 provide a discussion of the management practices and action plan strategies recommended during the planning process to enhance watershed health and the productivity of its natural capital.

The Estero Americano Watershed Management Plan should be viewed as a "living document." The goals and management strategies outlined in this watershed management plan are based on our current level of understanding of the ecological processes and health of the watershed. It is expected that management issues and priorities in the watershed will change through time as will the goals and objectives of the management plan. In order to monitor and document the implementation of this plan, as well as to foster an adaptive management approach to implementation, the RCD will create and maintain a program implementation matrix that will be posted on our website: http://www.goldridgercd.org.

CHAPTER 2

ECOLOGICAL RESOURCES OF THE ESTERO AMERICANO WATERSHED

Introduction

Considered one of California's most unique coastal wetland types, the Estero Americano contains a diverse assemblage of wetland communities and estuarine habitats. Originally formed from a "drowned river valley", the estuary has steeply sloping hillsides and an abrupt transition from upland areas to open water. This unique fjord-like quality is not seen in other California wetlands, with the exception of the neighboring Estero de San Antonio (Madrone Associates, 1977).

Tidal circulation in the Estero Americano extends over four miles inland. The Estero Americano is considered a "seasonal estuary" due to the formation of a sand bar at the mouth of the estuary during the late spring and summer months. A barrier beach across the mouth of the Estero controls the fluctuation and recurrence of tidal inflows. Bar formation appears to be a function of the prevailing northwest winds and to result from littoral currents carrying tidal sediment loads from local beaches and possibly from Doran Spit (Buell, 1988).

The diurnal tidal cycle and the fresh water inflow with its associated fluvial sediment load also influence the bar building process to an unknown degree (Madrone Associates, 1977; Buell, 1988). In winter, stormwater runoff breaches the sandbar and restores tidal influence. During summer months, when freshwater inflows are small, tidal influence is eliminated and evaporation is highest, waters within the estuary have at times become hypersaline and anaerobic. Salinity levels have been recorded up to 67 parts per thousand (ppt) compared to ocean salinity levels of 34 ppt (Commins et al., 1990).

The Estero Americano is an important coastal area for numerous plant and animal species of concern. The estuary is located in the heart of the Pacific Flyway (Hickey et al., 2003). The mudflats, open water, and extensive marsh area of the estuary provide seasonally important foraging habitat for migratory waterfowl and shorebirds, and resident long-legged wading birds. It provides potential rearing habitat for two federally listed endangered fish species, the tidewater goby and winter-run steelhead trout. The eelgrass beds located near the mouth of the Estero provide critically important habitat for many species of fish and water birds.

The ecological value and significance of these natural resources take on even greater significance when it is recognized that more than two-thirds of California's coastal wetlands have been degraded or destroyed in the last hundred years (Madrone Associates, 1977). The Estero Americano and its tributaries drain into Bodega Bay and the Gulf of the Farallones National Marine Sanctuary. The California Unified Watershed Assessment has identified the Bodega Bay Hydrologic Unit as a Category 1 Priority Watershed (USDA, NRCS, 1998). The estuary also received *critical habitat designation* for steelhead trout by NOAA Fisheries Service (NOAA, 2005).

California's Critical Coastal Areas (CCA) Program

The Estero Americano has also been listed as a Critical Coastal Area (#20) because it is an impaired waterbody that flows into a Marine Protected Area (State Coastal Commission, 2002). The Critical Coastal Areas (CCA) Program is an innovative program to foster collaboration among local stakeholders and government agencies, to better coordinate resources and focus efforts on coastal watersheds in critical need of protection from polluted runoff. A multi-agency statewide CCA Committee has identified an initial list of 101 CCAs along the coast and in San Francisco Bay.

Designated or Beneficial "Habitat" Uses of the Estero Americano

A designated use is a legally recognized description of an intended or desired use of a waterbody. In the State of California, Regional Water Quality Control Boards determine the beneficial uses of individual waterbodies. Designated beneficial "habitat" uses of the Estero Americano include: cold freshwater habitat, estuarine habitat, marine habitat, wildlife habitat, migration of aquatic organisms, spawning, reproduction, and/or early development, and rare, threatened, or endangered species (SWRCB, 2002).

This chapter provides an overview of the rich array of biological resources and habitats found in the Estero Americano Watershed. The majority of information presented on estuarine species and habitats was complied from a number of biological resources studies conducted in the late 1980s for the City of Santa Rosa, including bird census data, fisheries data, and aquatic invertebrate data. The information presented on upland habitats and species was derived primarily from the California Natural Diversity Data Base (CNDDB), The California Native Plant Species Inventory, The California Department of Forestry's California Land Cover Mapping and Monitoring Program (LCMMP), and earlier planning studies. A primary goal of the Estero Americano Watershed Management Plan is to enhance and protect the beneficial uses of the estuary, as well as to increase habitat value throughout the watershed. Detailed habitat enhancement goals and objectives are presented in *Chapter 6: Action Plan to Improve Natural Resources and Agricultural Sustainability*.

Changes in Estuarine Habitat

The following changes have likely altered the quality and/or quantity of estuarine habitat in the Estero Americano:

- Over the past 150 years, the Estero Americano Watershed has changed dramatically. Agricultural land use activities on the hills surrounding the estuary, including historic potato farming and instances of unmanaged livestock grazing, has increased rates of soil erosion. An estimated 1 million cubic yards of sediment was deposited in the open water of the Estero between 1850 and 1953 when potato farming was common.

- Severe erosion in the watershed has filled in large areas of the estuary. Parcel maps from 1850 show open tidal water in the Estero well upstream of Valley Ford, an area now covered by a broad pickleweed terrace with a narrow channel. On the same maps, confluences of the Estero and many tributary streams are shown as open water embayments. Today these are lobed deltas formed by sedimentation of the tributary mouths.

- Sediment entering the estuary has significantly reduced the amount of tidal marsh habitat.

- All streams in the watershed are now intermittent in most years, and no longer support fish resources above tidewater with the exception of Ebabias Creek. The lack of freshwater flow into the estuary during summer months has resulted in high salinity levels in the upper estuary, making it unsuitable habitat for upper estuary fish species such as the federally endangered tidewater goby.

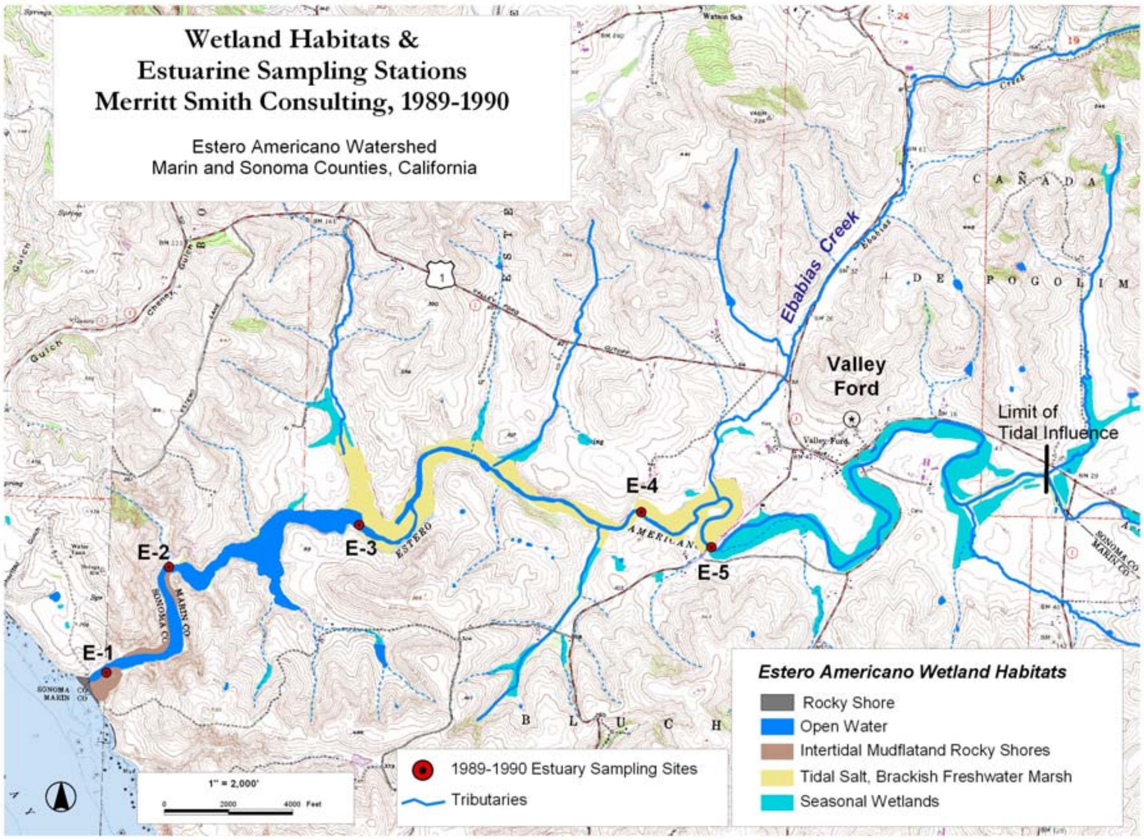
- Agricultural runoff from livestock ranches and dairies has resulted in elevated ammonia levels and anoxic conditions in the estuary resulting in periodic fish kills.

Table 2-1. Estuarine Wetland Habitats

National Wetlands Inventory (Class)	Acres
Intertidal Mudflat and Rocky Shores	**30**
Tidal Salt, Brackish, Freshwater Marsh	**240**
Open Water	**300**
Total Acres	**570**

Source: **California Resources Agency, Legacy Project, 2003.** *The National Wetlands Inventory (NWI) of the U.S. Fish & Wildlife Service produces information on the characteristics, extent, and status of the Nation's wetlands and deepwater habitats. The National Wetlands Inventory Center information is used by Federal, State, and local agencies, academic institutions, U.S. Congress, and the private sector.*

Figure 2-1. Estero Americano Wetlands and Estuary Sampling Stations, 1988-1989



Estuarine Habitat & Associated Biological Resources

The following section provides an overview of the distinct estuarine wetland habitats found in the Estero Americano Watershed (Table 2-1), along with the biological resources they support. The biological data reviewed in this section comes from a number of intensive sampling studies conducted between 1988 and 1989. Sampling was conducted at five monitoring stations located along the length of the estuary—from the mouth (Station E-1) to approximately 3.5 miles inland (Station E-5) (Figure 2-1). Although a single year of intensive sampling is insufficient to fully characterize biological resources and habitat conditions in such a highly variable estuarine environment, the study does provide a baseline assessment for that sampling year.

Open Water Habitat

There is an estimated 300 acres of open water habitat in the Estero Americano Watershed. The open water of the estuary supports large numbers of diving ducks, important marine and estuarine fish species, aquatic invertebrates, and submerged aquatic vegetation. Open water flora is dominated by algae species. Surveys conducted in the late 1980s identified thirty-eight algal species, including the classes Clorophyta, Phaeophyta, and Rhodophyta. A number of important flowering plant species are also present in the open water of the Estero. Pondweed (*Potamogeton nodosus*) is a submerged aquatic plant, arising from matted rhizomes, and is an important food for many water birds. Eelgrass (*Zostera marina*) is a flowering plant that grows in shallow subtidal and intertidal areas. Eelgrass beds are important habitat for multiple species in the Estero Americano.

Eelgrass *(Zostera marina)*

(Excerpted from *California's Living Marine Resources, A Status Report*, CDFG, 2001)

Eelgrass beds are generally regarded as highly productive habitats that support a rich assemblage of fish species and provide a refuge area for larval and juvenile fishes. Eelgrass habitat is also a very important resource for a variety of birds. It is associated with rich bottom fauna important to waterbirds, especially diving birds and mollusk-eaters. In California's bays and estuaries north of Monterey Bay, eelgrass provides spawning habitat for Pacific herring. Large numbers of waterbirds such as scoters, bufflehead, scaup, goldeneyes, American coots, eat eggs deposited onto eelgrass by Pacific herring during the mid-winter spawn. In addition, many birds such as surface-feeding ducks and other waterfowl, including the black brandt, feed directly on eelgrass.

Aside from its interaction in the marine and estuarine food webs, eelgrass assumes an important role in cycling nutrients. Organic material from natural decomposition processes or human influences are filtered and collected by eelgrass leaves, providing a nutrient source for the eelgrass bed community. Nutrients that otherwise would accumulate in the sediments or be flushed out to sea may thereby be retained and recycled within the estuarine ecosystem. In recent years, the importance of eelgrass communities has resurfaced as a significant measure of the health of bays and estuaries. Some protection of this ecosystem has been afforded over the years through management practices that protect it through disturbance avoidance or in-kind replacement mitigation.

The location, abundance and health of eelgrass appear to be highly sensitive to changes in environmental conditions. The distribution of eelgrasses within bay and estuarine ecosystems is dependent on a variety of parameters, including light, temperature, salinity, substrate, waves and currents, nutrients, and availability of seed. Most commonly, estuarine seagrasses are found in soft sediments of semi-sheltered areas where depth and turbidity conditions allow sufficient light. The historical presence of eelgrass along the California coast was much greater than it is today. Although few records exist that measure the aerial extent of eelgrass within the State's small coastal estuaries, the condition that existed prior to human disturbances in many of these locations were no doubt favorable to eelgrass bed communities.

In the Estero Americano, eelgrass beds extend from near the mouth of the estuary to a point about 1 mile inland, providing important substrate for many non-burrowing invertebrate species, such as hermit and Dungeness crabs (Commins et al., 1990). The Estero's eelgrass beds also function as important spawning habitat for Pacific herring and provide an important food source for migratory waterfowl (Madrone Associates, 1977).

Marine and Estuarine Fish Populations

The Estero Americano provides food, shelter and nursery habitat for many marine and estuarine fish species. The information presented in this section provides an overview of the most current information on the diversity, seasonal abundance, and general distribution of fish species in the Estero Americano. This information is close to 20 years old, and may not accurately reflect current conditions in the estuary.

The last fish survey conducted in the Estero Americano occurred between December 1988 and September 1989. Fish sampling was conducted on five or six separate occasions during that year using otter trawls and gill nets. Five sampling stations (E-1 through E-5) were used for the study (Map 2-1).

Thirty-five species of fish were identified in the estuary (Table 2-2 and Table 2-3). Six commercially important fish species are present in the estuary: English sole, Pacific sanddab, starry flounder, Pacific herring, northern anchovy and topsmelt. The Estero serves as a nursery for English sole and sanddab, and Pacific herring spawn in the estuary and nearshore coastal waters (Smith et al. 1988). Topsmelt and jacksmelt are also known to spawn in the Estero Americano.

Species Diversity, Seasonal Abundance & General Distribution:

The general pattern of seasonal use in the estuary showed the highest abundance in summer, decreasing in fall to low abundance in winter for all samples taken. The dominant species in the lower estuary (E-1 through E-2) were English sole, arrow goby, Bay pipefish, and Pacific sanddab. The dominant species in the middle to upper Estero Americano (Stations E-3 through E-5) were the plainfin midshipman, staghorn sculpin, surf smelt and Pacific herring.

The dominant species (30%) in the total trawl catch consisted of fingerling plainfin midshipman, a marine species that appeared in the upper estuary in large numbers in late summer (Table 2-2). The total catch by gill net is shown in Table 2-3. Complete catch results by station and date are provided in Appendix C. The main reason for gill net sampling was to capture fast-swimming and mid-water species that avoid the otter trawl (Commins, et al., 1990). The two dominant species caught using gill nets were topsmelt (49%) and staghorn sculpin (28%). Topsmelt were more dominant in the upper estuary and staghorn sculpin in the lower estuary.

Larval fish were collected as part of the sampling study using 505 µm mesh tows. Larval gobies were collected more consistently than other fishes (Commins, et al., 1990). Larvae of northern anchovy, topsmelt or jacksmelt, and Pacific herring were also common. Northern anchovy spawn in the ocean, whereas Pacific herring, topsmelt and jacksmelt spawn in the estuary, depositing eggs on solid substrates and aquatic vegetation such as eelgrass and seaweed. The sampling study found that total numbers of larvae were generally highest at the upper estuary stations E-4 and E-5, with highest overall numbers occurring in summer months.

Threatened, Endangered and Sensitive Species

There are two federally listed endangered fish species with potential habitat in the Estero Americano Watershed. The tidewater goby (*Eucyclobius newberryi*) and winter-run steelhead trout (*O. mykiss*). The virtual absence from the Estero Americano of habitat-sensitive upper estuarine species such as the tidewater goby suggests that water quality and other habitat factors make the system unsuitable for such species. Although the Estero Americano Watershed may have provided habitat for salmonids in the past, only a single steelhead trout was caught in the estuary during the 1988-1989 sampling study. The single steelhead trout caught during the sampling year at station E-5 was a male ready to spawn. Biologists conducting the sampling study concluded that the fish had undoubtedly strayed into the wrong estuary.

Tidewater Goby
(*Eucyclogobius newberryi*)

Tidewater goby (photo taken by the NPS)

The tidewater goby is a two-inch long, greyish brown fish that lives in coastal lagoons, estuaries, and marshes with relatively low salinities. It has lost a major portion of its habitat during the past 150 years to coastal development activities. The tidewater goby was listed as a federally endangered species in 1994. The tidewater goby has nearly disappeared in California due to habitat loss and degradation. The tidewater goby requires continuous low salinity conditions and tidal wetland habitat typical of upper estuaries.

Bimonthly fish sampling conducted in the Estero Americano in 1988 and 1989 found only a few individuals of this species, although the fish were abundant in the neighboring Estero de San Antonio. The biologists conducting the study concluded that high salinity concentrations in the upper Estero Americano, along with impacts to tidal wetland habitat from livestock use were likely responsible for the near absence of this species in the estuary. During summer months, salinity levels in the upper estuary are often hypersaline (>34 parts per thousand or above ocean salinity levels). This is due to the absence of perennial streamflow, and other factors such as the length, depth, and shape of the estuary—as water evaporates during the summer months, salinity concentrations increase in the remaining water.

Steelhead Trout (*Oncorhynchus mykiss*)

The Estero Americano and its tributary, Ebabias Creek, are designated as *Critical Habitat* for "winter run" steelhead trout by the National Oceanic and Atmospheric Administration (NOAA) (50 CFR 226). However, due to conditions in the estuary and its tributaries such as declines in year-round freshwater flow, siltation of former spawning areas, denuded stream corridors, fish passage barriers, and poor water quality, the system does not currently provide suitable habitat for salmonids.

Limiting Factors

Fisheries biologists assess habitat suitability based on an evaluation of limiting factors or habitat requirements for specific species. Limiting factors for salmon and steelhead trout can be defined as conditions that limit the ability of habitat to fully sustain healthy populations. Steelhead trout and other anadromous salmonids spawn in freshwater, spend various lengths of time in an estuary before migrating to the ocean, and then return to their natal streams to complete their life cycle. Healthy populations of anadromous salmonids require the following habitat conditions:

- Cool, clean, well oxygenated water
- Clean spawning gravel
- Complex stream channel structure (e.g., riffles, pools, and glides)
- Adequate summer stream flows and deep pools
- Diverse, well-established riparian vegetation
- Complex instream habitat elements such as large woody debris
- Abundant food supply

Steelhead trout spawning habitat in Dutch Bill Creek

According to a CDFG staff biologist, Ebabias Creek is likely the only potentially restorable freshwater habitat for steelhead trout in the larger Estero Americano Watershed. Based on a riparian corridor assessment conducted for this management plan, there are approximately 3.5 stream miles in the upper Ebabias Creek sub-basin that meet some of the spawning and rearing habitat requirements for steelhead trout. There are, however, at least three significant fish passage barriers between the estuary and spawning habitat in the upper watershed. An extensive stream survey and cost-benefit analysis should be conducted for Ebabias Creek to determine restoration potential and economic feasibility.

Table 2-2. Total Catch in Otter Trawls in the Estero Americano, 1988-1989

	Station						
Species	**E-1**	**E-2**	**E-3**	**E-4**	**E-5**	**Total**	**Percent**
Plainfin midshipman	0	0	1	61	425	**487**	30%
Staghorn sculpin	1	24	61	155	115	356	22%
Surf smelt	0	0	94	44	6	144	9%
Pacific herring	0	0	0	127	0	127	8%
English sole	54	16	4	1	0	75	5%
Bay pipefish	1	31	1	16	23	72	5%
Arrow goby	3	35	5	14	7	64	4%
Shiner surfperch	1	15	10	24	12	62	4%
Threespine stickleback	0	1	1	2	41	45	3%
Pacific sanddab	30	2	4	3	1	44	3%
Starry flounder	0	1	1	24	18	44	2%
Prickly sculpin	1	0	0	1	27	29	0.60%
Penpoint gunnel	9	1	0	0	0	10	0.50%
Crevice kelpfish	0	8	0	0	0	8	0.50%
Longfin smelt	0	8	0	0	0	8	0.37%
Hybrid sole	0	0	1	2	3	6	0.37%
Speckled sanddab	6	0	0	0	0	6	0.12%
Cabezon	2	0	0	0	0	2	0.12%
Sebastes (juvenille) "A"	0	2	0	0	0	2	0.12%
Striped bass	0	0	0	2	0	2	0.06%
Black surfperch	0	1	0	0	0	1	0.06%
Buffalo sculpin	1	0	0	0	0	1	0.06%
Cheekspot goby	0	0	0	0	1	1	0.06%
Lingcod	1	0	0	0	0	1	0.06%
Northern anchovy	0	0	0	1	0	1	0.06%
Pacific tomcod	0	1	0	0	0	1	0.06%
Sand sole	1	0	0	0	0	1	0.06%
Sebastes (juvenille) "C"	1	0	0	0	0	1	0.06%
Tidewater goby	0	1	0	0	0	1	0.06%
Topsmelt	0	0	0	1	0	1	0.06%
Total	**112**	**151**	**183**	**478**	**679**	**1603**	**100**

Source: Commins, M. L., J. C. Roth, M. H. Fawcett and D. W. Smith. 1990. Estero Americano and Estero de San Antonio Monitoring Program, 1988-1989 Results. Santa Rosa Subregional Water Reclamation System. Technical Memo E8.

Table 2-3. Total Catch in Gill Nets in the Estero Americano, 1988-1989.

	Station						
Species	**E-1**	**E-2**	**E-3**	**E-4**	**E-5**	**Total**	**Percent**
Topsmelt	10	1	9	45	26	**91**	49%
Staghorn sculpin	4	25	4	10	10	**53**	28%
Shiner surfperch	2	2	2	0	0	**8**	4%
Pacific herring	2	3	0	2	0	**7**	4%
Starry flounder	0	3	1	3	0	**7**	4%
Jacksmelt	1	5	0	0	0	**6**	3%
Striped bass	0	0	0	5	0	**5**	3%
Leopard shark	0	1	3	0	0	**4**	2%
Longjaw mudsucker	0	0	0	1	1	**2**	1%
Opaleye	1	0	0	0	0	**1**	0.5%
Spiny dogfish	1	0	0	0	0	**1**	0.5%
Steelhead trout	0	0	0	0	1	**1**	0.5%
Surf smelt	0	1	0	0	0	**1**	0.5%
Total	**21**	**41**	**21**	**66**	**38**	**187**	**100%**

Source: Commins, M. L., J. C. Roth, M. H. Fawcett and D. W. Smith. 1990. Estero Americano and Estero de San Antonio Monitoring Program, 1988-1989 Results. Santa Rosa Subregional Water Reclamation System. Technical Memo E8.

Invertebrates in the Estero Americano


Dungeness crab (*Cancer magister*)

Invertebrates consume algae and detritus and are a central link in the estuary's food chain. They also constitute the main food source for larger animals such as fish and waterbirds. Invertebrate sampling was conducted in the Estero Americano during the 1988-1989 sampling year by Merritt Smith Consulting, Inc. for the City of Santa Rosa (Commins, et al., 1990). Sampling efforts focused on three groups of aquatic organisms: plankton (small, free-swimming animals), nekton/epibenthos (such as crab and shrimp), and benthos (animals that live in sediment such as worms and clams). The number of invertebrate species collected was greatest near the mouth of the estuary and decreased upstream.

- Dominant zooplankton species collected in the estuary included the mysid shrimp (*Neomysis mercedis*), the copepod *Acartia clause*, and pea crab.

- Over 30 species of epibenthic invertebrates were collected in the Estero Americano during 1988 and 1989. Economically important shellfish species such as the shrimps *Crangon franciscorum* and *C. nigricauda*, and the Dungeness crab (*Cancer magister*), were collected throughout the estuary. Dungeness crab occurred primarily as large juveniles, and were most abundant between May and October. The yellow shore crab (*Hemigrapsis oregonensis*) was also abundant throughout the estuary, and is an important food source for shorebirds and some fishes.

Over 70 species of benthic invertebrates were collected in the Estero Americano during 1988 and 1989. Most of these were annual species, which are typically eliminated from the upper estuary by freshwater flows during winter months. The number of benthic species was highest at Station E-2, and diminished further upstream. The proximity to the ocean (the source of invertebrate larvae) and the relative consistency of salinity levels close to the mouth of the estuary, along with the presence of dense eelgrass beds at this location, contributed to the density of benthic invertebrates found there (Commins et al., 1990).

Shorebirds and Waterfowl

The Estero Americano is at the heart of the Pacific Flyway and supports a very large and diverse winter and migratory bird community. The Estero was identified in the Southern Pacific Shorebird Conservation Plan (Hickey et al., 2003) as one of only two "wetlands of importance" for migratory shorebirds and waterfowl in Sonoma County (Figure 2-2). The open water of the estuary provides foraging habitat for many species of migratory waterbirds. Most of these birds are exclusively winter residents, arriving in the estuary in late fall and staying through early spring. Table 2-4 lists the shorebirds and waterfowl found in the estuary during a 1988-1989 bird census (Connors and Maron, 1989).

The study identified 62 species of water-associated birds. Population numbers were very high for a number of species with seasonal peaks of almost 4,000 Western Sandpipers, over 800 Least Sandpipers, 3300 Dunlin, 250 Willets, and 500 Bufflehead. The birds are thought to be taking advantage of the tide lag between Bodega Harbor and the Estero, basically increasing the amount of time during which they can feed at low tide (ibid). Bird distributions were most striking by season. Distributions also varied by tide and location within the estuary according to species. Diving ducks were found primarily in the open water of the lower estuary. Dabbling ducks occurred most frequently in the middle and upper estuary. Shorebirds primarily use mudflats and salt marsh habitat, which are common in the middle estuary.

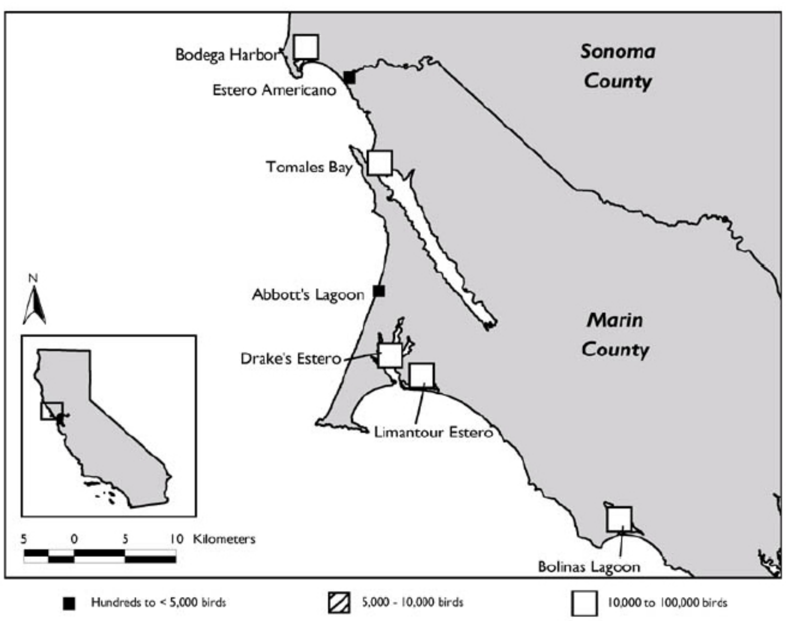


Figure 2-2. Important Wetlands and Beaches of Sonoma and Marin Counties.

Wetlands of importance are determined by level of shorebird use. Beaches of importance are currently determined by importance to Snowy Plover.

Source: Hickey, C., W.D. Shuford, G.W. Page, and S. Warnock. 2003. Version 1.1. The Southern Pacific Shorebird Conservation Plan: A strategy for supporting California's Central Valley and coastal shorebird populations. PRBO Conservation Science, Stinson Beach, CA.

Table 2-4. Estero Americano Waterfowl and Shorebird Species List, 1988-1989

Common Name	Scientific Name	Max Count	Date	Tide
Greater Yellowlegs	*Tringa melanoleuca*	10	2/28/1989	High
Spotted Sandpiper	*Actitis macularia*	2	5/14/1989	High
Wondering Tattler	*Heteroscelius incanus*	1	8/20/1989	Low
Red-necked Phalarope	*Phalaropas lobatus*	5	5/14/1989	High
Short-billed Dowitcher	*Limnodromus griseus*	338	8/20/1989	Low
Black Turnstone	*Arenaria melanocphala*	4	1/27/1989	Low
Dunlin	*Calidris alpina*	3302	12/17/1988	Low
Sanderling	*Calidris alba*	32	1/27/1989	Low
Western Sandpiper	*Calidris mauri*	3965	9/19/1989	Low
Least Sandpipier	*Calidris minutilla*	834	8/20/1989	Low
Heermann's Gull	*Larus heermanni*	1	7/23/1989	High
Bonaparte's Gull	*Larus philidelphia*	2	11/19/1988	Low
Ring-billed Gull	*Larus delawarensis*	132	7/23/1989	Low
Mew Gull	*Larus canus*	88	11/19/1988	Low
Herring Gull	*Larus argentatus*	2	11/19/1988	High
Glausous-winged Gull	*Larus glaucescens*	7	12/17/1988	High
Western Gull	*Larus occidentalis*	1	9/19/1989	Low
Forster's Tern	*Sterna forsteri*	32	12/17/1988	Low
Caspian Tern	*Sterna caspia*	12	9/3/1989	High
Osprey	*Pandion haliaetus*	7	5/14/1989	Low
Belted Kingfisher	*Ceryle alcyon*	3	2/28/1989	High
Common Loon	*Gavia immer*	3	12/17/1988	Low
Arctic Loon	*Gavia arctica*	3	11/19/1988	Low
Red-throated Loon	*Gavia stellata*	8	12/17/1988	Low
Western Grebe	*Aechmophorus occidentalis*	5	11/19/1988	High
Red-necked Grebe	*Podiceps grisegena*	1	1/27/1989	Low
Horned Grebe	*Podiceps auritus*	1	1/27/1989	Low
Eared Grebe	*Podiceps nigricollis*	1	1/31/1989	High
American White Pelican	*Pelecanus erthrorhynchos*	60	7/23/1989	Low
Double-crested Cormorant	*Phalacrocorax auritus*	56	3/27/1988	Low
Black-crowned Night-Heron	*Nycticorax nicticorax*	9	7/23/1989	Low
Green-backed Heron	*Butorides striatus*	1	9/19/1989	High
Snowy Egret	*Egretta thula*	21	9/3/1989	Low
Great Egret	*Casmerodius albus*	15	8/20/1989	High
Great Blue Heron	*Ardea herodias*	22	6/5/1989	Low
Tundra Swan	*Cygnus colombianus*			
Mallard	*Anus platyrhynchos*	15	2/28/1989	High
Green-winged Teal	*Anas crecca*	29	2/28/1989	High
American Widgeon	*Anas americana*	215	2/28/1989	high
Northern Pintail	*Anas acuta*	9	9/3/1989	High
Northern Shoveler	*Anas clypeata*	1	1/27/1989	High
Cinnamon Teal	*Anas cyanoptera*	70	2/28/1989	High
Ruddy Duck	*Oxyura jamaicensis*	49	1/31/1989	Low

Source: Connors, P. G. and J. L. Maron. 1989. Estero Americano Bird Population Study. Santa Rosa Subregional Water Reclamation System. Technical Memo E13.

Table 2-4 cont. Estero Americano Waterfowl and Shorebird Species List, 1988-1989.

Common Name	Scientific Name	Max Count	Date	Tide
Greater Scaup	*Aytha marila*	64	1/31/1989	High
Black Scoter	*Melanitta nigra*	3	2/28/1989	Low
White-winged Scoter	*Melanitta fusca*	8	1/27/1989	High
Surf Scoter	*Melanitta perspicillata*	80	1/31/1989	Low
Common Goldeneye	*Bucephala clangula*	17	2/28/1989	High
Bufflehead	*Bucephala albeola*	497	2/28/1989	Low
Common Merganser	*Mergus Merganser*	8	5/14/1989	High
Red-breasted Merganser	*Mergus swerrator*	5	7/23/1989	Low
Hooded Merganser	*Lophodytes cucullatus*	4	11/19/1988	Low
Virginia Rail	*Rallus limicola*	1	1/27/1989	Low
American Coot	*Fulica americana*	2	1/27/1989	Low
American Avocet	*Recurvirostra americana*	38	1/31/1989	High
Semipalmated Plover	*Chardrius semipalmatus*	82	1/27/1989	Low
Killdeer	*Chardrius vociferus*	47	11/19/1988	Low
Black-bellied Plover	*Pluvialis squatarola*	2	10/25/1989	Low
Lesser Golden Plover	*Pluvialis dominica*	3	9/3/1989	High
Marbled Godwit	*Limosa fedoa*	61	1/27/1989	Low
Whimbrel	*Numenius phaeopus*	17	5/2/1989	Low
Long-billed Curlew	*Numenius americanus*	25	9/3/1989	Low
Willet	*Cataptrophorus semipalmatus*	248	9/3/1989	Low

Intertidal Mudflat Habitat

Mudflats are formed when upstream and marine-born sediments are deposited in shallow areas in the estuary. This intertidal habitat is characterized by soft substrate invertebrates and algal species. Invertebrate species include: bivalves (softshell clam, sand clam, and bent-nosed clam), snails (limpets and sea slugs), polychaete worms (*Glycera* and *Streblospio*), and various species of crustacean, including Dungeness crab, opossum shrimp, rock lice, amphipods, bas crabs, and ghost shrimp (Madrone Associates, 1977). Mudflats are the most important feeding areas within an estuary for shorebirds (low tide) and waterfowl (high tide). Amphipoda, small crustaceans living in the mud or on mudflat algae, are an important common food source for shorebirds. In the Estero Americano, the value of mudflats as feeding habitat for water birds is most pronounced during periods of tidal influence, typically late fall through spring when the sand bar has been breached.

Coastal Brackish Marsh Habitat

The National Wetlands Inventory GIS data layer shows 240 acres of tidal marsh in the Estero Americano Watershed, primarily in the upper reaches of the estuary. Coastal or “seasonal” brackish marsh is characterized by plant assemblages that contain elements of both salt marsh and freshwater marsh plant communities. Vegetation in this wetland habitat has evolved in response to a unique set of ecological conditions including extreme fluctuations in salinity levels, seasonal variations in flooding frequency and duration, and periodic desiccation. This wetland habitat is similar to coastal salt marsh at higher elevations. Dominant plant species in coastal brackish marsh include pickleweed (*Salicornia spp*.), Jaumea (*Jaumea spp.)*, and salt grass (*Distichlis spicata* var. *spicata*), saltbush (*Atriplex triangularis*) and Frankenia (*Frankenia salina*). Coastal brackish marsh has been classified by the CDFG as a sensitive natural community (CDFG, 1995). During periods of tidal influence, when much of the area of coastal brackish marsh is inundated, water-associated birds congregate in the hundreds (Connors and Maron, 1989).

Upland Habitat & Associated Biological Resources

Annual grasslands in the Estero Americano Watershed

The topography of the watershed varies from rolling hills to steep, incised valleys. The gently sloping, wind swept hills of the watershed are dominated by annual grasslands and coyote bush, with pockets of oak woodland and oak-bay-madrone woodland occurring in the steeper valleys (Table 2-5). A mix of Redwood and Douglas Fir forests are found at higher elevations along the northeastern boundary of the watershed. The numerous intermittent streams located throughout the area contain willow riparian and mixed riparian woodland. Many of the valleys and low-lying areas support seasonal wetlands, freshwater marshes, and vernal pools. Remnant populations of coastal prairie and northern coastal scrub can still be found in the watershed. Patches of northern coastal scrub are generally found on drier hillsides with shallow rocky soils.

Table 2-5. Terrestrial Vegetation, LCMMP GIS Data

Vegetation Type	Acres
Annual Grasses	21,528
California Bay	99
Oak Woodland	130
Redwood/Douglas Fir	293
Hardwoods	143
Monterey Cypress or Pine	11
Non-native shrubs (e.g., gorse)	125
Coyote Bush/native shrubs	542
Willows	47
Riparian Woodland	139

Data Source: 2003, CDF-FRAP California Land Cover Mapping and Monitoring Program (LCMMP GIS Data). Available through the California Spatial Information Library (CSIL)

Freshwater Marshes, Ponds, and Seeps

National Wetland Inventory data identified roughly 55 acres of freshwater ponds in the Estero Americano Watershed. Freshwater ponds and vernal pools provide important habitat for numerous salamanders, snakes, toads, and frogs for some part of their life cycle. The 575 acres of seasonal wetlands identified in the watershed are important habitat for terrestrial birds, and provide habitat connectivity, refugee, and other habitat values for many aquatic and terrestrial animal species. A species list of terrestrial birds in the watershed is provided in Table 2-6. The bird census was conducted during 1988 and 1989.

Freshwater pond in the Estero Americano Watershed

Seeps are located where the slope of a hill or bluff intersects the groundwater table or where springs seep water out of the ground. Seeps are common throughout the watershed, and may form permanently or temporarily wet conditions. Plants associated with seep areas include the locally rare seep thistle (*Cirsium breweri* var. *wrangelii*), western chain fern, coast hedge nettle, arroyo willow, wax myrtle, loosestrife, yellow money-flower, fireweed, poison hemlock, pearlwort, and western lilaeopsis.

Threatened, Endangered and Sensitive Species in Upland Areas

(The following section was prepared for the Gold Ridge Resource Conservation District by Prunuske Chatham, Inc)

Special-status species are taxa listed as endangered or threatened by the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NOAA Fisheries Service), or California Department of Fish and Game (CDFG); taxa designated as candidates for listing; or any species of concern or local concern by USFWS, NOAA Fisheries Service, and/or CDFG. In addition, the California Native Plant Society (CNPS) has compiled a list of plant species that are considered rare, threatened, or endangered. Consideration of these plants must be included during project evaluation in order to comply with the California Environmental Quality Act (CEQA) Guidelines concerning special-status species.

According to the CDFG Natural Diversity Data Base (CNDDB) (CDFG 2006) and CNPS Online Inventory of Rare and Endangered Plants (CNPS 2005), a number of special-status plant and animal species have been reported within the watershed on the Two Rock and Valley Ford USGS quadrangles. The CNDDB reports occurrences of special-status species that have been entered into the database and does not generally include inventories of more common animals or plants. The absence of a species from the database does not necessarily mean that they do not occur in the area, only that no sightings have been reported. In addition, sightings are subject to observer judgment and may not be entirely reliable as a result.

Special Status Plants

CNDDB and CNPS records identified the potential presence of the following 41 special-status plants and one lichen on the Valley Ford and Two Rock quadrangles. These include pink-sand verbena (*Abronia umbellate* ssp. *breviflora*), Blasdale's bent grass (*Agrostis blasdalei*), Point Reyes bent grass (*A. clivicola* var. *punta-reyesensis*), Sonoma alopecurus (*Alopecurus aequalis* var. *sonomensis*), bent-flowered fiddleneck (*Amsinckia lunaris*), Point Reyes blennosperma (*Blennosperma nanum* var. *robustum*), coastal bluff morning-glory (*Calystegia purpurata* ssp. *saxicola*), swamp harebell (*Campanula californica*), San Francisco spineflower (*Chorizanthe cuspidata* var. *cuspidata*), woolly-headed spineflower (*C. cuspidata* var. *villosa*), Franciscan thistle (*Cirsium andrewsii*), Raiche's red ribbons (*Clarkia concinna* ssp. *raichei*), Point Reyes bird's-beak (*Cordylanthus maritimus* ssp. *palustris*), Baker's larkspur (*Delphinium bakeri*), yellow larkspur (*D. luteum*), western leatherwood (*Dirca occidentalis*), fragrant fritillary (*Fritillaria liliacea*), dune gilia (*Gilia capitata* ssp. *chamissonis*), woolly-headed gilia (*G. capitata* ssp. *tomentosa*), hayfield tarplant (*Hemizonia congesta* ssp. *leucocephala*), short-leaved evax (*Hesperevax sparsiflora* var. *breviflora*), Point Reyes horkelia (*Horkelia marinensis*), Contra Costa goldfields (*Lasthenia conjugens*), perennial goldfields (*L. macrantha* ssp. *macrantha*), Pitkin Marsh lily (*Lilium pardalinum* ssp. *pitkinense*), Sebastopol meadowfoam (*Limnanthes vinculans*), Baker's goldfields (*L. macrantha* ssp. *bakeri*), rose leptosiphon (*Leptosiphon rosaceus*), rose linanthus (*Linanthus rosaceus*), Tidestrom's lupine (*Lupinus tidestromii*), marsh microseris (*Microseris paludosa*), robust monardella (*Monardella villosa* ssp. *globosa*), North Coast semaphore grass (*Pleuropogon hooverianus*), California beaked-rush (*Rhynchospora californica*), round-headed beaked rush (*Rhynchospora globularis* var. *globularis*), Point Reyes checkerbloom (*Sidalcea calycosa* ssp. *rhizomata*), thamnolia lichen (*Thamnolia vermicularis*), showy Indian clover (*Trifolium amoenum*), Santa Cruz clover (*Trifolium buckwestrorum*), saline clover (*T. depauperatum* var. *hydrophilum*), and San Francisco owl's clover (*Triphysaria floribunda*).

Special-Status Animals

The CNDDB records identified the potential presence of 20 special status animal species on the Valley Ford and Two Rock USGS quadrangles. These include tricolored blackbird (*Agelaius tricolor*), California tiger salamander (*Ambystoma californiense*), pallid bat (*Antrozous pallidus*), red tree vole (*Arborimus pomo*), great egret (*Ardea alba*), great blue heron (*A. herodias*), San Bruno elfin butterfly (*Callophrys mossii* bayensis), northwestern pond turtle (*Clemmys marmorata marmorata*), western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), globose dune beetle (*Coelus globosus*), black swift (*Cypseloides niger*), monarch butterfly (*Danaus plexippus*), California red-legged frog (*Rana aurora draytonii*), tidewater goby (*Eucyclogobius newberryi*), bumblebee scarab beetle (*Lichnanthe ursine*), ashy storm-petrel (*Oceanodroma homochroa*), Myrtle's silverspot (*Speyeria zerene myrtieae*), California freshwater shrimp (*Syncaris pacifica*), and American badger (*Taxidea taxus*).

Annual Grassland:

Annual grasslands dominate the landscape of the Estero Americano Watershed. There is an estimated 21,528 acres of annual grasslands in the watershed (Table 2-5). Non-native grasses dominate annual grasslands. Human disturbances such as clearing and grazing have allowed this non-native grassland to establish in areas that were previously coastal prairie, coastal scrub or other native vegetation (ibid.). Growth of annual grasslands generally begins with the first rain, and depending on rainfall and grazing, large amounts of dead stand can be found in summer months.

Most non-native grasses were introduced from the Mediterranean region during European colonization of the area. Common non-native grasses include European hairgrass (*Aira caryophyllea*), slender wild oat (*Avena barbata*), wild oat (*A. fatua*), ripgut brome (*Bromus diandrus*), barnyard grass (*Echinochloa crus-galli*), wild barley (*Hordeum murinum* ssp. *leporinum*) and wild rye (*Lolium multiflorum*). Common herbaceous plants found in annual grasslands include filaree (*Erodium botrys*), bur-clover (*Medicago polymorpha*), white clover (*Trifolium repens*), and hayfield tarweed (*Hemizonia congesta* ssp. *congesta*) (Bartholomew, 1996).

The proportion of native to non-native plants in annual grasslands is low (ibid). Some special status plant species can be found in this community including bent-flowered fiddleneck (*Amsinkia lunaris*), swamp harebell (*Campanula californica*), Baker's larkspur (*Delphinium bakeri*), hayfield tarplant (*Hemizonia congesta* ssp. *leucocephala*), Contra Costa goldfields (*Lasthenia conjugens*), March microseris (*Microseris paludosa*), robust monardella (*Monardella villosa* ssp. *globosa*), showy Indian clover (*Trifolium amoenon*), saline clover (*Trifolium depauperatum* var. *hydrophilum*) and San Francisco owl's-clover (*Triphysaria floribunda*). (Species Report, Prunuske Chatham, 2005)

Special status animal species found in annual grasslands are the Tricolored blackbird (*Ageblaius tricolor*) nesting colony and Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*). Raptors including red-tailed hawks, white-tailed kites and American kestrels hunt prey in these open grass fields. (Madrone Associates, 1977) Occasionally a golden eagle or rough-legged or ferruginous hawk has been spotted in the watershed. In wet years, the grasslands act as an extension of shorebird and wading bird habitat. Jackrabbits, deer, voles, and pocket gophers favor grasslands. Grey fox, burrowing owls and California ground squirrels can also be found in these grasslands.

Table 2-6. Estero Americano Terrestrial Birds, Species List 1988-1989.

Common Name	Scientific Name
Turkey Vulture	*Cathartes aura*
Golden Eagle	*Aquila chrysaetos*
Bald Eagle	*Haliaeetus leucocephalus*
Black-shoulder Kite	*Elanus caeruleus*
Northern Harrier	*Circus cyaneus*
Sharp-shinned Hawk	*Accipiter straitus*
Cooper's Hawk	*Accipiter cooperii*
Red-shouldered Hawk	*Buteo lineatus*
Red-tailed Hawk	*Buteo jamaicensis*
Ferruginous Hawk	*Buteo regalis*
American Kestrel	*Falco sparverius*
Peregrine Falcon	*Falco peregrinus*
Prairie Falcon	*Falco mexicanus*
California Quail	*Callipepla californica*
Mourning Dove	*Zenaida macroura*
Great-Horned Owl	*Bubo virginianus*
Barn Owl	*Tyto alba*
Northern Flicker	*Colaptes auratus*
Western Kingbird	*Tyrannus verticalis*
Black Phoebe	*Sayornis nigricans*
Say's Phoebe	*Sayornis sava*
Horned Lark	*Eremophila alpestris*
Violet-green Swallow	*Tachycineta thalassina*
Bank Swallow	*Riparia riparia*
Cliff Swallow	*Hirondo pyrrhonota*
Barn Swallow	*Hirondo rustica*
Scrub Jay	*Aphelocoma coerulscens*
American Crow	*Corvus brachyrhynchos*
Common Raven	*Corvus corax*
Wrentit	*Chamaea fasciata*
Bewick's Wren	*Thryomanes bewickii*
Western Bluebird	*Sialia mexicana*
American Robin	*Turus migratorius*

Source: Connors, P. G. and J. L. Maron. 1989. Estero Americano Bird Population Study. Santa Rosa Subregional Water Reclamation System. Technical Memo E13.

Coastal Prairie/Native Grassland:
Perennial bunch grasses, native herbs and patches of coastal scrub dominate native grasslands. In 1977, an estimated 17 acres of coastal prairie existed in the Estero Americano Watershed (Madrone Associates, 1977). Native perennial grasslands are found in areas not heavily disturbed on slopes and hilltops in isolated populations (ibid.). Annual non-native grasses have replaced most of the native grasslands due to historic potato farming and current rangeland management practices.

Photo Courtesy of the Bodega Marine Lab

Vegetation within this plant community consists of native bunchgrasses such as *Festuca californica*, Pacific reedgrass (*Calamagrostis nutkaensi*), purple needlegrass (*Nasella pulchra)* and wild blue rye (*Elymus glaucus*), as well as other native grasses including California bromegrass (*Bromus carinatus*), California oatgrass (*Danthonia californica*), and slender hairgrass (*Deschampsia elongate*). Native prairie also contains coastal scrub bushes, coyote brush (*Baccharis pilularis*), ocean spray (*Holodiscus discolor*), California sagebrush (*Artemisia californica)*, coffeeberry (*Rhammus californica*), poison oak (*Toxidendron diversilobum*), and native herbs including Douglas iris (*Iris douglasiana*) and lupine (Madrone Associates, 1977; Bartholomew, 1996).

Special status plants that can be found in this habitat include bent-flowered fiddleneck (*Amsinkia lunaris*), swamp harebell (*Campanula californica*), Baker's larkspur (*Delphinium bakeri*), hayfield tarplant (*Hemizonia congesta* ssp. *leucocephala*), Contra Costa goldfields (*Lasthenia conjugens*), March microseris (*Microseris paludosa*), robust monardella (*Monardella villosa* ssp. *globosa*), North Coast semaphore grass (*Pleuropogon hooverainus*), showy Indian clover (*Trifolium amoenon*), saline clover (*Trifolium depauperatum* var. *hydrophilum*) and San Francisco owl's-clover (*Triphysaria floribunda*).

Animals found in native prairies and grasslands are similar to those in annual non-native grasslands. Raptorial birds including red-tailed hawks, white-tailed kites and American kestrels hunt prey in these open fields. Occasionally a golden eagle or rough-legged and ferruginous hawks have been spotted in the Estero Americano Watershed. Table 2-6 presents a species list of terrestrial birds identified in the watershed during a bird census study in 1988 and 1989. Jackrabbits, deer, voles, and pocket gophers favor grasslands. Grey fox, burrowing owls and California ground squirrels can also be found (Madrone Associates, 1977). Special status animal species found in native grasslands are the Tricolored blackbird (*Ageblaius tricolor*) nesting colony and Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*).

Northern Coastal Scrub:
Coastal scrub is characterized as being a "softer" chaparral, and grows under conditions of high winds and salt spray. For these reasons, vegetation is often short in statue, and includes a diverse and hearty array of shrubs. Shrubs are generally 1 to 6 feet in height and have mesophytic leaves and shallow roots (Bartholomew, 1996). It is located on gentle slopes adjacent to the coastline. As of 1977, coastal scrub covered approximately 237 acres in the Estero Americano Watershed (Madrone Associates, 1977).

Yellow Bush Lupine
Photo Courtesy of Bodega Marine Laboratory

Vegetation found within the Estero Americano Watershed coastal scrub plant community is dominated by native plants such as bush lupine (*Lupinus succulentus*) and coyote brush (*Baccharis pilularis*). Other common natives found in this habitat type include snowberry (*Symphoricarpos mollis*), ocean spray (*Holodiscus discolor*), California sagebrush (*Artemisia californica),* coffeeberry (*Rhammus californica*), poison oak (*Toxidendron diversilobum*), and bracken fern (*Pteridium aquilinum* var. *pubescens*). Plants such as Indian paintbrush (*Castilleja affinis* ssp. *affinins*), Western sword fern (*Polystichum munitum*), yerba buena (*Satureja douglasii*), and California oatgrass (*Danthonia californica*) are common plants found in the understory (Bartholomew, 1996).

Special status plants (potentially) in this community include bent-flowered fiddleneck (*Amsinckia lunaris*), Baker's larkspur (*Delphinium bakeri*), yellow larkspur (*Delphinium luteum*), hayfield tarplant (*Hemizonia congesta* ssp. *leucocephala*), Point Reyes horkelia (*Horkelia marinensis*), Marsh microseris (*Microseris paludosa*), robust monardella (*Monardella villosa* ssp. *globosa*), showy Indian clover (*Trifolium amoenom*) and San Francisco's owl's-clover (*Triphysaria floribunda*).

Introduced rosebush (*Rosa eleganteria*) has replaced native vegetation resulting in lesser habitat value of this area, which is habitat for such animals as the raccoon, striped skunk, grey fox and long-tailed weasel. Many small seed-eating birds, rodents and small mammals eat and nest in this habitat (Madrone Associates, 1977)

Delphinium bakeri
Photo Courtesy of Cal Flora

Conclusion

Recommended "Action Plan" elements to protect and enhance key habitat in the Estero Americano Watershed can be found in *Chapter 6: Action Plan to Improve Natural Resources and Agricultural Sustainability*. Additional information on habitats and biological resources can be found in the following appendices of this document: Appendix A: Biological Resources; Appendix D: Riparian Assessment; Appendix E: Fisheries Enhancement Report; and Appendix F: Monitoring Needs and Guidelines.

Key Habitat Goals:

- Assess, Protect, and Enhance Riparian Habitat
- Assess, Protect, and Enhance Instream Habitat
- Assess, Protect, and Enhance Freshwater Wetland Habitat
- Assess, Protect, and Enhance Estuarine and Tidal Habitat
- Promote Biodiversity and Native Species Abundance in Upland Habitats

CHAPTER 3

WATER QUALITY:

AN INDICATOR OF WATERSHED HEALTH

Introduction

The 2002 California Water Quality Assessment Report published by the State Water Resources Control Board (SWRCB) listed 199 acres of the Estero Americano and the full length of Americano Creek as impaired waterbodies due to nutrient pollution. The Estero Americano is also listed as impaired due to sedimentation/siltation. Potential sources of excess nutrient loads include range and pasture grazing in upland and riparian areas, intensive animal feeding operations, manure ponds, and dairies. Potential sources of excess sediment include range and riparian area grazing, modified drainage pathways, removal of riparian vegetation, destabilized streambanks, and upland erosion.

Impaired water quality can potentially affect the health of humans, livestock, wildlife, and aquatic organisms. The North Coast Regional Water Quality Control Board (NCRWQCB) classifies any stream in the region as a potential source of drinking water (NCRWQCB, 2006). Although Americano Creek and its tributaries are not currently used as a source of domestic or municipal drinking water, the creeks are used as a water source for livestock. Nutrient and sediment pollution can also significantly alter, degrade or eliminate important wildlife and aquatic habitat.

According to the U.S. Environmental Protection Agency (EPA), water quality goals for a particular watershed must be based on the designated beneficial uses of its waterbodies (EPA, 2005). A designated use is a legally recognized description of an intended or desired beneficial use, such as aquatic life support, fish consumption, drinking water supply, or body contact recreation. These are uses that the State has designated for the waterbody. The Federal Clean Water Act requires that waterbodies attain or maintain the water quality standards needed to support designated or existing uses. The water quality standards for specific designated uses are established by the U.S. Environmental Protection Agency (EPA) and the State.

Designated beneficial uses of the Estero Americano and Americano Creek that may be impacted by water quality impairments include: municipal and domestic water supply, agricultural water supply, industrial service supply, groundwater recharge, navigation, water contact recreation, non-contact water recreation, commercial and sport fishing, cold freshwater habitat, estuarine habitat, marine habitat, wildlife habitat, migration of aquatic organisms, spawning, reproduction, and/or early development, and rare, threatened, or endangered species.

Total Maximum Daily Load (TMDL): What is it and why is it important?

Section 303(d) of the Federal Clean Water Act (CWA) requires States to identify all the waterbodies that do not meet applicable water quality standards for their designated uses. For waterbodies that are "impaired," States must establish TMDLs. The States must also rank these impaired waterbodies by priority, taking into account the severity of the pollution and the beneficial uses of the waterbody. Lists of prioritized impaired waterbodies are known as the CWA Section "303(d) lists" and must be submitted to the U.S. Environmental Protection Agency (EPA) every two years.

Establishing the TMDL for a waterbody is accomplished by calculating the maximum amount of a pollutant (or load) that a waterbody can receive and still meet protective water quality standards. A TMDL is the sum of the allowable loads from all contributing natural and land management inputs. Once allowable loads are determined, all of the sources of that pollutant in a watershed are identified, and loading rates are allocated among existing sources. Acceptable loading rates are generally allocated based on percent reductions for each source.

The CWA recognizes two types of water pollution: pollution discharged by *point sources* and pollution discharged by *nonpoint sources*. Point sources include water treatment plants, factories, and other "discernible confined discrete conveyances." Nonpoint source pollution (NPS) is more dispersed in the landscape, and includes, for example, any pathogens, bacteria, metals, nutrients and pesticides delivered to waterbodies in stormwater runoff. NPS pollution also includes sediment discharged to waterbodies from roads, streambanks, gullies, and sheet and rill erosion. Table 3.1 lists point and potential nonpoint sources of pollution in the Estero Americano watershed.

The TMDL allocated to a point source of pollution is known as a "waste load allocation," and is enforced through waste discharge requirements (WDRs) inserted into a National Pollutant Discharge Elimination System (NPDES) permit. The portion allocated to nonpoint sources of pollutant (including load estimates from natural sources) is known as a "load allocation," and is enforced through the State's nonpoint source management program.

Nonpoint source pollution is typically controlled through "best management practices." For example, an agricultural best management practice (BMP) for preventing runoff from land application of manure might require a vegetated buffer strip around farm fields. The EPA and the U.S. Department of Agriculture (USDA) have developed BMPs for most types of nonpoint source pollution, and have shown that agricultural nonpoint source pollution can be reduced by 20 to 90 percent through management measures aimed at soil retention and runoff reduction (USDA, NRCS, 1997; EPA, 2005).

TMDL determinations are currently scheduled for the Estero Americano Watershed in 2019. Proactive and voluntary measures taken at the watershed-scale to reduce nonpoint sources of pollution entering a 303(d) listed waterbody can potentially eliminate or significantly minimize a mandatory regulatory process. This document, and the planning process on which it is based, were designed to help reduce water quality impairments in the watershed through a collaborative, voluntary planning process.

Table 3-1. Summary of Potential Pollutants and Sources in the Estero Americano Watershed

Pollutant	Potential Sources		Impacts on Waterbody
	Point Source	**Nonpoint Source**	
Pathogens	• CAFOs • Landfill	• Animals (domestic, livestock, wildlife) • Pasture and rangeland • Malfunctioning septic systems • Land application of manure	• Primarily human health risks
Metals	• CAFOs • Landfill • Urban runoff	• Hazardous waste sites (unknown)	• Aquatic life impairments • Risk to livestock • Fish contamination
Nutrients	• CAFOs • Landfill	• Lawns, golf course • Animals (domestic, livestock, wildlife) • Pasture and rangeland • Malfunctioning septic systems • Land application of manure	• Aquatic life impairments • Recreational impacts • Human health impacts • Habitat impacts
Sediment		• Rangeland erosion • Streambank erosion • Landslides & gullies • Urban runoff • Roads • Construction	• Aquatic habitat impairments • Recreational impacts • Navigational impacts • Hydrologic impacts • Habitat impacts
Temperature		• Sediment (turbidity increases stream temperatures) • Lack of riparian shading • Shallow or wide stream channels (due to hydrologic modification)	• Aquatic life impairments • Recreational impacts

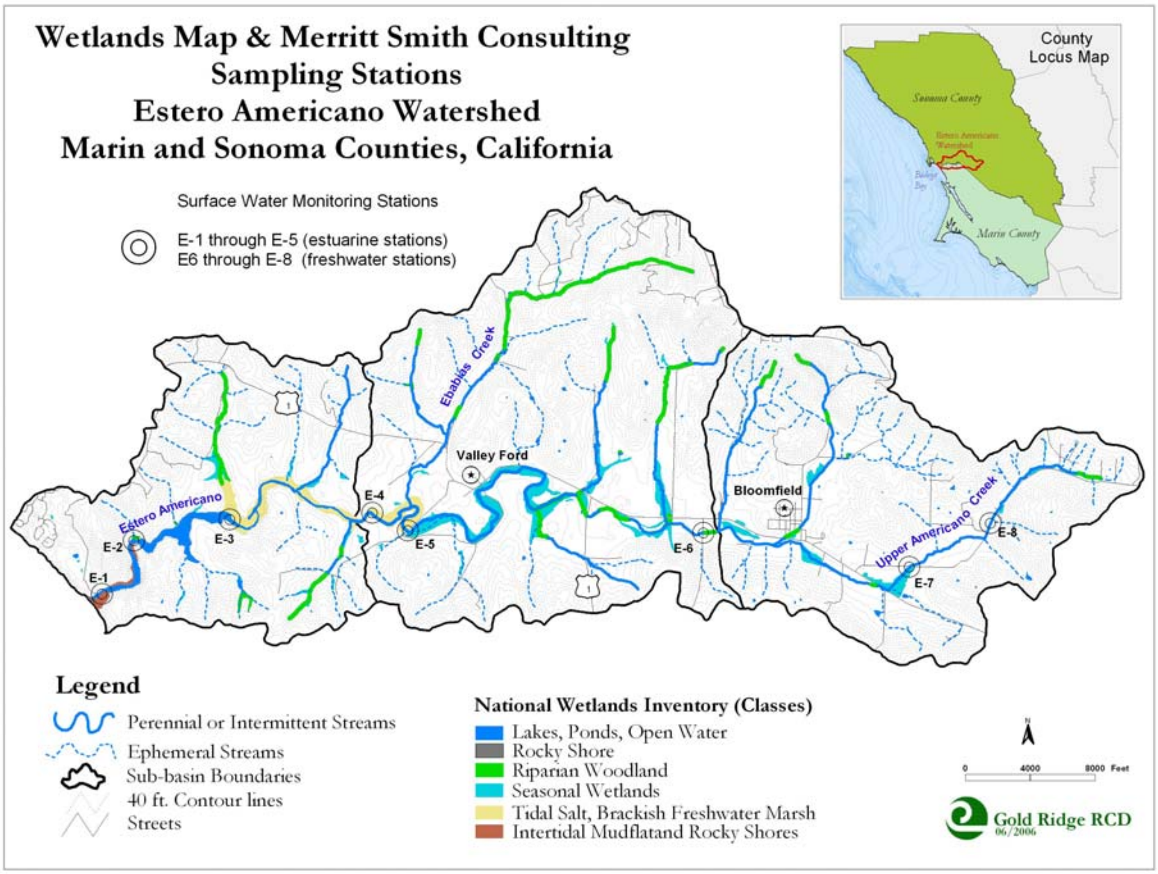
Water Quality in the Estero Americano Watershed

Inorganic nutrients, primarily from animal waste, are discharged into the Estero and its tributaries during rainfall runoff events. Nutrients (nitrate and phosphate) can cause environmental problems in a variety of ways. Un-ionized ammonia (a reduced form of nitrogen) is toxic and can be present in such high concentrations that it kills aquatic organisms. In aquatic ecosystems, nutrients can cause blooms of algae. In coastal waters, nitrogen is the nutrient of concern causing overfertilization of aquatic plants. In freshwater systems, phosphorus is the nutrient of concern. Algal blooms and the die-off of aquatic plants in coastal waters both cause oxygen depletion in the water column, resulting in poor habitat conditions for aquatic species.

Sediment impairments due to the cumulative effects of erosion in the watershed include degradation or elimination of domestic or agricultural water supplies, destruction of fisheries habitat, degradation of aquatic life support and recreational values, and instream sediment accumulation contributing to increased flood frequency and severity. High turbidity and suspended sediment loads can harm aquatic communities in a number of ways. Suspended sediment in the water column can block sunlight from aquatic plants causing a general decrease in productivity along the food chain. Stream temperature can also increase due to sediment deposition by eliminating deep pools and moving water closer to the surface where it is warmed by the sun. High turbidity can cause declines in the entire aquatic ecosystem by impairing physiologic functioning, foraging behavior, and habitat utilization. Fine sediment can smother the eggs of aquatic organisms, and destroy spawning habitat for salmonids.

Baseline water quality data were collected monthly at five Estero Americano and three Americano Creek monitoring stations between 1988 and 1990 by Merritt Smith Consulting, Inc. for the City of Santa Rosa (Commins et al., 1990). Figure 3-1 shows the monitoring sites throughout the watershed. Monitoring stations E1 (Estero mouth) through E5 (Franklin School House Rd. bridge) are estuarine sites. Stations E6 through E8 are freshwater sites located along Americano Creek. Data on nutrient levels, dissolved oxygen content, water temperature, and turbidity are summarized to present a snapshot of these critical water quality parameters in the watershed. Detailed monthly monitoring data at these sites are presented in Appendix B.

***Figure 3-1**. Map of the Estero Americano Watershed showing water quality sampling locations and aquatic habitat types.*



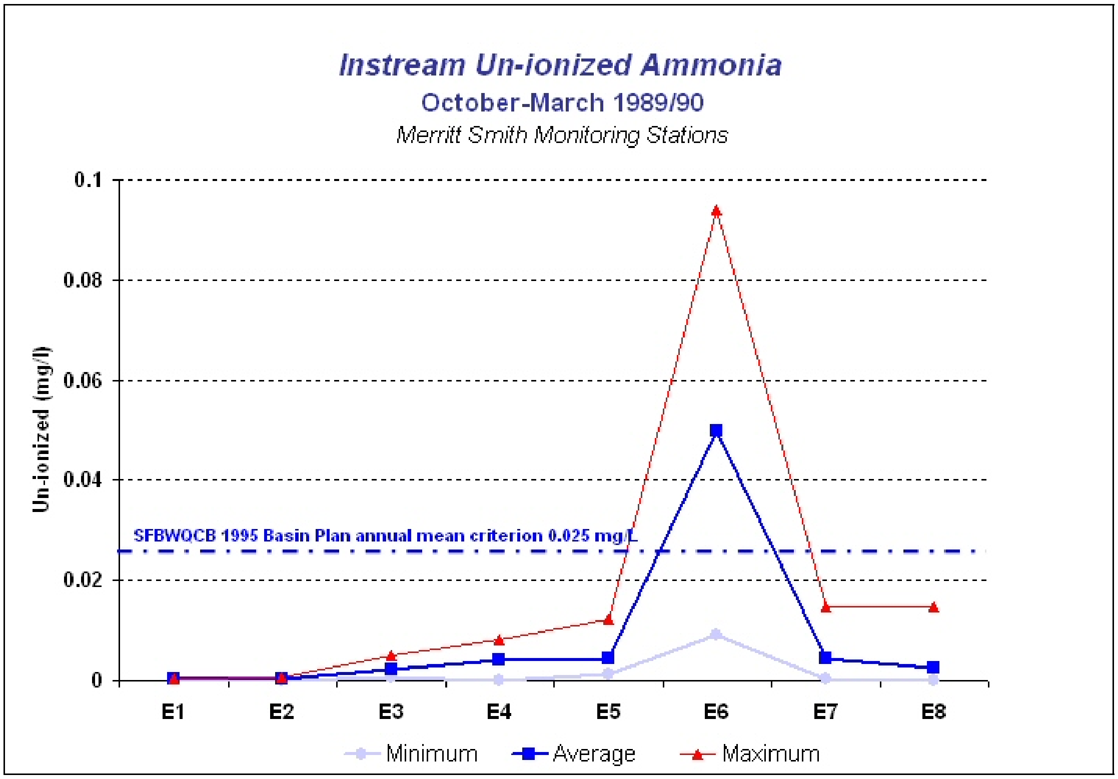
Ammonia (a reduced form of nitrogen)

Ammonia results from decomposition of manure and other organic debris by microbes and is toxic to fish and aquatic invertebrates. Total ammonia is composed of two forms; ionized ammonia (NH_4^+), and un-ionized ammonia (NH_3). Of these two forms, the un-ionized NH_3 is far more toxic. Un-ionized ammonia concentrations are a function of total ammonium concentration, pH, temperature and salinity. The percent of total ammonia in the harmful un-ionized form increases with higher temperatures and pH values. Un-ionized ammonia can be lethal to aquatic life at concentrations of 0.025 mg-N/L.

Ammonia is naturally produced by fish and is excreted primarily through the gills. Ammonia excretion is reduced if there are high ammonia levels in surrounding waters, causing high blood ammonia levels in fish. Fish respond to this increase in blood ammonia by reduced feeding which slows metabolic ammonia production. High blood ammonia levels increase a fish's need for oxygen, while at the same time reducing the ability of the fish's blood to transport oxygen. High ammonia levels can damage gills and ultimately kill fish.

Water quality monitoring data from the late 1980s found that the average concentration of un-ionized ammonia in Americano Creek is between 0.01 and 0.1 mg-N/L, depending on season and location (Figure 3-2). The U.S. Environmental Protection Agency (EPA) water quality criterion for ammonia is variable but typically about 0.025 mg-N/L. Over a two-year period, about 40 percent of the ammonia observations in Americano Creek exceeded the acute criterion. The EPA chronic criterion was exceeded in about 25 percent of observations in the upper portion of the Estero Americano. Spikes in un-ionized ammonia concentrations occurred between sampling stations E-5 and E-7 (Figure 3-2). The exceedances were coincident with animal waste loads that occur with runoff in winter and spring (Commins et al., 1990).

Figure 3-2. Un-ionized ammonia levels at sampling stations in the watershed during the 1989/1990 winter.



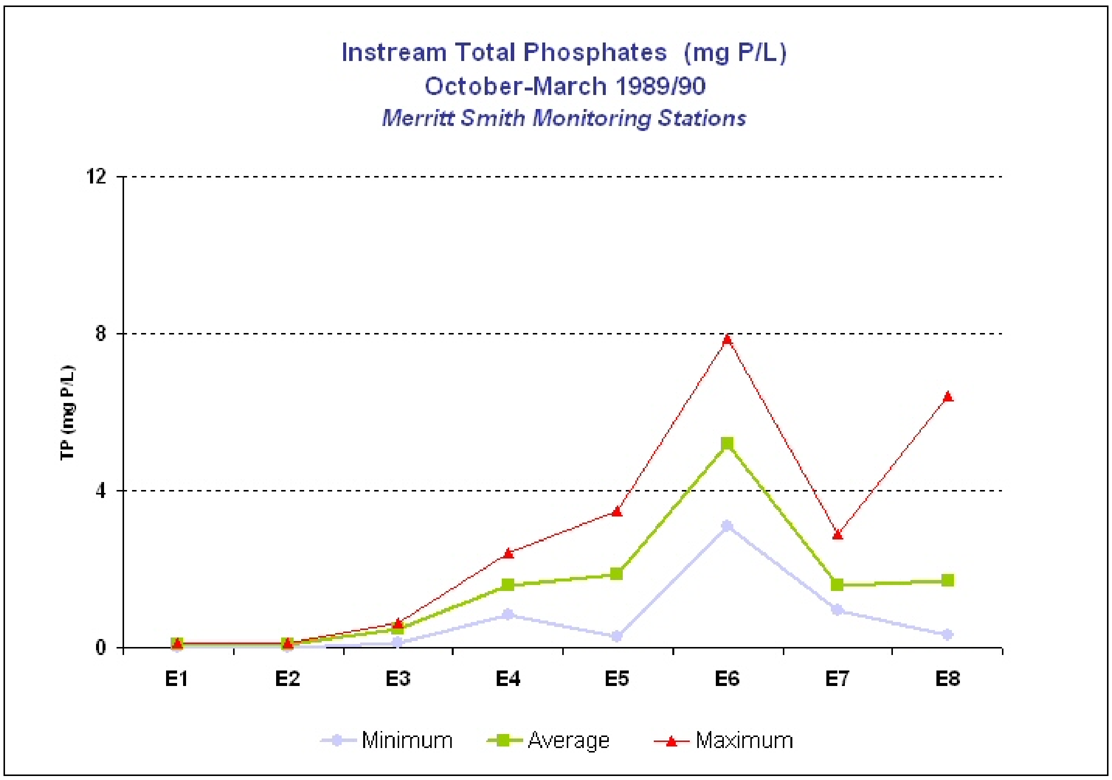
Nitrogen loading estimates are most critical when assessing potential pollutant inputs to groundwater and coastal waters. Healthy coastal waters generally have extremely low nitrogen concentrations, so even relatively small inputs above naturally occurring levels are problematic. Nitrogen moves easily in surface water and groundwater, and can indicate the presence of other dissolved pollutants such as bacteria and viruses, and some toxic chemicals.

Phosphorus

High phosphorus levels overfertilize fresh waterbodies resulting in excessive algal production and lowered dissolved oxygen levels. Phosphorus tends to be associated with sediment and is a good indicator of other runoff-borne pollutants such as metals and bacteria. Unlike nitrogen which is highly soluble and mobile, areas contributing phosphorus to surface waterbodies appear to be localized to soils with high soil phosphorus saturation and hydraulic connectivity to surface drainage networks (Heathwaite et al., 2000). Phosphorus's tendency to attach itself to sediment means that the most effective phosphorus control measures are controlling erosion and stormwater runoff, as well as protecting vegetative buffers along stream channels.

Total phosphate concentrations generally increase with distance from the ocean (Figure 3-3). Most of the intensive agricultural operations in the watershed are located between stations E-5 and E-7.

Figure 3-3. Total phosphates levels in the watershed during the 1989/1990 winter.

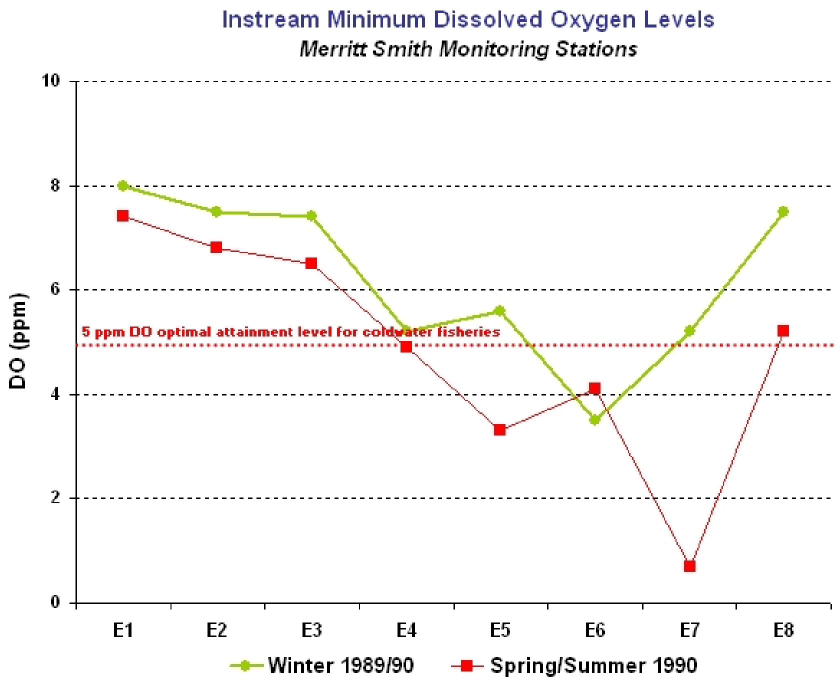


Dissolved Oxygen

Dissolved oxygen is often referred to by the initials DO, and is a measure of the oxygen that is dissolved in water. DO is critical for all aquatic life, just like oxygen in air is essential to humans and other terrestrial organisms. Low levels of DO weaken and eventually kill aquatic organisms. DO is one of the most critical parameters in assessing the health of aquatic environments. Because DO makes up a very small percentage of water, changes as seemingly minor as 1 part per million (ppm) can have a large impact on aquatic life. Young organisms are particularly sensitive to changes in DO levels due to their higher metabolism and limited mobility in seeking higher-oxygen waters.

Dissolved oxygen in Americano Creek and the upper estuary fluctuates diurnally. In spring, following animal waste loading during winter, dissolved oxygen declines to near 0 ppm each night. DO optimal attainment levels for cold water fisheries should be around 5 ppm in the estuary and 6 ppm in the tributaries. Instream minimum dissolved oxygen levels in the upper Estero Americano and Americano Creek fall below these attainment levels (Figure 3-4). Seasonal minimum DO levels are sufficiently low to be fatal to most fish.

Figure 3-4. Average minimum Dissolved Oxygen levels at sampling stations throughout the watershed during the 1989/1990 sampling season.



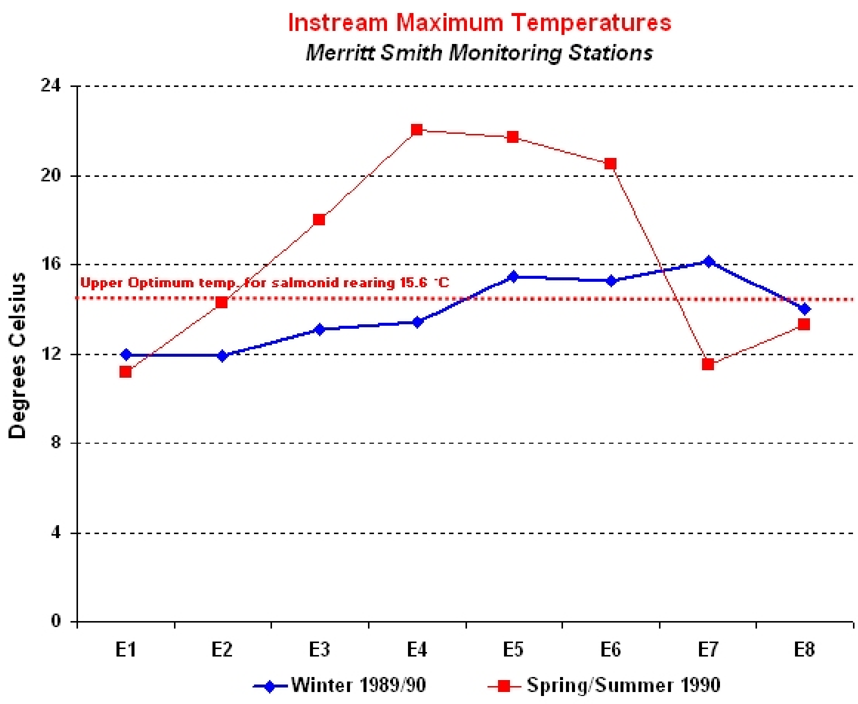
Nutrient inputs have resulted in excess algal blooms, which result in reduced dissolved oxygen levels in the water column. Blooms of nuisance macroalgae, Ulva and Enteromorpha, occur on the mud flats near the mouth of the Estero. These nuisance algae are typically associated with elevated nutrient concentrations (Smith and Hollibaugh, 1990).

Temperature

Temperature is important because it directly affects aquatic organisms, and also influences the physical characteristics of water and pollutants such as dissolved oxygen and ammonia discussed above. Cool water contains higher levels of dissolved oxygen than warmer water and has lower levels of toxic un-ionized ammonia. Extreme temperatures have harmful effects on fish and aquatic invertebrate metabolism, feeding, growth, disease resistance, and reproduction. Higher temperatures are also associated with harmful algal blooms, and the abundance of disease organisms and parasites.

Seasonal mean temperatures in the watershed ranged from 12 °C (winter, Station E1) to 23.5 °C (summer, Station E4). Temperatures generally increased with distance upstream of the mouth of the Estero, and then decrease in Americano Creek (Figure 3-5). The temperature differential was strongest during summer months. Temperature in the lower Estero is almost certainly controlled by ocean temperatures. Temperature in the middle and upper Estero is probably affected primarily by air temperature and sunlight energy (Smith, et al., 1989).

Figure 3-5. Maximum water temperatures throughout the watershed during the 1989/1990 sampling period.



Primary environmental or human factors influencing surface water temperatures in the Estero Americano Watershed include heat loadings from direct sunlight due to lack of riparian vegetation and high turbidity levels due to high rates of erosion in the watershed. The Estero Americano is considered critical habitat for salmonids (steelhead trout) by the state and the federal government. The upper optimum temperature for salmonid rearing is 15.6 °C; the lower optimum temperature is 10 °C.

Salinity

The salinity of local seawater in Bodega Bay is 32 parts per thousand (ppt). Salinity in the upper Estero Americano (sampling stations E4 and E5) varies from near zero to 44 ppt. During the 1989 to 1990 sampling season, salinity in the upper estuary reached 34 ppt during summer months (Figure 3-6). The lack of freshwater inflow, and evaporation in and poor exchange of the upper estuary with the well-flushed lower estuary often leads to hypersaline conditions (>32 ppt) in the upper estuary. Hypersaline conditions can be lethal to aquatic organisms. Salinity in the lower Estero Americano is less variable and tends to be similar to ocean salinity levels (Figure 3-7).

Figure 3-6. Salinity (ppt) in the Estero April-September 1990.

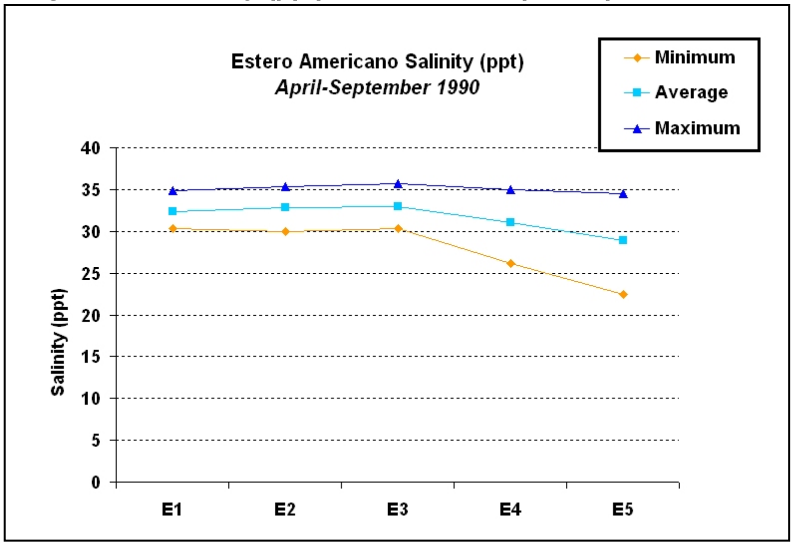
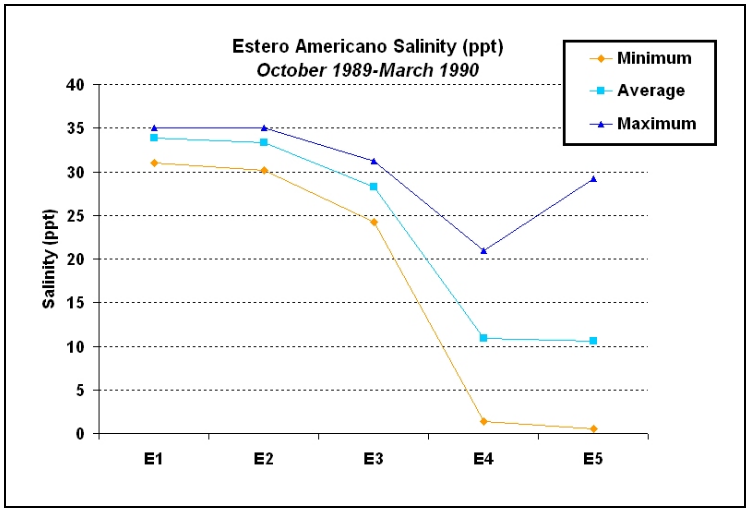


Figure 3-7. Salinity (ppt) in the Estero during the winter of 1989/1990



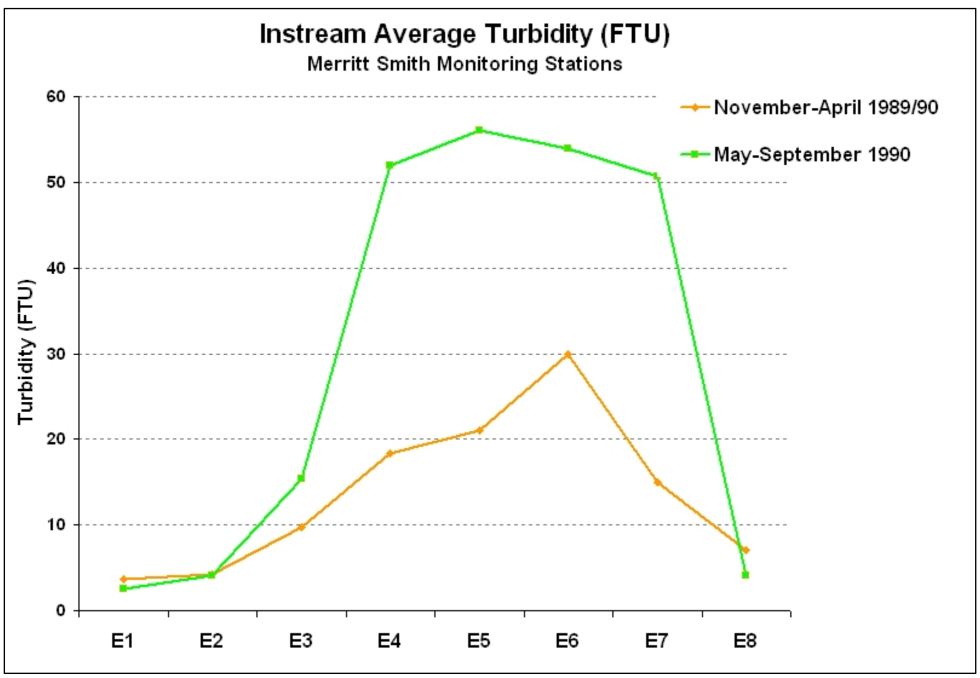
Turbidity

Turbidity, which can make water appear cloudy or muddy, is caused by the presence of suspended and dissolved matter, such as clay, silt, finely divided organic matter, plankton and other microscopic organisms. Sources of turbidity include: soil erosion, streambank erosion, animal waste, road and urban runoff, and excessive algal growth.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates.

Monitoring data shows turbidity increased with distance from the mouth of the estuary during all seasons (Figure 3-8.). Low turbidity near the mouth of the estuary reflects the influence of relatively clear ocean water. Increased turbidity in the shallow middle section of the estuary (monitoring stations E4 and E5) is probably due to suspended sediment caused by wind-induced turbulence and phytoplankton (Smith et al., 1989). Researchers conducting the monitoring work did not provide an explanation for the high levels of turbidity during the summer months of 1990.

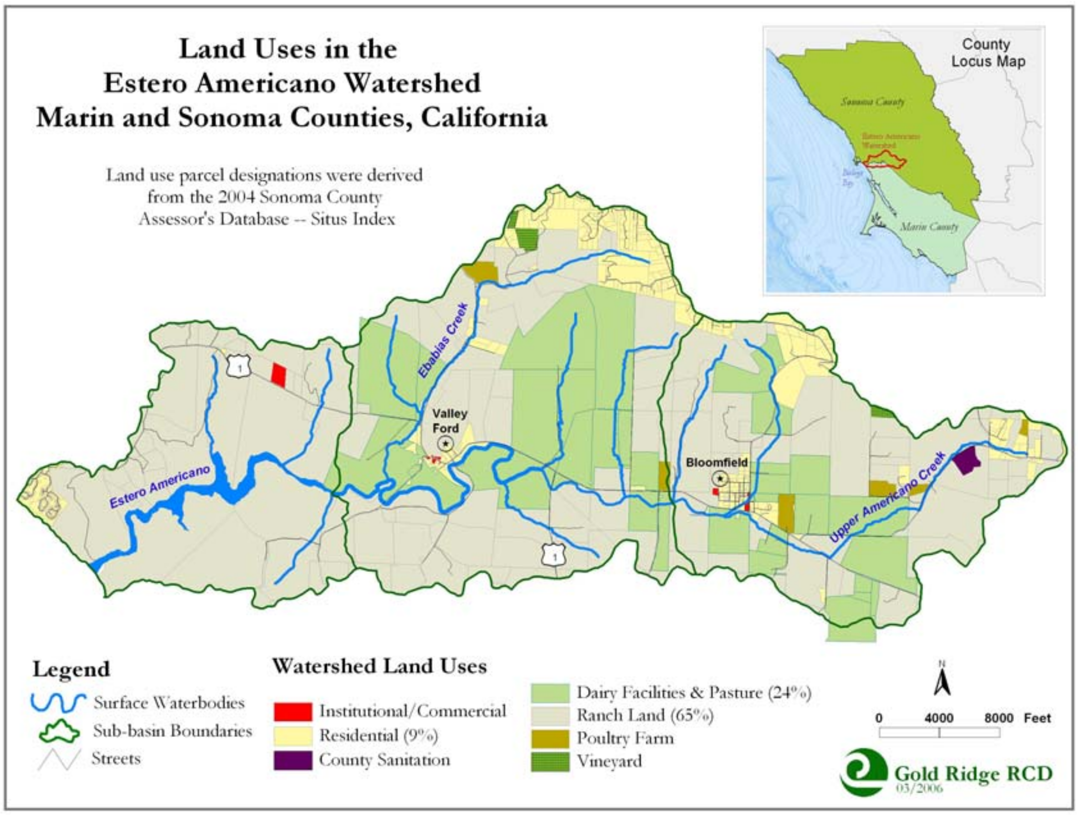
Figure 3-8. Average seasonal turbidity at sampling stations throughout the watershed.



Estimating Nutrient Loads from Different Sources

Nutrient loading estimates for nitrogen and phosphorus were determined using *STEPL*, a public domain simplified spreadsheet tool (see Appendix C for a discussion of modeling methods and results). Modeling results were based on a land use assessment conducted for this management plan (Figure 3-9), which included an estimate of the number and type of agricultural operations in the watershed; the number and type of livestock per agricultural operation; the number of feedlots; the acreages of developed areas (e.g., roads, subdivisions, commercial activities), rangeland and cropland; and the number of septic systems in the watershed.

Figure 3-9. Map of land use distribution in the watershed.



Agricultural Land Use and Nutrient Loads:

Over 80 percent of the Estero Americano Watershed is in some form of agricultural operation. Of the 24,335 acres of land in the watershed, over 16,000 acres is managed as rangeland. There are approximately 16 beef cattle ranches, 8 sheep ranches and 12 dairies operating in the watershed. Half of the dairies in the watershed are either certified organic, or are in the process of receiving organic certification. An estimated 116 acres are used for silage or hay production. There is also a small commercial nursery located in the upper watershed along Roblar Road. Based on modeling results, over 90 percent of nitrogen and phosphorus loadings in the watershed are derived from agricultural land uses (Table 3-2).

Loadings by Sub-watershed (Figures 3-10 and 3-11)*:*

In the Lower Estero sub-watershed, there are 5 beef cattle ranches and 2 sheep ranches. Much of the pasture and rangeland for livestock in this sub-watershed consists of large tracts of open land on the hillsides above the estuary. Consequently, modeling results show nutrient loadings in this sub-watershed to be lowest. The two larger sub-watersheds, the Middle Estero sub-watershed and the Upper Americano Creek sub-watershed, have a mix of agricultural land uses including dairies, chicken farms, beef cattle and sheep ranches. Most of the 12 dairies located in these two sub-watersheds are located on the estuary or one of its larger tributaries. The Middle Estero sub-watershed, which encompasses 17 square miles around the Town of Valley Ford, produces the largest nutrient load based on land area and the number and type of livestock present.

Non-Agricultural Land Use and Nutrient Loads:

There are 618 residential parcels in the watershed, accounting for 9 percent of land use. In addition, there are roughly 41 acres in the watershed used for commercial or institutional purposes. A decommissioned county landfill is located on 49 acres in the upper watershed along Roblar Road.

Based on modeling results, non-agricultural land uses account for less than 10 percent of overall nutrient loads produced in the watershed. Urban land uses (roads, subdivisions, commercial and institutional activities) are estimated to contribute 4 percent of both nitrogen and phosphorus loadings in the larger Estero Americano Watershed. The 749 septic systems identified in the Sonoma County parcel data contribute an estimated 2 percent of nitrogen loading and 4 percent of phosphorus loading in the watershed.

Table 3-2. Estimated Nutrient Loads (lbs/yr)

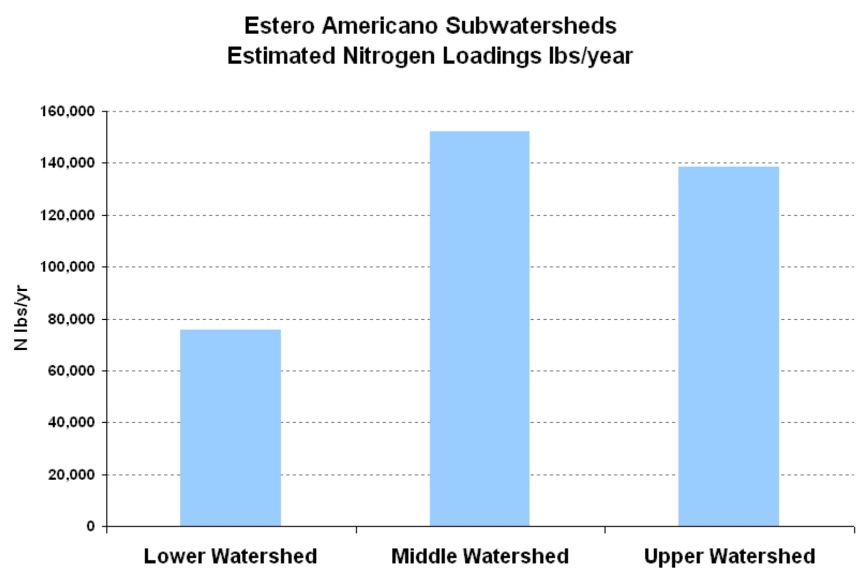
An estimated 366,194 lbs of nitrogen are produced in the watershed on an annual basis. Fifty-two percent of this load is derived from feedlots. Of the estimated 58,245 lbs of phosphorus that is produced annually, approximately 65 percent is derived from feedlots.

Nutrient Sources	N Load (lbs/yr)	P Load (lbs/yr)
Urban	11,203	1,727
Cropland	2,558	594
Pastureland	155,776	15,947
Feedlots	191,281	37,872
Septic	5,375	2,105
Total	**366,194**	**58,245**

Nitrogen Loading

Modeling estimates show a total annual load of 366,194 lbs of nitrogen is produced in the Estero Americano Watershed. The middle sub-watershed contributes the largest percentage of annual loadings (152,207 lbs/yr). This is the largest of the three sub-watersheds, and includes 5 beef cattle ranches, 6 dairies, and 5 sheep ranches within a 17 square mile area. The upper sub-watershed contributes an estimated 138,555 lbs of nitrogen annually. There are 6 beef cattle ranches, 6 dairies, and 2 sheep ranches in this 11 square mile sub-watershed. The lower sub-watershed contributes an estimated 75,662 lbs of nitrogen annually. There are no dairies in the area around the open water of the estuary.

Figure 3-10. Annual Nitrogen loading in the three Subwatersheds.



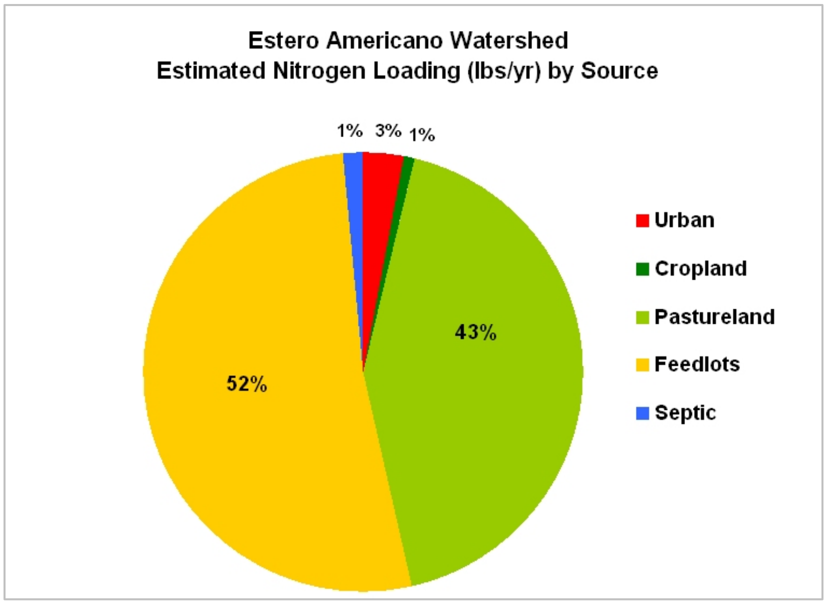


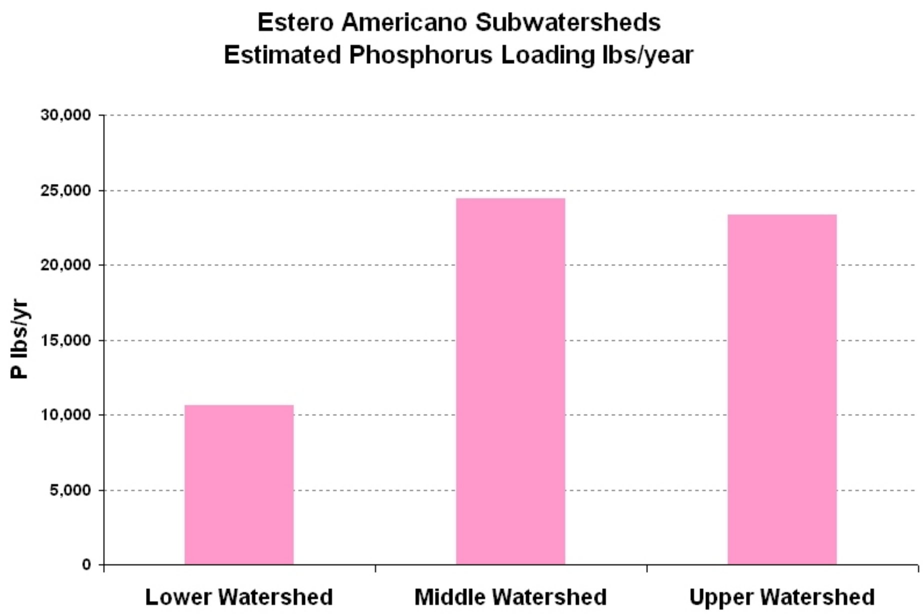
Chart 3-1. N Loading (lbs/yr) by Source

Agricultural operations account for 96 percent of estimated annual nitrogen loads in the Estero Americano Watershed. Septic systems and urban land uses account for 4 percent of total loadings.

Phosphorus Loading

Unlike nitrogen, which is highly soluble and moves easily in surface water and groundwater, phosphorus is primarily transported to surface water attached to sediment. Management measures to control phosphorus loading to surface water generally focus on areas connected to surface drainage networks, reducing erosion and sediment, and keeping livestock away from stream corridors. Modeling estimates show a total annual load of 58,245 lbs of phosphorus is produced in the Estero Americano Watershed. The middle sub-watershed potentially contributes the largest percentage of annual loading (24,413 lbs/yr).

Figure 3-11. Annual Phosphorus loading by subwatershed.



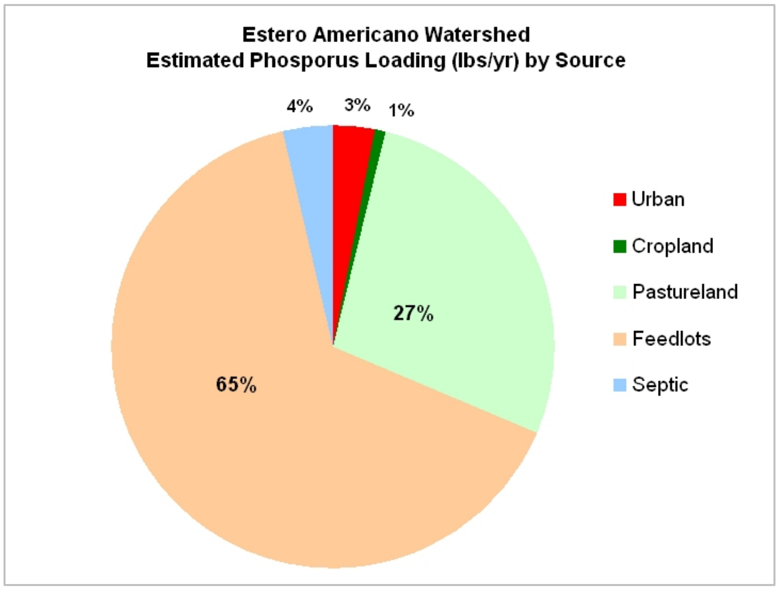


Chart 3-2. P Loading (lbs/yr) by Source
Agricultural operations account for 93 percent of estimated annual phosphorus loads in the Estero Americano Watershed. Septic systems and urban land uses account for 7 percent of total loadings.

Conclusion

Agricultural producers in the Estero Americano Watershed have already taken significant steps to reduce and control agricultural run-off. Most of the dairy operators, and many of the large livestock producers, are working actively with state and federal resource agencies to adopt pollution control measures and to employ agricultural best management practices. Often, agricultural operators in the watershed work simultaneously with the RCD and USDA, NRCS staff to conduct conservation planning and to make operational improvements such as better stormwater drainage and erosion control.

Over half the dairies in the watershed are participating in the *Estero Americano Watershed Dairy Enhancement Program*, which includes funding for comprehensive nutrient management planning and practices. Most of the dairies have also participated in UCCE's *California Dairy Quality Assurance Program* to become environmentally certified under that program. Based on the level of participation in these technical assistance programs, we feel confident that existing water quality impairments can be addressed through a voluntary and collaborative process.

Please refer to Chapter 4 of this document for an extended discussion on water quality and sediment sources and impacts. Recommended "best management practices" to reduce agricultural nonpoint sources of pollution as well as estimated load reductions based on recommended management practices can be found in *Chapter 5: Agricultural Best Management Practices*. Recommended "Action Plan" elements to protect and enhance water quality in the Estero Americano Watershed can be found in *Chapter 6: Action Plan to Improve Natural Resources and Agricultural Sustainability*. Additional information on water quality can be found in the following appendices of this document: Appendix B: Water Quality Monitoring Data, 1988-1990; Appendix C: Watershed Modeling Methods and Results; and Appendix F: Monitoring Needs and Guidelines.

Water Quality Goals:

- Promote the Beneficial Uses of the Estuary and its Tributaries
- Improve Agricultural Management Practices to Reduce Runoff
- Measurably Reduce Nutrient Loadings to the Estuary and its Tributaries through Nutrient Management Planning

CHAPTER 4

SEDIMENT:

SOURCES AND IMPACTS

Introduction

The Estero Americano is highly sensitive to changes in the rate and volume of sediment delivery. Sediment delivered to the upper portions of the Estero has little chance of being flushed out to sea, due to the shape and length of the estuary. Over the past 150 years, erosion rates and sediment transport in the watershed have significantly altered channel form and processes; impairing ecological functions and habitat values of the estuary and its tributaries.

Since the time of European colonization, agriculture has been the mainstay of the local economy in the Valley Ford area. Beginning in the late 1880s, much of the land in the watershed was cleared of native vegetation and used for cultivated crops. Potatoes were the primary crop through the late 1800s and early 1900s. As potatoes were harvested in the late fall, the heavily disturbed soil was exposed at the onset of the fall/winter rains. Excessive amounts of topsoil were washed off of the barren fields and into the waterways during this period. An estimated 1 million cubic yards of sediment was deposited in the Estero between 1850 and 1953 when potato farming was common (Circuit Rider Productions, Inc., 1987). Potato farming slowly transitioned into grains such as barley and wheat, and then to hay production in the 1970s. Today there are no large-scale cultivated crops grown in the watershed, and only a few hay fields. Eighty percent of the land is currently used for pasture and rangeland grazing.

Waterways and upland slopes in the watershed are still adjusting to the effects of historic crop farming on land characterized by highly erodible soils, steep slopes, and unstable geologic material. Changes to watershed hydrology from physical modification of drainages and concentration of flows over disturbed ground have led to dramatic increases in sheet and rill formation as well as gully development. The long term impacts of these changes to watershed hydrology and sediment transport include: loss of estuarine and riparian habitat, degraded fisheries, increased flooding from channel aggradation, and the loss of productive soils and agricultural land.

Although erosion and sedimentation are natural processes, human land use activity can greatly accelerate erosion. Current rates of erosion and sedimentation in the Estero Americano Watershed are much lower than they were historically, yet the majority of sediment that reaches the estuary from upland sources continues to originate from land in agricultural production. A primary goal of this watershed management plan is to identify critical erosion repair sites as well as to promote agricultural management practices that will significantly reduce existing erosion problems.

Sediment impacts to estuarine and riparian habitats

Parcel maps from 1850 show open tidal water in the Estero well upstream of Valley Ford, an area now covered by a broad pickleweed terrace with a narrow channel. On the same maps, confluences of the Estero and many tributary streams are shown as open water embayments. Today these are lobed deltas formed by sediment deposition at the tributary mouths. Sedimentation of the Estero Americano has reduced the tidal prism by 25 percent over the last 118 years (Harvey et al., 1990). The sedimentation of the estuary has decreased the estuary's depth, reducing tidal exchange and the estuary's ability to scour and transport sediment out of the system. Changes to the estuary's form and hydrologic processes, in conjunction with streamflow reductions and water quality issues, have had significant effects on fish and wildlife habitat in this critical area.

Altering the hydrology and sediment production/delivery in a watershed by changing land uses will produce complex responses in channel form and processes. The conversion of native perennial grassland to row crops and European annual grasses, in concert with the removal of the dense willow and alder riparian thickets in the late 1800s, dramatically changed stream channels. Increased sediment production from agricultural lands combined with augmented streamflows (due to reduced infiltration) led to rapid sedimentation of stream channels and the estuary with fine grained material (Prunuske Chatham Inc., 2004, 2005). The result has been decreased channel capacity and instream habitat features such as pools, riffles, and woody debris.

Natural channel response to changes in sediment supply and hydrology is either rapid incision followed by channel widening or channel bed aggradation followed by widening. It appears that in the Estero Americano Watershed high sediment loads have aggraded the channels and floodplains, resulting in increased flooding frequency, degraded aquatic habitat, and eroding stream banks. Lack of riparian vegetation, necessary to stabilize channel banks and filter fine sediment, is exacerbating channel sedimentation and bank erosion.

Watershed Geology and Soils

The Estero Americano Watershed is underlain by two main geologic formations—the Franciscan mélange formation, a matrix of crushed shale, sandstone, chert, greenstone, and schist; and the overlying Merced formation, a relatively young, fine-grained marine sandstone. Franciscan formation rocks generally outcrop in lower elevation areas along steep-sided streambeds or rugged coastline and are inherently weak. This weak matrix affects the stability of any slope it underlies and as a result landslides are common in the region. The Merced formation occupies higher elevation areas capping the Franciscan materials. It is a massive, weakly cemented unit, which often contains fossils and is highly erosive where it is exposed and unprotected (Circuit Rider Productions, Inc., 1987).

A thin layer of alluvium is found along the streams and inland valleys (Madrone Associates, 1977). The thickness of the alluvium increases towards the mouth. This alluvial material from the watershed has filled a deeper valley cut during the last ice age (10-20K years ago) when sea level was much lower than today.

The rolling, gently sloping to steep hills that characterize the Estero Americano Watershed are dissected marine terraces. Soils on the marine terraces are predominantly Steinbeck and Tomales loams. These soils are moderately well drained, with a subsoil of mainly clay loam. Slopes are 2 to 50 percent, with elevations ranging from 0 to 600 feet above sea level. Los Osos clay loams occur at higher elevations, but are shallower than the Steinbeck and Tomales loams. Kneeland sandy loam, sandy variants occur on the top of marine terraces on the northern side of the Estero

Americano. The Kneeland series, sandy variants consist of well-drained coarse sandy loams that are underlain, at a depth of 15 to 36 inches, by soft sandstone. A summary of these soils and their distribution is provided in Table 4-1.

Table 4-1. The predominant soils in the Estero Americano Watershed, the characteristics that effect erosion potential, and their distribution throughout the watershed.

Soils Series	Location	Runoff	Soil Texture	Acres	Percentage
Blucher	Floodplain	Medium	Fine-loam	1309	**5%**
Kneeland	Higher Elevations	Varies	Sandy loam	1032	**4%**
Los Osos	Higher Elevations	High to Very-High	Clay loam	2955	**12%**
Pajaro	Floodplain	Very Low	Coarse-loam	436	**2%**
Steinbeck	Marine Terrace	Medium to High	Fine-loam	13561	**55%**
Tomales	Marine Terrace	High	Fine, mix-loam	3686	**15%**

Source: Miller, Vernon C. 1972. Soil Survey of Sonoma County, California. U.S. Department of Agriculture, Soil Conservation Service, in Cooperation with the University of California Agricultural Experiment Station.

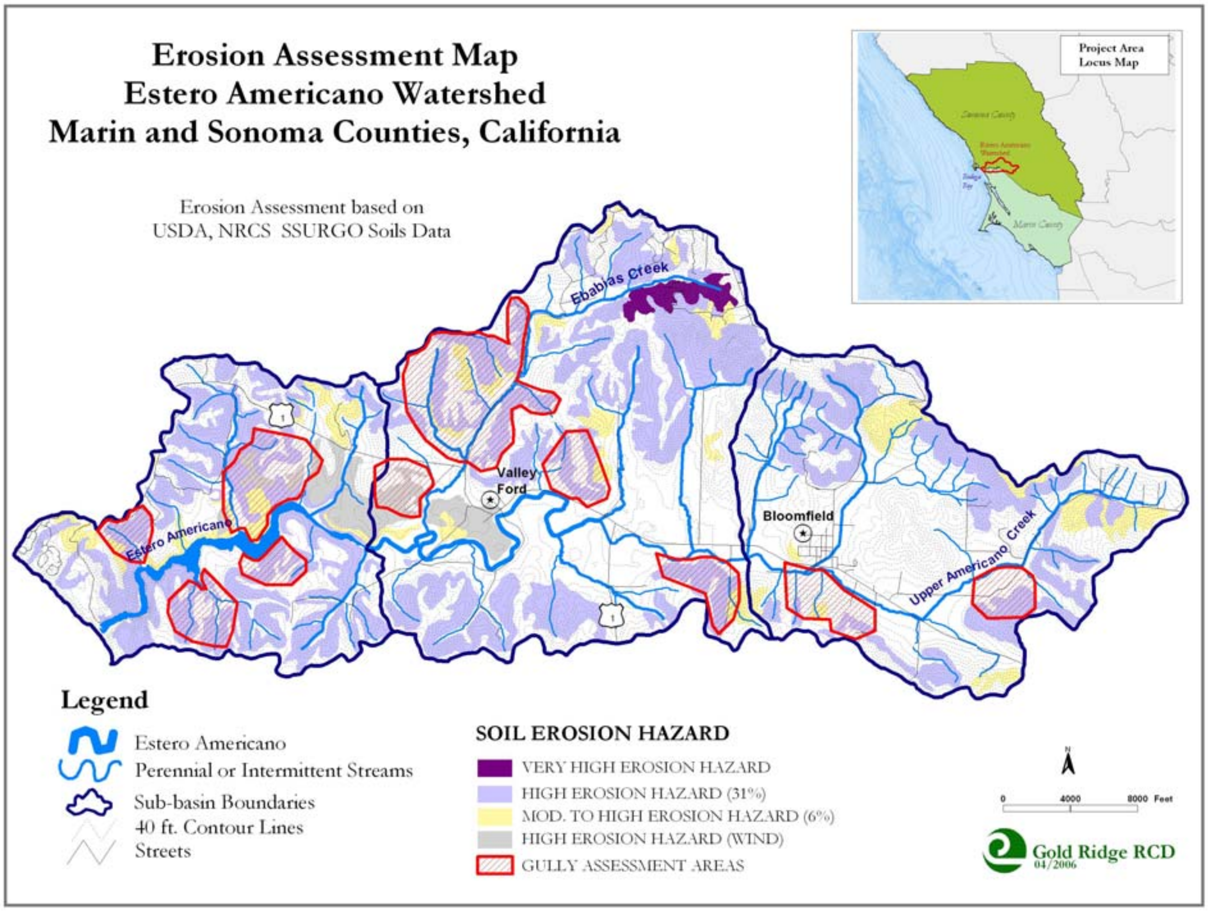
Soil Erosion Assessment

Most of the bedrock underlying the soils in the watershed is soft and weakly consolidated sandstone and siltstone. As a result, erosion does not necessarily stop when the soil is stripped away and the bedrock exposed, as it would if the bedrock was hard. Though the soils are commonly only 4 or 5 feet deep, gullies in the area are frequently 10-25 feet deep, and can be as much as 50 feet deep. Many of the soils in the area also have a clayey subsoil. The clayey subsoil and weakly consolidated bedrock provide sufficient stability so the walls of many gullies in the area stand almost vertically. With time, vertical walls will slough and contribute large amounts of sediment downstream (Circuit Rider Productions, Inc., 1987).

Soils in the watershed are also prone to mass wasting or landslides. Landslides are common in areas with clayey subsoils or where soils are underlain by sedimentary rock. The many springs in the watershed exacerbate the problem by increasing the weight of the soil mass. Much of this slippage is natural, and slump areas will often develop into gullies. Soils in the watershed are generally fertile and relatively easy to revegetate, although they are also high in silts, very fine sands, and fine sands (ibid.).

These factors produce a landscape that is susceptible to high rates of erosion, and that is sensitive to changes in vegetative cover and drainage characteristics. A soil assessment was conducted in a Geographical Information System (GIS) using the NRCS, SSURGO Soils database to determine the areas of highest erosion hazards (See Figure 4-1). The assessment found that 31 percent of soils in the watershed (7,752 acres) have a high erosion hazard rating, and an additional 6 percent of soils have a medium to high erosion hazard. In the Lower Estero Watershed the percentage of soils with a high erosion hazard increases to 41 percent. According to NRCS, these soil erosion hazard ratings are based almost entirely on slope, as slope is the primary factor in determining erodibility (personal communication).

Figure 4-1. Erosion hazard and assessment map of the Estero Americano Watershed.



The last extensive field survey of erosion problems in the watershed occurred in 1986 as part of *The Sonoma Coastal Wetlands Restoration Program* funded by the State Coastal Conservancy (Circuit Rider Productions, Inc., 1987). Only a portion of the watershed was surveyed during this study; 112 gullies and 66,480 feet of streambank were assessed. The Gold Ridge Resource Conservation District is currently seeking funding to conduct a more extensive and up-to-date gully erosion field assessment from which priority erosion stabilization sites will be selected in the Lower Estero sub-watershed, the Ebabias Creek sub-watershed, and for gully erosion located above dairies or livestock high-use areas. Figure 4-1 shows these areas in red outline. Gully assessment areas were identified during a recently completed watershed assessment (2006) that used high-resolution color orthophotography to map large gullies in the watershed. Assessment areas were selected based on proximity to the estuary or one of its principal tributaries.

Sediment Sources

Sediment is derived from three principal sources: mass wasting, surface erosion, and streambank or channel erosion. Although erosion and sedimentation are natural processes, human land use activity can greatly accelerate erosion in a watershed. Sediment is collected and transported by stream and overland flow. Accelerated erosion is the term used to describe human-induced erosion. Sources of accelerated erosion include inadequately managed grazing land, denuded stream corridors, poorly constructed and maintained roads, and slope instability due to livestock grazing or road failure.

Most sediment generated in a watershed is deposited at the base of hillslopes, on floodplains following high flows or floods, and in stream channels. A small fraction is transported to the ocean and out of the system. Depending on the frequency and magnitude of storm events, sediment may be stored in a floodplain or channel bed for decades or centuries. Sediment produced during a single event, i.e., during a landslide, can take months to years before it is finally delivered to a surface waterbody. Frequently, a major storm will wash years of accumulated sediment down into a low gradient stream segment or into the estuary itself in the space of a few days.

Although erosion and sedimentation rates have decreased substantially in the watershed with the conversion of cropland to pasture and rangeland, agricultural land use practices continue to cause accelerated erosion. Without treatment of existing sediment sources and better land management practices, current erosion rates will continue to have irreversible environmental and economic impacts in the watershed.

Soil compaction and reduction of herbaceous vegetation from grazing have increased stormwater runoff and the occurrence of sheet, rill, and gully erosion. Increased flows in stream channels during storm events, the filling of stream channels with sand and silt, and the denuding of stream corridor vegetation by livestock have exacerbated streambank erosion. Road construction and improper road maintenance have also altered natural drainage patterns, concentrated flows, and increased sediment loads to surface waterbodies.

Sediment Load Assessment

Sediment loading estimates for the different erosion types in the watershed were calculated using two standardized loading models (see Appendix C). Sheet and rill erosion were estimated using *STEPL*, a public domain simplified spreadsheet tool. The model relies on a standardized Curve Number (CN) and the Universal Soil Loss Equation (USLE) to estimate runoff and loadings from various land use/land cover classes. Erosion and sediment loadings from streambank and gully erosion were estimated using the *Channel Erosion Equation (*Michigan Department of Environmental Quality, 1999*),* which uses the direct volume method to calculate annual average sediment loadings and reductions.

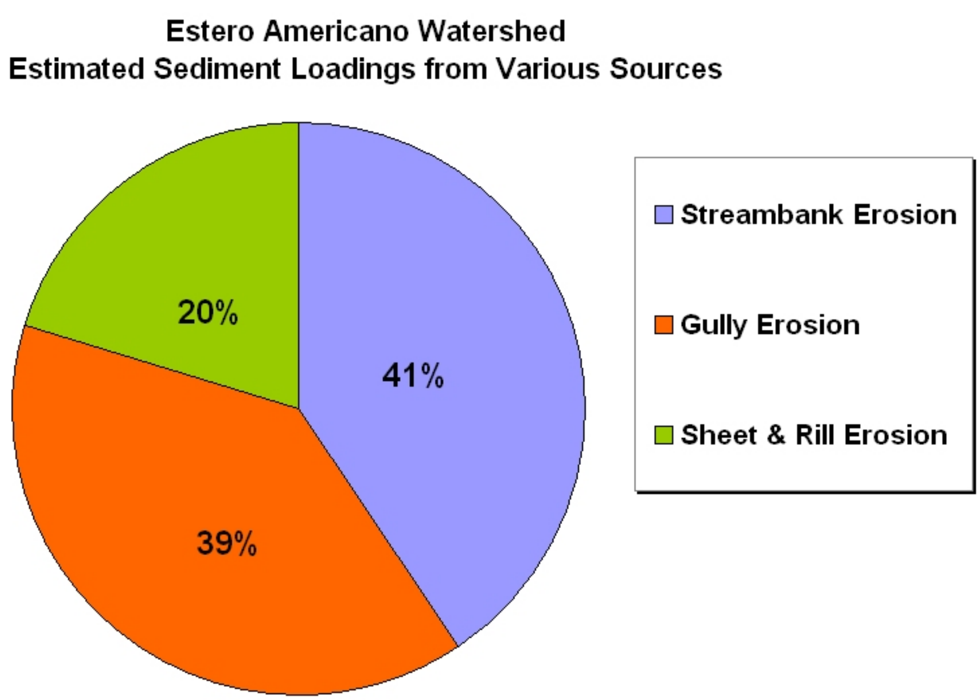
Modeling results estimate that 23,921 tons of sediment are produced in the watershed on an average annual basis (Table 4-2). Modeling estimates are highly generalized based on standardized parameters. To address this issue, the results of an early and more in depth erosion and sediment study conducted in neighboring Stemple Creek Watershed were used as a benchmark (USDA, 1992). In addition, sediment loadings from ranch roads and mass wasting were not quantified due to a lack of available data. It is important to note that numerous studies have found that watershed roads frequently contribute the majority of sediment reaching surface waterbodies, as high as 70 percent in some systems (Weaver and Hagans, 1994).

In agricultural watersheds, it is estimated that 1 to 30 percent of the sediment produced by erosion eventually reaches a surface waterbody (USDA, 1997). Based on modeling results, streambank erosion contributes the largest amount of sediment to surface waterbodies, an estimated 9,700 tons/yr. Gully erosion contributes an estimated 9,390 tons/yr, and sheet and rill erosion contributes an estimated 4,831 tons/yr (Table 4-2).

Table 4-2. Summary of sediment loading calculation results.

Source	Subwatershed			Total	
	Lower (tons)	Middle (tons)	Upper (tons)	(tons)	(percent)
Blueline Streams:	499	5,147	2,523	8,169	**34%**
Seasonal Streams:	342	535	654	1,531	**6%**
Gullies:	**1,972**	**4,695**	**2,723**	**9,390**	**39%**
Sheet & Rill	740	2,294	1,797	**4,831**	**20%**
Subtotal	**3,553**	**12,671**	**7,697**	**23,921**	**100%**

Chart 4-1. Estimated Sediment Loadings. *Based on modeling results, 40 percent of watershed average annual sediment yields are derived from streambank erosion (9,700 tons/yr); 39 percent from gullies (9,390 tons/yr); and 20 percent from sheet and rill erosion (4,831 tons/yr). These percentages do not include sediment loading from roads and mass wasting.*



Stream Channel Stability and Erosion

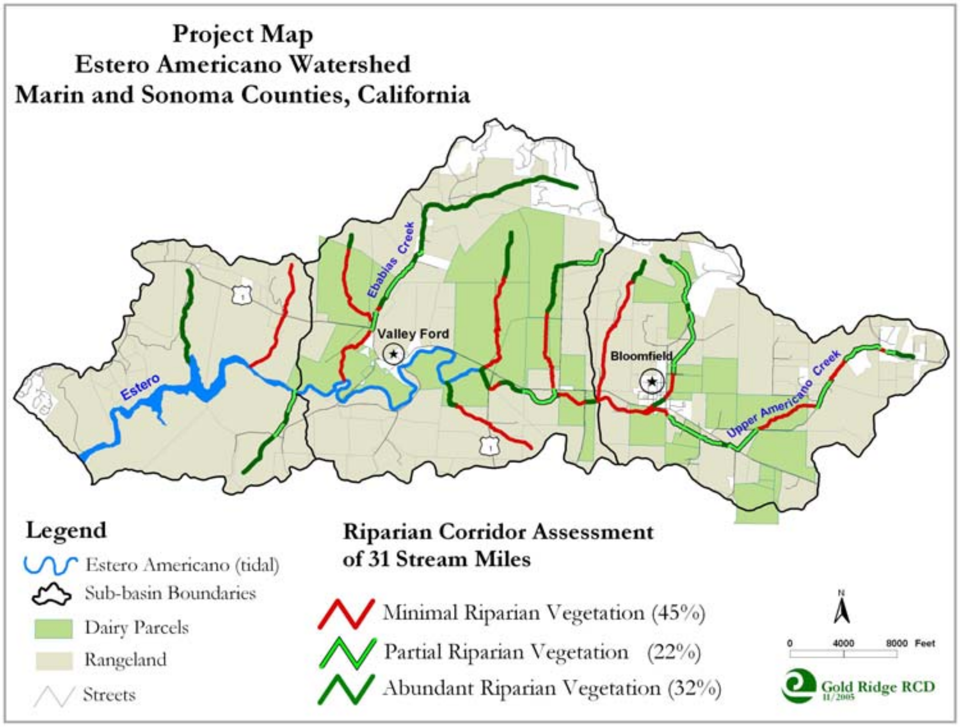
The condition of a stream channel, its morphology, sediment distribution, and associated habitat value, is often a direct reflection of the density and diversity of the riparian plant community and upland vegetation. This is especially true in alluvial valley systems like Americano Creek. Removal of riparian vegetation destabilizes channel banks, making them more susceptible to erosion during high flows. Rehabilitation of complex riparian vegetation along stream channels and drainage systems in the watershed will improve aquatic habitat, sediment retention, and eventually channel conveyance. Riparian vegetation will help stabilize stream banks and produce flow conditions that initiate instream sediment transport and habitat feature development. Over time, stream channels will become deeper, narrower and more stable; requiring larger and larger peak flows to cause erosion.

Americano Creek was once a perennial stream. Based on aquatic life surveys conducted in the late 1980s, researchers found that the creek is ephemeral in all or nearly all years and supports no fish resources above tidewater (Smith et al., 1989). Flowing water persists in Americano Creek and its tributaries only during the rainy season. Soil compaction and denuded streambanks associated with livestock presence were found to be almost universal throughout the stream system. Functional riparian plant communities were either nonexistent or in a highly degraded condition. In most areas, even where willows are present, streambanks were sloughed (ibid.).

Stream erosion in the mainstem of Americano Creek and the lower reaches of tributaries is currently high. The hydraulic geometry of Americano Creek, the main tributary to the Estero, is predominantly rectangular and much wider in most areas than it would be naturally. Fine sediment (sand, silt) deposition in the channel bottom is excessive, and resulting aggradation of the stream channel relative to bank height is reported to exacerbate local flooding problems near Bloomfield and Valley Ford (Buell, 1988). Sediment transport during storm events is high, and based on deposition patterns in the streambed, the supply of fine sediment to Americano Creek significantly exceeds the carrying capacity of the stream (ibid.).

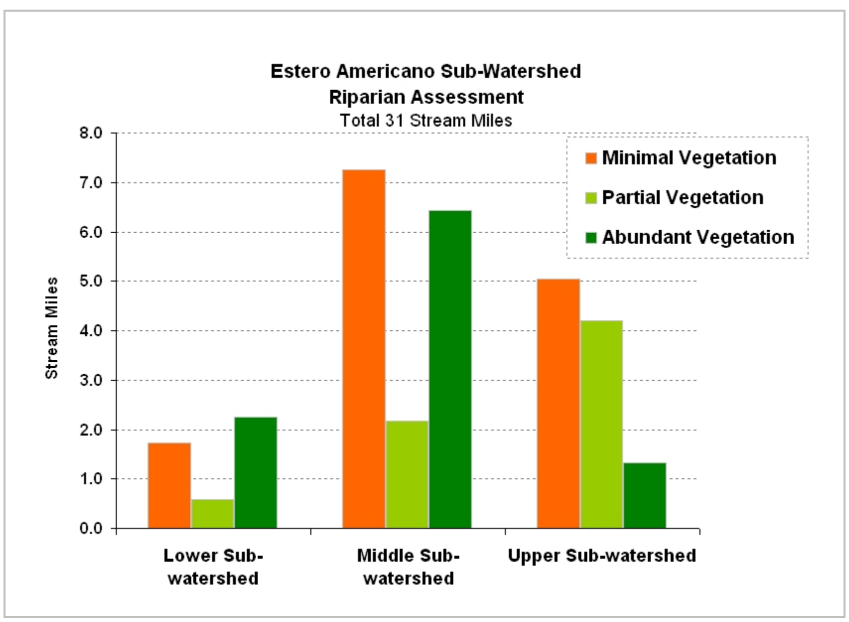
A primary goal of this management plan is to identify and seek funding for stream bank stabilization and riparian corridor revegetation along tributaries to the Estero Americano. There are approximately 31 miles of ephemeral or intermittent streams in the watershed, and an additional 56 miles of smaller seasonal streams draining into these larger tributaries. A riparian corridor assessment was conducted to identify degraded stream corridors in the watershed. Stream segments were coded in a Geographical Information System (GIS) based on abundance of riparian vegetation (minimal vegetation, partial vegetation, or abundant vegetation), using high-resolution aerial photography (Figure 4-2).

Figure 4-2. Abundance of riparian vegetation along major tributaries.



The assessment found that over 14 stream miles have minimally vegetated riparian corridors, with approximately 104 acres of riparian area in need of restoration. In addition, there is an estimated 7.1 stream miles that have only partially vegetated stream corridors, needing 51.4 acres of riparian area restoration. Most of the stream segments with minimally vegetated riparian areas are located in the middle and upper sub-watersheds (Chart 4-2). Refer to Appendix D: *Riparian Assessment* for a more detailed description of the assessment.

Chart 4-2. Riparian Assessment by Sub-watershed



Effects of Livestock on Stream Corridors:

Unrestricted access by livestock to stream and riparian areas produces a variety of changes that work together to fundamentally alter freshwater systems. Livestock naturally congregate in streamside areas, especially during warm weather. This tendency to congregate leads to localized soil compaction and changes in plant species composition in riparian communities, including significant reductions in important livestock forage species. Functionally important fibrous-rooted perennial species give way to shallow-rooted annuals or taprooted forbs and shrubs that can be supported on land with a lowered water table.

The effects of accelerated runoff and diminished infiltration combine with decreased water retention capabilities of soils to produce dramatic decreases in groundwater recharge, the disappearance of fringe wetlands, substantial increases in soil erosion, increased sediment deposition in stream channels, increased flooding of low-lying areas and significant seasonal reductions in or complete disappearance of perennial stream flows.

Recovery of riparian areas in the Estero Americano Watershed can be greatly accelerated by a judicious planting program using selected successional and climax species. Strategic plantings of various herbaceous and woody species may eliminate the necessity of actively "treating" the entire riparian corridor by acting as seed stock for downstream areas. Protecting and planting areas which were probably once-active springs (areas on surrounding hillsides which stay green into the summer) will tend to develop both water and seed sources, provided downslope areas are also protected (Buell, 1988).

In the Estero Americano Watershed, runoff control will be greatly enhanced if riparian recovery can extend up tributary areas, even small ravines, to establish vegetation belts from potential spring areas on surrounding hillsides. The more natural water retention that can be developed in upper watershed watercourses, the greater will be the resulting reduction in runoff peaks in the Bloomfield and Valley Ford areas (ibid.). The restoration of riparian plant communities, including wetland plant species, serves a number of valuable water quality functions. Riparian vegetation traps and utilizes excess inorganic nutrients (nitrate and phosphate). Riparian areas also serve as relief floodways and water and sediment retention areas during periods of very high runoff.

Gully Erosion

Although gullies are a natural feature of some landscapes, management actions (intensive grazing or road drainage problems) may cause gullies to form or expand. Gully erosion can be assessed by observing the number and physical characteristics of gullies in an area and/or assessing the severity of erosion on individual gullies. Estimates of average annual sediment yields in the Estero Americano Watershed derived from gully erosion are on the order of 9,390 tons/yr.

Gully formation is a natural process in the watershed given the widespread occurrence of highly erodible soils, weakly cemented bedrock, and groundwater piping in the area. A typical gully in the watershed is 4 to 6 feet deep and 150 to 400 feet long, and can erode 70 to 100 tons of sediment annually. Larger gullies (18’ deep and 200’ long) can potentially erode over 400 tons of sediment annually. Given these conditions, and the expense of mitigating or restoring large gully systems, landowners in the watershed should employ best management practices to prevent gully formation, as well as management measures to mitigate erosion from existing gullies.

Restricting livestock access to critical areas such as steep slopes, maintaining adequate vegetative cover on rangeland, and designing ranch roads and livestock trails away from critical areas are important management considerations in mitigating and reducing the extent of gully formation in the watershed.

Gully Erosion Treatments:

Not all gully restoration projects require expensive structural treatments. There are a number of treatment levels and options based on the location, extent, and erosion activity of the gully (Lewis et al., 2000):

- The first level of treatment that should be considered, particularly where sediment delivery rates to watercourses are still low, is fencing the area surrounding the gully. Fencing reduces or eliminates the effects of trampling and allows vegetation to recover.

- The second level of treatment includes adding a rock apron at the headcut of the gully. This technique can control the migration of the headcut upslope by diverting water onto the rock.

- The third level of treatment entails placement of grade stabilization structures along the gully bottom to reduce runoff velocity, increase aggradation, and reduce lateral recession.

- The fourth level of treatment, and most expensive, includes all of the above plus reshaping of the gully along with extensive replanting.

Watershed Gully Assessment

High-resolution 2004 aerial photographs were used to map gullies throughout the watershed (See Appendix C: *Watershed Modeling Methods and Results*). Two hundred and eighty-three gullies were mapped; of these, 166 occur on soils with a high erosion hazard (close to 60% of gullies mapped). Aerial photo-interpretation identified 14 gullies directly adjacent to the estuary, and 42 gullies that drain into Ebabias Creek (Table 4-3). Although aerial photo-interpretation can provide valuable information on the location and extent of large gullies in the unwooded portions of the watershed, the type of erosion (landslide, sheet, channel bank) and erosion activity levels of individual gullies cannot be determined from aerial photographs.

Table 4-3. Distribution of aerial-photo mapped gullies in the watershed.

Estero Americano Watershed	
Mapped Gullies	**283**
Gullies on High Erosion Hazard Soils	**166**
Large Gullies along the Estuary	**14**
Gullies draining to Ebabias Creek	**42**

The last extensive field survey of erosion problems in the watershed cited gully formation as the most frequently documented type of erosion problem in the watershed (Circuit Rider Productions, Inc., 1987). The field survey found that large gullies, in the range of 500 feet long, 20 – 30 feet deep and 20 – 30 feet wide with active headcutting and downcutting were common. One of the large gully systems identified was estimated to contribute up to 4,000 tons of sediment per year to the estuary. Bank erosion on tributary streams was also identified as a major source of sediment reaching the estuary. Sheet and rill erosion were identified as common problems in heavily grazed areas.

Priority Gully Restoration Sites

When grant funds become available, a priority gully restoration assessment will be conducted on gullies draining directly to the estuary; gullies located in the sub-watershed of Ebabias Creek; and on gullies in the larger Estero Americano Watershed located in close proximity to livestock corrals or other areas where livestock congregate. The assessment will select restoration sites based on a sediment delivery inventory using the four criteria recommended by the University of California, Division of Agriculture and Natural Resources (Lewis et al., 2000).

Identified erosion “source sites” which meet the following four criteria will be considered priority restoration sites. The four selection criteria are:

1) Potentially deliverable sediment that is actually delivered to a watercourse;
2) Potential sediment delivery that is management induced;
3) Potential sediment delivery that is reasonably responsive to mitigation; and
4) Potentially deliverable sediment that is greater than a recommended threshold value.

A careful assessment of the drainage patterns, soil types, slope, vegetation, and hydrologic connectivity above and below selected erosion sites will be used to determine the potential for sediment delivery. Due to the extent of natural erosion processes in the watershed (e.g., highly erosive soils, landslides, and seeps), priority restoration sites will be limited to erosion problems that are management induced, and have the highest mitigation potential. Priority site selections and treatment methods chosen will be based on cost effectiveness and recommended sediment volume thresholds (the annual amount of deliverable sediment measured in cubic yards). Recommended sediment threshold values typically range from 10 to 50 cubic yards (Lewis et al., 2000).

Sheet & Rill Erosion

Erosion on rangeland is often difficult to detect. Erosion can reduce productivity so slowly that the reduction may not be recognized until the site has reached a threshold level. Also, erosion can increase future runoff because of reduced infiltration. Increased runoff reduces soil water, which affects plant growth. Less plant growth means less residue, and less vegetation and residue provide less cover, which increases erosion (USDA, 1997).

The first stage of erosion is sheet erosion. Sheet erosion begins when raindrops splash on bare soils, detaching soil particles. Detached soil particles are then transported by a thin flow of water across the ground surface. Rill erosion begins when water movement causing sheet erosion concentrates in discrete flow paths. Sheet and rill erosion produces the greatest amount of soil loss worldwide. In the Estero Americano Watershed, sheet and rill erosion produce an estimated average annual sediment yield of 4,831 tons (Table 4-2).

Indicators of water erosion on pasture and rangeland:

- Pedestalled plants and rocks
- Base of plants discolored by soil movement from raindrop splash or overland flow
- Exposed root crowns
- Formation of miniature debris dams and terraces
- Puddled spots on soil surface with fine clays forming a crust in minor depressions, which crack as the soil surface dries and the clay shrinks
- Rill and gully formation
- Accumulation of soil in small alluvial fans where minor changes in slope occur
- Surface litter, rock, or fragments exhibit some movement and accumulation of smaller fragments behind obstacles
- Flow patterns contain silt and/or sand deposits and are well defined and numerous

Erosion and Sedimentation from Roads

Roads are a major source of erosion and sediment. Compacted road surfaces increase rates of runoff; road cuts can intercept the groundwater table, increasing surface flow; and water flowing along a road can erode the road surface and precipitate slope failure. Road surfaces and ditches concentrate stormwater runoff and can transport sediment to nearby stream channels. Culverts can easily plug or become overwhelmed during large storm events, causing fill wash outs or gullies where the diverted streamflow drains down hillslopes. Roads built on steep or unstable slopes, which are common in the Estero Americano Watershed, can trigger landslides. Lack of inspection and maintenance of drainage structures and unstable road fills can also result in erosion and sediment delivery to the estuary and its tributaries.

Road construction does not have to result in increased erosion and sediment impacts to streams. Proper planning, design, construction, and maintenance of roads and drainage structures can prevent water quality problems and significantly extend the useful life of a road. New roads can be planned and located to avoid unstable, erodible areas. Stream crossings can be planned, built and maintained to minimize the potential for post-construction erosion or slope failure. Older roads can be decommissioned or treated to mitigate erosion problems (Weaver and Hagans, 1994).

Factors that increase erosion potential from roads:

- Exposed soils
- High runoff velocities
- Concentrated volumes of water
- Inadequate maintenance
- Sandy or silty soil types
- Overly steep cutbanks
- Poor compaction
- Steep road grades
- Disturbances to unpaved road surfaces
- Road surface drainage problems
- Improper placement of road drainage measures
- Undersized road drainage (i.e., culverts)
- Unvegetated roadsides and hillsides

Conclusion

Since the last comprehensive erosion assessment conducted by Circuit Rider Productions, Inc., in 1986, the RCD and USDA, NRCS through its Environmental Quality Incentives Program (EQIP) have been working with ranchers in the watershed to identify, manage, and treat erosion problems. Over the last few years, the RCD has sponsored the design, permitting, and restoration of nine large, actively eroding gullies. Sediment savings from these restoration/mitigation projects combined is on the order of 1,250 tons per year. In addition, close to 1.5 miles of riparian corridor along the mainstem of Americano Creek has been revegetated and fenced to control access by livestock. These RCD sponsored projects were grant funded through the State Water Resources Control Board and the State Coastal Conservancy. The RCD and its resource agency partners are actively working with agricultural producers in the Estero Americano Watershed to implement conservation-oriented ranch plans in order to reduce sheet and rill erosion and to lessen the impacts of livestock on sensitive areas.

Recommended “Action Plan” elements to reduce soil erosion and sedimentation in the Estero Americano Watershed can be found in *Chapter 6: Action Plan to Improve Natural Resources and Agricultural Sustainability*. Recommended “best management practices” to reduce erosion and sedimentation can be found in *Chapter 5: Agricultural Best Management Practices*. Additional information on water quality and sedimentation can be found in the following appendices of this document: Appendix B: Water Quality Monitoring Data, 1988-1990; Appendix C: Watershed Modeling Methods and Results; Appendix D: Riparian Assessment; and Appendix F: Monitoring Needs and Guidelines.

Erosion & Sediment Reduction Goals:

- Reduce the Adverse Impacts of Erosion and Sediment from Farm Fields
- Reduce the Adverse Impacts of Erosion and Sediment from Unstable Streambanks
- Reduce the Adverse Impacts of Erosion and Sediment from Private and Public Roads

CHAPTER 5

AGRICULTURAL BEST MANAGEMENT PRACTICES:

Introduction

Managing agricultural operations to comply with changing environmental regulatory goals and the increasingly competitive demands of the marketplace is a constant challenge for the agricultural community. Resource agencies such as USDA's Natural Resources Conservation Service (NRCS), local Resource Conservation Districts (RCDs), and UC Cooperative Extension were established to provide agricultural producers with the technical and funding assistance they need to be good land stewards as well as economically profitable businesses. Over the course of the last decade, agricultural producers in the Estero Americano Watershed have been working proactively with resource agencies and other organizations such as Western United Dairymen and the California Certified Organic Program to adopt agricultural best management practices (BMPs) to reduce non-point sources of pollution entering the estuary and its tributaries (see Table 5-1.).

As part of these broader efforts, and to help meet the specific goals and objectives of this watershed management plan, the RCD is currently developing technical assistance and funding programs for dairy operators and livestock ranches in the Estero Americano Watershed. Programs will include conservation ranch planning and nutrient management planning assistance as well as funding opportunities for infrastructure improvements and recommended best management practices. In addition, the RCD will implement a long-term water quality monitoring program to measure overall BMP effectiveness and water quality improvements at the watershed-scale. Management objectives, indicators and target values along with estimates of potential load reductions from the implementation of these management practices are presented in Table 5-2 and Table 5-3.

The Importance of Reducing Agricultural Runoff

Agricultural research studies have shown that nonpoint source pollution can most effectively be controlled through management measures aimed at soil retention and control of runoff (USDA, 1997). Stormwater runoff from agricultural areas can carry high loads of contaminants to surface waterbodies. These contaminants include nutrients, bacteria, pathogens, sediment and organic matter that deplete oxygen, raise turbidity and temperature, and cause other adverse impacts to water quality.

To address pollutant loadings from agricultural land, the RCD will seek grant funds to improve on-farm infrastructure and management practices to control runoff, reduce erosion, and divert stormwater flows away from heavy use areas on agricultural land in the Estero Americano Watershed. The promotion of better manure management practices is also a funding priority identified in this watershed management plan. Comprehensive nutrient management planning, along with better tracking and management of land application of manure to farm fields will help to insure reductions in the amount of nutrient pollution reaching surface waterbodies in the watershed.

***Table 5-1. Existing Conservation Programs in the Estero Americano Watershed*.**

Stakeholder	Existing Program or Policy	Pollutant Addressed
Gold Ridge RCD	Gully restoration	Sediment
	Streambank stabilization	
	Riparian revegetation	
	Ranch road sediment mitigation	
	Nutrient management planning	Nutrients
	Soil, manure and vegetation sampling	
	Agricultural waste management	
USDA, NRCS	Gully restoration (EQIP)	Sediment
	Streambank stabilization (EQIP)	
	Riparian revegetation (EQIP)	
	Conservation Planning (EQIP)	
	Comprehensive Nutrient Management (EQIP; CNMP)	Nutrients & Pathogens
	Agricultural waste management (EQIP; CNMP)	
UCCE	Ranch Water Quality Plans	Nutrients, Pathogens &Sediment
California Dairy Quality Assurance Program	Nutrient Management Planning	Nutrients
	Environmental Stewardship Short-Course	Nutrients & Pathogens
Western United Dairymen	Environmental Planning Assistance	Nutrients & Pathogens
Marin Agricultural Land Trust (MALT)	Conservation Easements	All
	Natural Resource Assessments	All
	Vegetated buffers	Nutrients & Pathogens
	Off-channel water development	
	Gully restoration	Sediment
	Conservation tillage	
	Cross-fencing	
	Riparian revegetation	
Sonoma Agricultural Preservation & Open Space District	Conservation easements	All
	Vegetated buffers	Nutrients & Pathogens
Sonoma Land Trust	Conservation Plan	All
	Grazing plan	Sediment
	Ranch road sediment mitigation	
	Gully restoration	
Clover Stornetta Certified Organic	Environmental Planning Assistance	All
	Pasture management	Nutrients & Sediment
	Nutrient management planning	Nutrients
	Soil and manure sampling	

Table 5-2. Management Objectives, Indicators and Target Values

Management Objective	Indicator and Target Value
Reduce nitrogen loads from land application of manure; improve stormwater controls around livestock heavy use areas and dairy facilities; reduce direct loadings from livestock access to stream channels.	*Un-ionized Ammonia as NH_3*: The target for un-ionized ammonia is 0.025 mg/L as NH_3 (the targets for temp. and pH must be achieved in order for the target for total ammonia to apply). *Temperature °C:* The targets are 20 degrees C. during May through November and 13.8 degrees C. during December through April. *pH:* The target range for pH applies during late spring and early summer is 7.0 to 8.5. *Above targets are based on the TMDL and Attainment Strategy for Stemple Creek.
Reduce erosion from upland and riparian areas through grazing management practices; stabilize and revegetate stream corridors; mitigate erosion from gullies and ranch roads.	*Sediment:* Reduce sediment loads in the watershed 5% annually over the next 10 years. The current average annual watershed sediment load is estimated to be 24,921 tons.
Improve aquatic habitat through streambank stabilization and stream corridor revegetation.	*Riparian vegetation:* Increase riparian cover along 14 streams miles that are currently unvegetated. *Temperature °C:* The targets are 20 degrees C. during May through November and 13.8 degrees C. during December through April.
Support designated uses for aquatic life; eliminate anoxic conditions.	*Temperature °C:* The targets are 20 degrees C. during May through November and 13.8 degrees C. during December through April. *Dissolved Oxygen:* The targets for dissolved oxygen are 5.0 mg/L in the Estero Americano and 6.0 mg/L in Ebabias Creek; 7.0 mg/L in the estuary and Ebabias Creek wherever and whenever the aquatic habitat is suitable for salmonid migration, rearing and spawning; and 9.0 mg/L during critical spawning and egg incubation periods, which is defined as applicable when and where anadromous fish redds are located. *Above targets are based on the TMDL and Attainment Strategy for Stemple Creek.
Increase native biodiversity and upland habitats; map remnant populations of coastal prairie; reduce highly invasive species such as gorse and develop eradication plans.	*Location map of native species:* Target is a habitat conservation plan for the watershed. *Extent of Invasive species:* Target is to map and control the spread of gorse in the watershed.
Improve rangeland health; assess and monitor rangeland health indicators.	*Rangeland Health:* The target will include ranch plans and rangeland health assessments for all high priority parcels in the watershed.

Recommended Best Management Practices for Reducing Nutrient Pollution & Other Agricultural Sources of Pollution:

On-farm and watershed-wide efforts to reduce nutrient loads to surface waterbodies will require a combination of management practices including better livestock management, manure management, vegetation management, and more controls to reduce or prevent commingling of stormwater runoff with animal wastes. The following "points of intervention" in the control of NPS pollution entering surface water drainage networks are recommended (Lewis et al., 2005b):

- Managing the distribution, timing, frequency, and intensity of livestock use of various management units (e.g., pastures, corrals, feedlots) to reduce the quantity and availability of sediment, nutrients, and bacteria potentially discharged to surface waterbodies.

- Managing the collection, storage, and distribution of manure to prevent contamination of stormwater runoff and potential discharges to surface waterbodies.

- Managing vegetation to increase ground cover and streambank protection in order to decrease runoff and erosion, and promote infiltration and filtering of pollutants.

- Installing infrastructure to better control surface runoff, and to either capture or filter out sediment, nutrients, and bacteria, including gutter installation and clean water and wastewater drainage conveyance structures.

Estero Americano Watershed Dairy Enhancement Program

Small-scale dairy operations account for close to 25 percent of land acreage in the Estero Americano Watershed. There are 10 family run dairies and 2 leased dairies. Many of these dairy facilities are located on or at the base of hillsides, on soils with high runoff rates that are prone to gully formation. The Gold Ridge Resource Conservation District was recently awarded a Dairy Water Quality Grant through the State Water Resources Control Board (SWRCB) to assist watershed dairy operators in adopting a "user friendly" nutrient management program that will include a nutrient budget modeling application, soil, vegetation, and manure sampling, and a land application tracking system.

The grant program will also fund priority infrastructure improvements such as gutter installations, clean water diversions, and better animal waste management systems to reduce the volume of stormwater runoff contaminated by contact with animal wastes (refer to Table 5-3 for estimated load reductions from the adoption of management practices). A recent study on manure management conducted in the Tomales Bay Watershed found that stormwater flow volumes are indicative of pollution transport potential, a loading unit's manageability, and an important variable in prioritizing water quality concerns (Lewis *et al.,* 2005).

The end goal of these efforts is to have dairy operators quantify and better manage on-farm nutrient production and use, and to reduce the likelihood of nutrient pollution entering the estuary and its tributaries. The RCD will work with Western United Dairymen, the California Dairy Quality Assurance Program, NRCS's Comprehensive Nutrient Management Program (CNMP), and UC

Cooperative Extension staff to help coordinate education and outreach efforts, and act as a liaison with regional Water Board staff to ensure local agricultural producers are meeting all water quality standards.

Establishing and maintaining adequate drainage diversions through and around manured areas to prevent co-mingling of stormwater and wastewater is an ongoing and expensive operational consideration, as are improvements in the collection and containment of animal waste.
As part of the dairy grant program, dairy producers in the watershed were surveyed to identify priority concerns and needed infrastructure improvements. Funding priorities identified by watershed dairy operators during the summer of 2005 included infrastructure improvements for more aggressive stormwater management and gutter installation, and improved manure collection, storage, and transfer capacity as well as better land application of manure methods.

Comprehensive Nutrient Management Plans:

Nutrient budgeting is an up and coming regulatory requirement for dairy and livestock producers. There is little doubt that nutrient management plans of some form will be mandated in the near future, including nutrient land application requirements (Meyer and Mullinax, 1999). USDA's Natural Resources Conservation Service has developed a comprehensive nutrient management program (CNMP) to assist dairy producers in managing their facilities to meet water quality standards.

A Comprehensive Nutrient Management Plan includes:

- Map of facility with a legend.
- Wastewater generated based on an animal inventory, length of confinement, milking schedule, milk barn sanitation, stall barn size and management, corral/feedlot size and management, and rainfall, among other necessary inputs.
- Manure storage availability based on existing measurements and management, as well as use and management of each structure.
- Facility inventory describing building sizes and uses, field sizes and uses, and corral/feedlot sizes and uses (each of these categories will have an annual use description).
- Monitoring: manure, soils and vegetation sampling
- Crop production and nutrient uptake requirements.
- Manure application rates and cost analysis.
- Overview of off-site (i.e., rented) property with all of the above included.

Animal Waste Management Systems:

Animal waste management systems comprise a variety of best management practices or combination of BMPs used at concentrated animal feeding operations (CAFOs) and farms to manage animal waste and related animal by-products. These systems include engineered facilities and management practices for the efficient collection, proper storage, necessary treatment, transportation, and distribution of waste. The BMPs are designed to reduce the discharge of nitrogen, phosphorus, pathogens, organic matter, heavy metals (such as zinc, copper, and occasionally arsenic, which are present in many animal rations), and odors. Improvements in animal waste management systems identified during a 2005 dairy needs assessment in the watershed included:

Clean Water Diversions: A number of the dairies in the Estero Americano Watershed are located on or at the base of hillslopes. Constructing and maintaining adequate drainage diversions away from or through heavy use areas can significantly reduce the amount of wastewater an operator must manage. Five out of the six dairy operators interviewed identified enhanced clean water diversions such as culverts, piping, drainage ditches, berms, and grassed swales as funding priorities.

Gutter Installation: Diverting stormwater runoff away from livestock areas reduces the amount of wastewater generated on-site. Four out of the six dairy operators interviewed identified gutter installation as a funding priority.

Manure and Wastewater Collection: Four out of the six dairy operators identified improvements in the collection and containment of manure and wash water as funding priorities. Improvements identified include enhanced manure and wastewater collection methods, better location of collection points; equipment and structural facilities for collection as well as structural features to prevent co-mingling of freshwater and animal wastes.

Manure Storage: Three out of the six dairy operators interviewed identified increased storage capacity as a funding priority.

Manure transfer: Three out of the six dairy operators identified improvements in the method, structures, and equipment used for the movement of manure and wastewater between collection, storage, and utilization locations as funding priorities.

Manure Treatment: Two out of the six dairy operators identified enhanced manure treatment technologies as a funding priority. Manure treatment includes such things as solids separators, anaerobic biodigestors, and composting etc.

Manure Land Application: Three out of the six dairy operators identified new equipment for manure distribution to farm fields as funding priorities.

Rangeland and Grazing Management Issues & Practices

Joe Pozzi, RCD District Manager

Rangeland health is the degree to which the integrity of soils, vegetation, water, and air are maintained. With over 80 percent of the Estero Americano Watershed in rangeland or pasture usage, maintaining rangeland health is essential to sustained agricultural productivity.

Rangeland health and soil quality are interdependent. Rangeland health is characterized by the functioning of both the soil and the plant community. The capacity of the soil to function affects ecological processes, including the capture, storage, and redistribution of water; the growth of plants; and the cycling of plant nutrients. Changes in the capacity of soil to function are reflected in soil properties that change in response to management or climate.

Changes in soil quality that occur as a result of management affect the amount of water from rainfall that is available for plant growth; runoff, water infiltration, and the potential for erosion; the availability of nutrients for plant growth; the conditions needed for germination, seedling establishment, vegetative reproduction, and root growth; and the ability of the soil to act as a filter and to protect water quality.

Infiltration and Overland Flow

Infiltration is the process of precipitation or irrigation water crossing the soil surface and entering the soil profile. There is a maximum rate at which a given soil type can absorb water. Water that infiltrates the soil can be used by plants, evaporate, percolate to groundwater aquifers, or become stream flow by means of later subsurface flow or groundwater discharge. Water that does not infiltrate the soil will pond on the soil surface and runoff as overland flow.

Overland flow has the potential to erode soil and transport non-point sources of pollution (i.e., sediment and manure) directly to surface waterbodies. Any management activity that impacts the process of infiltration will also impact overland flow, stream flow, nonpoint source pollution generation, and overall watershed hydrology. Maintaining or increasing infiltration rates, thus minimizing overland flow, is a key rangeland management objective.

Management strategies that promote infiltration:

- Increase the amount of plant cover, especially plants that promote infiltration.
- Decrease the extent of compaction by avoiding intensive grazing and the use of machinery when soils are wet.
- Decrease the formation of physical crusts by maintaining or improving plant cover or litter, thus reducing the impact of raindrops.
- Increase aggregate soil stability by increasing the amount of organic matter added to soil through residue decomposition and vigorous root growth.

Soil Organic Matter

Soil organic matter includes plant, animal, and microbial residue in various stages of decomposition. Roots are the primary source of organic matter. Plant composition and distribution control the amount and extent of organic matter in soil. Soil organic matter enhances soil functions in the following ways:

- It binds soil particles into stable aggregates, thus improving porosity, infiltration, and root penetration and reduces runoff and erosion.
- It enhances soil fertility and plant productivity by improving the ability of soil to store and supply nutrients, water, and air.
- It provides habitat and food for soil organisms.
- It reduces mineral crust formation and runoff.
- It reduces the negative water quality and ecological effects of pesticides, heavy metals, and other pollutants by actively trapping and transforming them.

Management strategies to enhance the content of organic matter in rangeland soils:

- Increase or maintain plant productivity.
- Promote the growth of species with high root production and promote a mix of species with different rooting depths and patterns.
- Protect soil from erosion by maintaining or increasing plant cover and reducing the amount of bare soil.
- Properly manage grazing and vehicle use.

Recommended Best Management Practices for Reducing Erosion on Rangeland

Grazing management techniques attempt to protect land and water and optimize production of domesticated livestock.

Grazing management is the primary treatment method for reducing agriculturally induced erosion in the Estero Americano Watershed. An important goal of this watershed management plan is to promote grazing at an intensity that will maintain enough cover to protect soils and to maintain or improve the quantity and quality of desirable vegetation. Management practices such as deferred grazing and planned grazing systems used in conjunction with other recommended best management practices like cross fencing, range seeding, fertilization, soil mechanical treatment, and stream corridor revegetation can significantly reduce the amount of sediment and excess nutrients entering the estuary and its tributaries.

Livestock grazing affects plant communities in a number of interrelated ways. Grazing animals defoliate plants, remove and/or redistribute nutrients, and cause physical impacts to soils and plants through trampling. These affects are complex and may have desirable or undesirable consequences on individual species, plant communities and grassland ecosystems (Bush, 2006). Grazing plans should address these potential impacts at the pasture-scale.

The Estero Americano Watershed Rangeland Water Quality Management Project

In November 2006, the Gold Ridge Resource Conservation District was awarded grant funds through the State Water Resources Control Board, Proposition 50 Coastal Nonpoint Source Pollution Control Program to conduct a rangeland water quality management program in the Estero Americano Watershed. The project will assist a potential 20 agricultural operators in the watershed to update ranch water quality management plans, to assess rangeland health, develop grazing plans, and to implement rangeland management practices.

Project goals include measurable reductions in nutrient and sediment loads to the estuary and its tributaries through better ranch planning and the adoption of conservation management practices and measures. Additional goals include enhancement and protection of wetland habitat for birds and aquatic organisms as well as implementation of a surface water ambient monitoring program for the watershed. Project implementation elements include restoration and protection of 6 miles of riparian corridor, streambank stabilization projects, off-channel water development, filter strips and drainage conveyances around heavy use areas, and reductions in streambank, gully, sheet and rill erosion through grazing management practices and structural improvements such as crossing-fencing and animal walkways (refer to Table 5-3 for estimated load reductions from the adoption of management practices).

Conservation Ranch Plans:

Developing a conservation plan or a ranch water quality management plan is the first step towards planning for long-term rangeland health. Conservation planning for grazing lands includes decisions for manipulating the plant community to manage soil, water, and animal resources. On grazing lands, vegetation is the key management variable. How vegetation is managed will affect soils, surface and ground water resources, and the health of livestock. Animals are resources, but they are also tools used in managing the plant resources that, in turn, affect rangeland soils and water quantity and quality. Therefore, proper use of grazing and browsing animals in managing plant communities is basic to achieving rangeland health and sustainable agricultural profitability.

Steps in the conservation planning process include (NRCS, 1997):

1) An inventory of all animal and natural resources.

2) An assessment of current management practices.

3) Identification of potential problems based on the resource base and current management practices.

4) Determination of new management measures and practices to enhance rangeland health and water quality protection in both upland and riparian areas.

Rangeland Health Indicators:

As part of its *Estero Americano Watershed Rangeland Water Quality Management Project*, the RCD will adopt a new rangeland health monitoring system developed by the Central Coast Rangeland Coalition (CCRC) under a grant from USDA, NRCS. The CCRC rangeland health indicator system (Ford and Huntsinger, 2007) utilizes a series of universal rangeland health indicators and special rangeland management indicators to assess and monitor rangeland health along the central coast of California. This indicator system was developed to assess the following ecological and economic conditions:

1) Degree of Soil Stability and Watershed Function

2) Integrity of Nutrient Cycles and Energy Flows

3) Presence of Functioning Recovery Mechanisms

4) Maintenance of Biological Diversity and Habitat Quality

5) Socio-Economic Sustainability.

California Guidelines for Residual Dry Matter (RDM) Management on Coastal and Foothill Annual Rangelands
(Bartolome *et al*., 2002):

Residual Dry Matter (RDM) is a standard used by livestock ranchers and natural resource agencies for assessing the level of grazing use on annual rangelands. RDM is the old plant material left standing or on the ground at the beginning of a new growing season. It indicates the combined effects of the previous season's forage production and its consumption by grazing animals of all types. The standard assumes that the amount of RDM remaining in the fall, subject to site conditions and weather variations, will influence subsequent species composition and forage production.

Properly managed RDM can be expected to provide a high degree of protection from soil erosion and nutrient losses. Maximum productivity within the 15- to 40-inch annual precipitation zone occurred with 750 lb/acre of RDM in fall. Depending on slope and woody vegetation, minimum RDM guidelines for annual grassland/hardwood range vary from 500 to 800 lb/acre of RDM in fall. For rangeland comprised of coastal prairie, minimum RDM guidelines vary from 1,200 to 2,100 lb/acre of RDM in fall. In general, low RDM reduces the fertility of the site, reduces infiltration rates, and exposes soil to more rainfall, increasing sheet and rill erosion and runoff. Treatment for low RDM includes better site preparation, seeding and fertilization, and increased grazing management.

Proper Grazing Use & Management Practices:

Deferred Grazing:

Compaction of wet rangeland soils from grazing can result in increased runoff, erosion, and reduced forage productivity. Deferred grazing is the postponing of grazing or resting of grazing land for a prescribed period of time. Deferred grazing can support an increase in forage yields, an increase in more desirable species, and benefit wildlife and livestock.

Planned Grazing:

A planned grazing system results in a more uniform use of plant species in a pasture. A planned grazing system is the alternate resting and grazing of two or more grazing units. Rest periods may occur throughout a given year or during the growing season of desirable plants species. During rest periods, plants will have more leaf area and recover quicker from grazing resulting in increased forage production and seed production.

Animal Trails and Walkways

Animal trails and walkways are facilities designed to allow livestock or wildlife to move through difficult or ecologically sensitive terrain. They are intended to reduce erosion by providing or improving animals' access to forage, water, or shelter; improving grazing efficiency and distribution; and diverting travel away from ecologically sensitive or erosive sites.

Critical Area Planting

Critical area planting is the planting of grasses, legumes, or other vegetation to stabilize slopes in small, severely eroding areas. The permanent vegetation stabilizes areas such as gullies, over-grazed hillsides and terraced backslopes. Although the primary goal is erosion control, the vegetation can also provide nesting cover for birds and small animals.

Diversion

Diversion is the redirection of a storm drain line or outfall channel so that it can temporarily discharge into a sediment-trapping device. Its purpose is to prevent sediment laden water from entering a watercourse, or to temporarily provide underground conveyance of sediment laden water to a sediment trapping device. A diversion channel is constructed across a slope and has supporting earthen ridge on the lower side.

Filter Strip

A filter strip is a strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater before they reach waterbodies or water sources, including wells.

Grade Stabilization Structure

A grade stabilization structure is designed to reduce channel grade (steepness) in natural or constructed watercourses to prevent erosion of a channel that results from excessive grade in the channel bed. This practice allows the designer to adjust the channel grade to fit soil conditions.

Grass Swale

Grass swales are elongated depressions in the land surface that are at least seasonally wet, usually heavily vegetated, and normally without flowing water. Swales direct stormwater flows into primary drainage channels and allow some of the stormwater to infiltrate into the ground surface. Swales are vegetated with erosion resistant, and flood tolerant grasses. Sometimes check dams are strategically placed in swales to moderate flow, and an engineered soil mixture might underlie swales.

Grassed Waterway

A grassed waterway is a natural or constructed channel that is shaped or graded and planted with suitable vegetation for the stable conveyance of runoff without causing erosion of the channel.

Prescribed Grazing

Prescribed grazing is the controlled harvest of vegetation with grazing or browsing animals, managed with the intent to maintain or improve water quality and quantity. For example, on grazed forest, native pasture, or rangeland, grazing is limited so that the grazing animals will consume no more than 50 percent (by weight) of the annual growth of high or medium preferred grazing species.

Reduced Tillage Systems

Reduced tillage refers to any system that is less intensive and aggressive than conventional tillage. The number of operations is decreased compared to conventional tillage, or a tillage implement that requires less energy per unit area is used to replace an implement typically used in conventional tillage system. The term is sometimes used to imply conservation tillage; however, for a system to be considered a conservation tillage system, 30 percent of the soil surface must be covered with residue after planting.

Riparian Pasture Development

Restricting livestock access during the wet season is a key element in protecting riparian vegetation and maintaining streambank stabilization. In the north coast region, riparian areas are generally less impacted when grazed during late summer or early fall, prior to heavy rains, and while wetland plant species are dormant. Timing, duration, and frequency of grazing, distribution of livestock, stocking rate, utilization levels and pasture design are all variables subject to management control, and can be adjusted to meet defined vegetation management goals and objectives.

Stream Channel Stabilization

Stream channel stabilization means stabilizing the channel of a stream with suitable structures to prevent erosion or siltation of the channel. A channel is considered stable if the channel bottom remains essentially at the same elevation over long periods of time. Stream channel stabilization methods include modifying the channel capacity, channel armoring, providing channel crossings for livestock, and seeding (vegetating or planting the channel to prevent erosion).

Streambank Protection

Streambank protection helps to prevent streambank erosion. Streambank protection methods are essentially the same as stream channel stabilization methods. They include modifying the channel capacity, channel armoring, providing channel crossings for livestock, and seeding (vegetating or planting the channel to prevent erosion).

Streambank Fencing

Fencing is used to control livestock access to streambanks because animal traffic erodes streambanks, increases sediment load, and contributes animal waste in and near the stream, impairing water quality.

Water and Sediment Control Basin

A water and sediment control basin is an earthen embankment or combination ridge and channel constructed across a slope and minor watercourse to form a sediment trap and water detention basin. Water collected in the basin is slowly released through an outlet structure.

Management Strategies for Riparian Pastures

The multiple resource values and ecological functions of riparian areas are important management concerns in agricultural watersheds. The productivity of riparian areas, including floodplains, wet meadows and stream corridors, and the abundant forage and water resources these areas provide for livestock are important considerations for sustained agricultural productivity.

Managing riparian areas for both their ecological and economic values is a primary goal of this watershed management plan. Over the last few years, RCDs in Marin and Sonoma counties have sponsored public workshops to promote riparian pasture development and management as an alternative to exclusionary fencing.

Successful riparian grazing systems involve managing livestock to meet objectives specific to riparian functions and values such as vegetation type, water quality, and wildlife habitat. The development of site-specific riparian grazing prescriptions should take into consideration factors influencing riparian health as well as associated upland watershed conditions and uses, the overall ranch operation, and plant community and wildlife needs (Creque, 2005).

Key Riparian Management Considerations:

- Restricting livestock access during the wet season is a key element in riparian pasture management. In the north coast region, riparian areas are generally less impacted when grazed during late summer or early fall, prior to heavy rains, and while wetland plant species are dormant. However, autumn use should be monitored to retain sufficient residual dry matter to protect the streambank from the erosive force of early rains.

- Timing, duration, and frequency of grazing, distribution of livestock, stocking rate, utilization levels and pasture design are all variables subject to management control, and can be adjusted to meet defined vegetation management goals and objectives.

- Grazing frequency and intensity must ensure plant vigor, regrowth and reproduction, as well as meeting the habitat requirements of important wildlife species. For riparian areas that are significantly degraded, livestock should be excluded for one or more years, or until riparian plant communities have become well established.

Table 5-3. Estimated Load Reductions from Currently Funded RCD Grant Programs, 2006-2010

Modeled estimates of sediment and nutrient load reductions from the implementation of selected agricultural BMPs were derived using the "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual" and Region 5 Loading Model (Michigan Department of Environmental Quality, June 1999).

	Potential Load Reductions		
Currently Funded Management Practices:	**Nitrogen (lbs/yr)**	**Phosphorus (lbs/yr)**	**Sediment (tons/yr)**
Streambank stabilization and revegetation (6 miles)	**4,689**	**2,154**	**2,534**
Increase residual dry matter on 3,249 acres by 10%	**1,681**	**833**	**593**
Runoff management on 10 acres of feedlots on livestock ranches	**21,619**	**8,918**	**N/A**
Waste management systems on 6 acres of feedlots on dairies	**31,242**	**7,029**	**N/A**
Nutrient management planning and practices (estimated 20% reduction from 8 participating dairies)	**13,377**	**2,065**	**197**
Gully stabilization projects	**619**	**609**	**364**
Estimated Total Load Reductions:	***73,227***	***21,608***	***3,688***
Percent of load reduction from agricultural sources:	***21%***	***40%***	***15%***

Conclusion

The primary purpose of this management plan is to address water quality impairments in the Estero Americano and its tributaries that have resulted from the cumulative, long-term impacts of various land use practices in the watershed. Reducing nutrient and sediment impacts to these waterbodies to within limits established by state regulatory agencies will require concerted efforts at both the watershed and farm scales. The RCD recognizes that to be successful in these efforts, recommended management actions need to be based on sound planning strategies. The final chapter of this watershed management plan, *Chapter 6*: *Action Plan to Improve Natural Resources and Agricultural Sustainability* provides an overview of the goals and objectives established during this watershed management planning process. The intended end result of this process is to establish a framework of action that both landowners and resource agencies can build upon to improve the overall health of the watershed within the context of a viable agricultural economy.

The RCD, along with its resource agency partners, is firmly committed to providing the agricultural community with the technical and funding support they need to stay economically competitive while at the same time enhancing the natural resource values of agricultural land in the watershed. The "Action Plans" presented in the following chapter were developed in order to provide direction in these efforts. Each action plan element includes goal statements as well as detailed descriptions of how each goal will be achieved, including respective time-frames and anticipated costs. The RCD will take the lead in facilitating the implementation of these recommended action strategies.

CHAPTER 6

ACTION PLANS TO IMPROVE NATURAL RESOURCES AND AGRICULTURAL SUSTAINABILITY

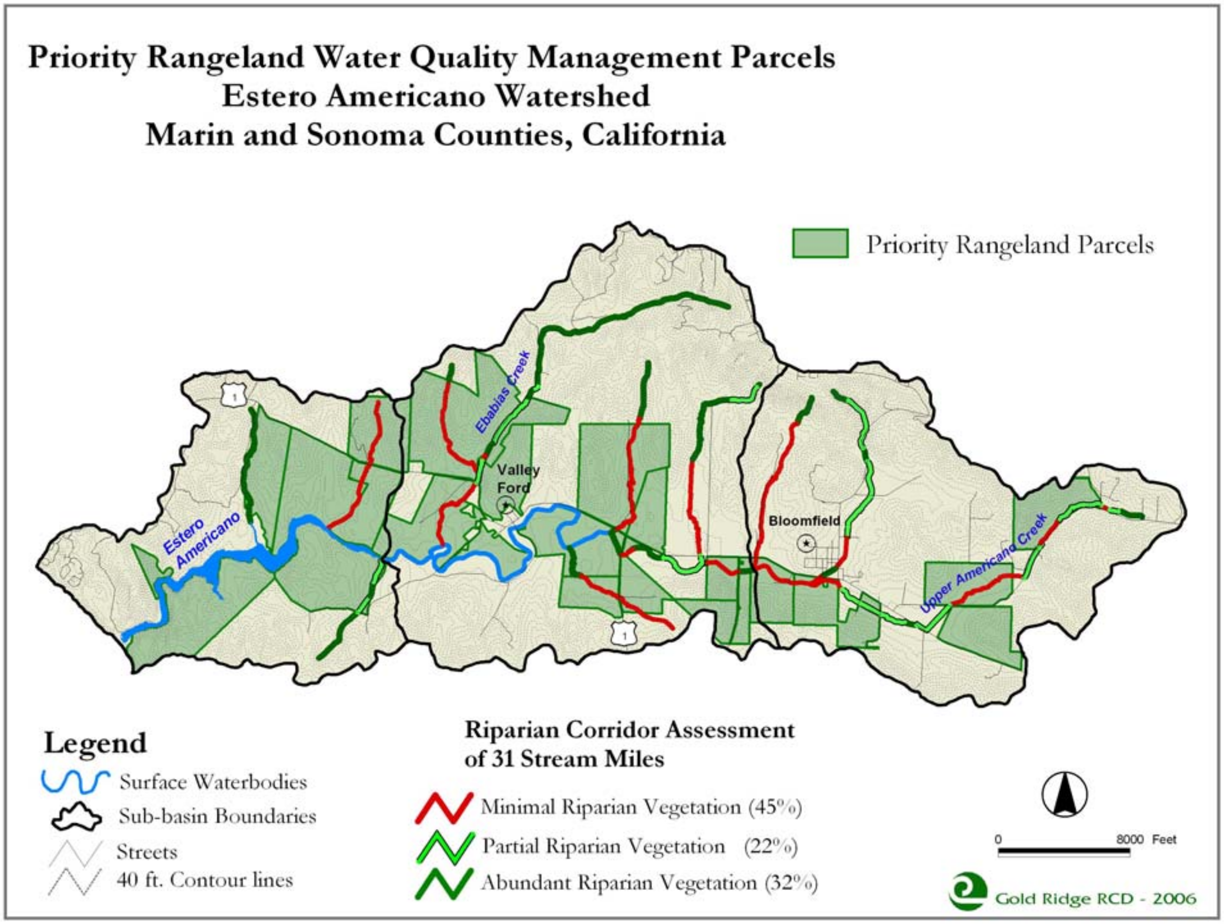
Introduction

To address 303(d) listed water quality impairments in the Estero Americano and its tributaries, the RCD, in collaboration with its partners, will assist livestock ranchers and dairy operators in the watershed achieve water quality attainment goals and improve the overall health of the watershed. This final chapter of the Estero Americano Watershed Management Plan provides an overview of the goals and strategies developed over the course of two-and-a-half years of planning efforts. The action plans presented in this chapter attempt to synthesize landowner identified resource management issues with the programmatic goals of the RCD, the water quality objectives of the North Coast Regional Water Quality Control Board (NCRWQCB), the best management practices promoted by the Natural Resources Conservation Service (NRCS) and UC Cooperative Extension (UCCE), and the habitat enhancement goals and objectives of the California Department of Fish & Game (CDFG) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries).

In many instances, the action plan strategies set forth in this chapter detail on-going conservation programs and practices currently being implemented in the Estero Americano Watershed (Table 5.1). For example, many of the livestock ranches and dairies in the watershed are already working with NRCS through its Environmental Quality Incentives Program (EQIP) to develop and implement conservation-oriented management plans. In addition, over the last decade, many of the agricultural producers in the watershed have been involved in ranch planning workshops and projects sponsored by the RCD and UCCE. Over half of the dairies in the watershed are currently participating in dairy enhancement programs sponsored by the RCD and the California Dairy Quality Assurance Program.

A primary intent of this planning document is to maintain or increase the technical assistance and funding opportunities available to watershed landowners, as most granting agencies now require an "approved" watershed management plan to be eligible for grant dollars. As part of this watershed management planning process, the RCD identified an initial 20 priority agricultural parcels located in key areas throughout the watershed where technical assistance and funding efforts will be directed (Figure 6-1). These agricultural parcels were selected based on land use intensity, proximity to waterbodies, and the ongoing commitment of their landowners to conservation-oriented land management practices and projects.

Figure 6-1. Map of parcels and stream reaches chosen for priority implementation of rangeland and riparian enhancement projects.



Detailed *Action Plans* are outlined in the following sections for the three types of watershed impairments: Water Quality, Erosion/Sedimentation, and Habitat Values. Each section contains goals, actions, and project steps for implementation and completion. Table 6-1 presents an outline of plan implementation goals, desired outcomes, milestones and selected indicators to monitor progress.

WATER QUALITY

Goals

Promote Beneficial Uses of the Estuary and its Tributaries

Nutrient pollution and sedimentation can have deleterious affects on aquatic life and overall water quality conditions. Actions to reduce animal manure and sediment reaching the estuary will significantly improve wetland habitat and the ecological functioning of the estuary.

Improve Agricultural Management Practices to Reduce Runoff

Stormwater runoff from agricultural areas can carry high loads of contaminants to surface waterbodies. These contaminants include nutrients, bacteria, pathogens, sediment and organic matter that deplete oxygen, raise turbidity and temperature, and cause other adverse impacts to water quality. Watershed-wide adoption of agricultural BMPs to improve water quality such as riparian corridor restoration, controlled grazing, and better drainage diversions will help to achieve regional water quality standards through reductions in nutrient and sediment loadings.

Measurably Reduce Nutrient Loadings to the Estuary and its Tributaries through Nutrient Management Planning

Agricultural operations in the watershed have individually and cumulatively lead to the exceedance of acceptable nutrient concentrations in the estuary and its tributaries. Comprehensive nutrient management planning, along with better tracking and management of land application of manure on farm fields, will help to insure measurable reductions in the amount of nutrient pollution reaching surface waterbodies.

Actions

Establish a water quality monitoring program to assess BMP effectiveness and to facilitate adaptive management measures at the watershed-scale by 2008.

Have all dairies adopt nutrient budgeting and management planning by 2010.

Develop a manure land application tracking system for the entire watershed by 2012.

Develop and implement pollution prevention and control measures on Confined Animal Feeding Operations and livestock ranches.

Provide technical assistance to dairy operators and livestock ranches to conduct on-farm facilities evaluations and nutrient budgeting.

Work with dairies and livestock ranches to complete nutrient management plans and to apply manure fertilizer to farm fields at agronomic rates.

Conduct soil, vegetation, and manure sampling to determine the proper fertilizer application rates for farm fields.

Assist dairy operators to become certified through the California Dairy Quality Assurance Program.

Work with agricultural producers to update or write ranch plans that address water quality protection measures.

WQ-01

Develop a Water Quality Monitoring Program for the Watershed

What
Develop a watershed surface water ambient monitoring program for the Estero Americano Watershed. Monitoring parameters will include flow, turbidity, temperature, pH, DO, conductivity, total ammonia, unionized ammonia, total phosphorous, and BOD at a minimum. Monitoring sites will be selected along the mainstem of Americano Creek, Ebabias Creek, and the estuary itself. A minimum of 8 monitoring sites will be selected, most of which will be located at public road crossings. A number of the sites will be coincident with earlier monitoring locations.

Why
A TMDL is scheduled for Americano Creek and the Estero Americano for elevated levels of ammonia, and associated low dissolved oxygen levels. Water quality monitoring data from the late 1980s found that the average concentration of un-ionized ammonia in Americano Creek to be between 0.1 and 1 mg-N/L, depending on season and location. Over a two-year period, about 40 percent of the ammonia observations in Americano Creek exceeded the acute criterion. The EPA chronic criterion was exceeded in about 25 percent of observations in the upper portion of the Estero Americano. The exceedances were coincident with animal waste loads that occur with runoff in winter and spring.

How
Step 1 Select Monitoring Locations and Parameters (RCD by 2008).

Step 2 Develop an Implementation Plan, Monitoring Plan, and Quality Assurance Project Plan (QAPP) (RCD by 2008).

Step 3 Begin baseline and trend monitoring (RCD).

Lead Agency:
RCD with assistance from UCCE and NCRWQCB.

Partners:
Sonoma Land Trust; Bodega Bay Marine Lab

Anticipated Costs
Water Quality Monitoring Program: minimum $75,000 annually.

Regulatory Issues: SWRCB – Data collected will be compatible with the Surface Water Ambient Monitoring Program (SWAMP).

WQ-02

Develop a Nutrient Budgeting & Management Program for Dairies and Livestock Ranches in the Watershed

What
Implement a proactive, on-farm nutrient management program that will include a "user" friendly nutrient budgeting model, soil, vegetation, and manure sampling protocols, and a land application tracking system. The program will assist watershed dairy operators to write nutrient management plans based on facility inventories and nutrient budgeting information. The program will draw from past RCD technical assistance and outreach efforts to watershed dairies, NRCS's Comprehensive Nutrient Management Planning Program (CNMP), and on-going nutrient budgeting research and planning studies conducted by UCCE..

Why
Nutrient budgeting is an up and coming regulatory requirement for dairy operators. There is little doubt that nutrient management plans of some form will be mandated for dairy operators in the near future, including nutrient land application requirements. Intensive animal feeding operations, manure lagoons, and dairies have been identified as potential sources of excess nutrient loads to Americano Creek and the Estero Americano.

How

Step 1 Develop a nutrient budgeting and management program through the RCD, and solicit participation by watershed dairy operators (RCD by 2007).

Step 2 Provide technical assistance to dairy operators to conduct on-farm facilities inventories and nutrient budgeting (RCD, NRCS and Consultants by 2008).

Step 3 Conduct soil, vegetation, and manure sampling to identify the proper fertilizer application rates for farm fields.
(RCD, NRCS and UCCE by 2008).

Step 4 Completed nutrient management plans and land application tracking systems for all participating dairies (RCD, NRCS and Consultants by 2009).

Lead Agency
RCD with assistance from NRCS.

Other Partners
UCCE, Dairy Industry and Engineering Consultants.

Anticipated Costs
Nutrient Management Program $175,000 - $200,000

Regulatory Issues
The California Water Code; NCRWQCB Waste Discharge Requirements.

WQ-03

Develop and Implement Pollution Prevention and Control Measures on Confined Animal Feeding Operations

What

The District will help fund priority infrastructure improvements for more aggressive stormwater management, gutter installation, manure collection, storage, and transfer as well as better land application methods on a minimum of 7 watershed dairies. Selected infrastructure improvements will be based on on-farm needs assessments to assist dairy operators to meet environmental compliance standards and to achieve CDQAP certification.

Why

Small-scale dairy operations account for close to 25 percent of land acreage in the Estero Americano Watershed. There are 10 family run dairies and 2 leased dairies. Many of these dairy facilities are located on or at the base of hillsides, on soils with high runoff rates that are prone to gully formation. Establishing and maintaining adequate drainage diversions through and around manured areas to prevent co-mingling of stormwater and wastewater is an ongoing and expensive operational consideration, as are improvements in the collection and containment of animal waste.

How

Step 1 Conduct on-farm needs assessments for water quality improvements (NRCS, Consultants by 2008).

Step 2 Select infrastructure improvements on a per farm basis (NRCS, Consultants by 2008).

Step 3 Design, permit, and install infrastructure improvements (GRRCD and Consultant by 2009).

Step 4 Monitor pollution control measure effectiveness (GRRCD and UCCE).

Lead Agency

RCD with assistance from NRCS

Other Partners

UCCE; Dairy Industry and Engineering Consultants.

Anticipated Costs

Infrastructure Improvements: $650,000 - $900,000.

Regulatory Issues

The California Water Code; NCRWQCB Waste Discharge Requirements

WQ-04

Provide On-going Technical Assistance to Agricultural Producers in the Watershed

What

Continue to build RCD capacity to provide outreach and technical assistance to the agricultural community in the watershed. RCD assistance should include a sound knowledge of all current and future water quality compliance standards and water quality programs, funding opportunities, and agricultural best management practices. The RCD will continue to collaborate with NRCS to encourage and provide cost share for landowner EQIP contracts, as well as to establish and maintain relationships with other agricultural industry groups and organizations.

Why

Over 80 percent of the Estero Americano Watershed is in some form of agricultural production. Small, family run livestock and dairy operations in the watershed are increasingly under pressure to adopt best management practices and technologies, as well as meeting more comprehensive environmental compliance standards. The RCD is well positioned through long-term relationships with both landowners and regulatory agencies to provide needed assistance and guidance to the agricultural community.

How

Step 1 Have RCD staff attend relevant workshops and policy forums to learn about and provide input on agricultural and environmental programs and issues (On-going).

Step 2 Have RCD staff solicit input from the agricultural community on needs and concerns (on-going).

Step 3 Work with NRCS to encourage landowner enrollment in EQIP (RCD and NRCS).

Step 4 Work with Western United Dairymen, the CDQAP, Sonoma County Farm Bureau, land trusts, other RCDs and organizations to identify programmatic and collaborative opportunities (on-going).

Step 5 Develop workshops, fact sheets, and newsletters to educate agricultural producers about programs and opportunities (on-going).

Step 6 Continue to seek funding to improve agricultural operations and natural resources management in the watershed.

Lead Agency

RCD with assistance from NRCS

Other Partners

UCCE; North Coast Regional Water Quality Control Board; Western United Dairymen; the CDQAP, Sonoma County Farm Bureau; land trusts, other area RCDs.

EROSION & SEDIMENT REDUCTION

Goal

Reduce the Adverse Impacts of Erosion and Sediment from Agricultural Farm Fields

Accelerated erosion on pastureland typically takes two forms: sheet and rill erosion and gully formation. Gullies will often form on land subject to persistent sheet and rill erosion. Grazing management practices can directly influence erosion on rangeland. Intensive grazing can result in low residual dry matter (RDM), reducing site fertility and infiltration rates, and exposing soil to more rainfall—increasing erosion and runoff. Treatment for low RDM includes better site preparation, seeding and fertilization, and increased grazing management. Identifying and treating gullies with the highest potential sediment yield that are connected to a surface waterbody will reduce annual sediment loads to the estuary and its tributaries.

Reduce the Adverse Impacts of Erosion and Sediment from Unstable Streambanks

The condition of a stream channel—its morphology, sediment distribution, and associated habitat value—is often a direct reflection of the density and diversity of the riparian plant community and upland vegetative cover. Streambank erosion is associated with the removal of riparian vegetation and bank trampling resulting from livestock access. Revegetating stream corridors and controlling livestock access will significantly reduce streambank erosion.

Reduce the Adverse Impacts of Erosion and Sediment from Private and Public Roads

Road surfaces, cut and fill slopes, and ditches are common sources of sediment in the watershed. Failures of road crossing fills or cut and fill slopes produce episodic sediment runoff, usually during large precipitation events. Better road maintenance, design and upgrading of ranch roads will reduce chronic sediment loading to the estuary and its tributaries.

Improperly sized and maintained culverts under county and state highways are a common problem in the watershed, causing increased debris jams, streambank erosion, and local flooding. Better maintenance and design of public road networks will help to reduce sediment impacts to surface waterbodies as well as enhance aquatic habitat conditions in the watershed.

Actions

Conduct an assessment to identify areas of low, medium, and high RDM on rangeland in the watershed by 2010.

Identify and implement priority infrastructure improvements for better grazing management practices such as cross-fencing, off-channel water development, livestock crossings and walkways, filter strips and drainage diversions around heavy use areas by 2010.

Design, permit, and implement stream channel stabilization projects, and revegetate stream corridors identified in this management plan (ongoing).

Select a ranch to function as a demonstration project for grazing best management practices in the watershed. Use the program to educate other agricultural producers in the watershed and the region, and to promote new and on-going participation in NRCS's Environmental Quality Incentives Program (EQIP) by 2010.

Restore or mitigate erosion from a minimum of 8 gullies in the watershed by 2010.

Enhance rangeland and pasture on livestock ranches and dairy operations in the watershed to reduce streambank erosion and sheet and rill erosion (ongoing).

Upgrade 30 miles of ranch roads in the watershed by 2010.

Improve county and state road maintenance practices.

SED-01

Implement a Rangeland Water Quality Management Program

What
Assist a minimum of 15 livestock ranches and dairies in the watershed to update ranch water quality management plans, and to implement rangeland water quality management practices to measurably reduce nutrient and sediment loadings to the estuary and its tributaries. Implementation elements will include restoration of riparian corridors, off-channel water development, filter strips and drainage conveyances around heavy use areas, and reductions in streambank, gully, sheet and rill erosion through grazing management practices and structural improvements.

Why
Intensive agricultural land use in the watershed has led to accelerated erosion. Soil compaction and reduction of herbaceous vegetation from grazing have increased stormwater runoff and the occurrence of sheet, rill, and gully erosion. Increased flows in stream channels, the filling of stream channels with sand and silt, and the denuding of stream corridors by livestock have exacerbated streambank erosion. Benefits from reductions in agricultural NPS pollution include improvements in freshwater, estuarine, and marine water quality and habitat values. In addition, reductions in nutrient and sediment loads will improve water quality for recreational uses and fishing, as well as domestic and agricultural water supplies.

How

Step 1 Assist a minimum of 15 livestock and dairy operators to update or write individual ranch water quality management plans (RCD by 2010).

Step 2 Conduct an assessment to identify areas of low, medium, and high RDM on rangeland in the watershed (RCD and NRCS by 2010).

Step 3 Identify and implement priority infrastructure improvements for better grazing management practices such as cross-fencing, off-channel water development, livestock crossings and walkways, filter strips and drainage diversions around heavy use areas (RCD and NRCS by 2010).

Step 4 Design, permit, and implement stream channel stabilization projects and revegetate riparian areas on 6 miles of stream corridors identified in this management plan (RCD by 2010).

Step 5 Establish a water quality monitoring program to evaluate program benefits and to facilitate adaptive management measures.

Step 6 Select a ranch to function as a demonstration project for grazing “best management practices” in the watershed. Use the program to educate other agricultural producers in the watershed and the region, and to promote new and on-going participation in NRCS’s Environmental Quality Incentives Program (EQIP) (RCD, NRCS, UCCE by 2010).

Lead Agency:
RCD with assistance from NRCS.

Other Partners:
UCCE, Landowners, Sonoma Land Trust, Sonoma County Agricultural Preservation and Open Space District, Marin Agricultural Land Trust.

Anticipated Costs*:*
Ranch Plans: $2,000 each
Infrastructure improvements: Range $271,400 - $500,000.
Riparian restoration of 6 miles (includes streambank stabilization, revegetation, fencing, off-channel water development etc.): Range $509,350 - $800,000.
Other Costs (program administration, design and permitting etc.): $100,000.
Water Quality Monitoring Program: minimum $75,000.

SED-02

Reduce Sediment Loads to the Estuary from Gully Erosion

What:
Four to 6 large gullies will be selected for restoration/mitigate that drain to the estuary or Ebabias Creek, as well as 2 to 3 gullies located above dairies that drain to the mainstem of Americano Creek. Priority gully restoration/mitigation sites will be selected based on a careful assessment of soils, slope, vegetation, and hydrologic connectivity above and below sites. Priority sites will be limited to erosion problems that are management induced, and have the highest mitigation potential. Treatment levels will range from fencing out the area to grade stabilization structures and reshaping. Recommended treatment levels will be based on cost effectiveness and sediment load thresholds.

Why:
The Estero Americano is unusually sensitive to sedimentation. Fine and coarse sediment delivered to the estuary has little chance of being reworked by waves and flushed out to sea. Severe erosion in the watershed has filled in large areas of the estuary's open water, eliminated salt and brackish marsh, and is a factor in the intermittent closure of the estuary's mouth and reduced tidal flushing of pollutants entering the estuary from upland sources. Current rates of sedimentation are diminishing critical wetland habitat and other beneficial uses. Priority gully restoration/mitigation sites will be selected and treated to reduce sediment yields to the estuary.

How:

Step 1 Complete an erosion assessment on the 14 gullies draining directly into the estuary, the 42 gullies draining directly into Ebabias Creek, as well as on any drainage gully located above a dairy that is also located on the mainstem of Americano Creek (Consultant by 2010).

Step 2 Select 4 to 6 gullies for restoration/mitigation that deliver high sediment loads to the estuary or Ebabias Creek. Determine cost effective treatment levels (RCD and NRCS by 2010).

Step 3 Design, permit, and implement gully restoration/mitigation projects (RCD and NRCS by 2010).

Lead Agency:
RCD with assistance from UCCE and NRCS.

Other Partners:
Landowners, Sonoma Land Trust, Sonoma County Agricultural Preservation and Open Space District, Marin Agricultural Land Trust.

Anticipated Costs:
Erosion Assessment to identify restoration/mitigation sites: $15,000 – $30,000.
Design & Planning for 8 restoration/mitigation treatments: $130,000 - $200,000.
Construction Costs: $500,000 - $700,000.
Other Costs (administration etc.): $60,000 - $100,000.

SED-03

Implement a Private Roads Erosion Reduction Program

What:
Conduct a roads survey and sediment source assessment of private ranch roads in the lower Estero Americano Watershed and in the Ebabias Creek sub-watershed to quantify sediment loadings and to prescribe treatments to control associated fill failures, stream crossing erosion, washouts, and ditch relief gully erosion. Select 10 miles of private roads for upgrades or decommissioning, and pursue grant funding for these projects. Hold public workshops for watershed landowners to educate them about proper road maintenance and design, and the effects of road-induced erosion on water quality and habitat conditions. Hold a workshop for contractors and public works departments on proper maintenance and design for both private and public road networks.

Why:
Roads can be a major source of sediment and erosion in a watershed. Soil eroded from streamside roads can discharge runoff and sediment directly into streams. Erosion of streambanks may also erode the road base, increasing siltation and road failures. Compacted road surfaces increase the rate of runoff, and road cuts intercept and bring groundwater to the surface. Road ditches concentrate runoff and can transport sediment to streams; culverts at stream crossings can plug, causing fill wash outs or gullies where the diverted stream flow runs down nearby roads and hillsides. Properly designed and maintained roads can significantly reduce sediment from entering surface waterbodies.

How:

Step 1 Pursue funding for and complete a roads survey and erosion assessment on private ranch roads in the lower Estero Americano Watershed and in the Ebabias Creek sub-basin (RCD and PWA by 2008).

Step 2 Select failing ranch roads to upgrade or decommission, and to use for demonstration projects (RCD and PWA by 2012).

Step 3 Hold public workshops for landowners and for contractors and public works departments (RCD and PWA by 2010).

Step 4 Pursue funding for implement projects (RCD and PWA by 2010).

Lead Agency:
RCD

Other Partners:
Pacific Watersheds Associates, Landowners.

Anticpated Costs:
Road Surveys and Erosion Assessments: $75,000 - $100,000.
Road Upgrades or Decommissioning: 10 miles -- $650,000 - $900,000.
Public Workshops: Landowner Workshop $3,500; Public Works Dept. $13,000

KEY HABITAT

Goal

Assess, Protect, and Enhance Riparian Habitat

Agricultural land use activities, primarily livestock grazing, have severely impacted riparian corridor conditions throughout the watershed. Over half of the stream miles in the watershed lack healthy riparian vegetation. Revegetating and protecting stream corridors will improve water quality, instream and riparian habitat, and will significantly reduce sediment loading to the estuary and its tributaries from streambank erosion.

Assess, Protect, and Enhance Instream Habitat

Land use activities have severely degraded the quality of instream habitat conditions. Although the National Marine Fisheries Service (NMFS) considers the watershed to be critical habitat for steelhead trout, there is currently no spawning or rearing habitat in the system. Examples of degraded habitat include loss of instream habitat structure, reduced woody debris, reduced or altered flows, fish passage barriers, siltation, and nutrient pollution. Protecting and enhancing instream habitat will help restore the system for freshwater and estuarine fish species and other aquatic organisms.

Assess, Protect, and Enhance Freshwater Wetland Habitat

Freshwater wetlands throughout the watershed have been degraded, have filled with sediment, or have been converted to other uses, particularly in the floodplain and upper reaches of the estuary. This has lead to increased flooding, bank erosion, and loss of habitat. Assessing existing conditions, prioritizing wetland enhancement projects, and protecting remaining freshwater wetlands will improve water quality, decrease flooding and enhance habitat conditions for wetland obligate and facultative species.

Assess, Protect, and Enhance Estuarine and Tidal Habitat

Much of the estuary's open water and tidal habitat have filled in with sediment due to historical agricultural practices in the watershed. Assessing, protecting and enhancing remaining estuarine and tidal habitat is essential for preserving the beneficial uses of the estuary, particularly its habitat value for waterfowl, migratory shorebirds, and aquatic organisms.

Promote Biodiversity and Native Species Abundance in Upland Habitats

Coastal prairie is one of the most biologically diverse grassland plant communities in the United States, and supports a potential 30 endangered plant and animal species. Assessing, protecting and restoring coastal prairie will enhance habitat values in the watershed for many sensitive species, and will assist in regional and state-wide conservation planning efforts to promote biodiversity and native species abundance in California.

Actions

Refine the National Wetlands Inventory GIS data layer for the watershed.

Conduct a Wetlands Functional Assessment for all tidal wetlands in the watershed.

Work with PRBO and the Bodega Bay Marine Lab to develop a Conservation Management Plan for the estuary by 2014.

Enhance 30 acres of tidal wetland habitat by 2016.

Promote restoration of native perennial grasses and plant communities (ongoing).

Develop an invasive species eradication plan, especially for gorse and scotch broom.

Enhance habitat values and habitat connectivity on private lands.

HAB-01

Protect and Enhance Riparian and Instream Habitat

What
Enhance and protect stream corridors in the watershed. This will include stabilizing streambanks using bioengineering techniques, enhancing instream habitat complexity, replanting riparian areas with native vegetation, constructing fencing along stream channels, as well as removing any barriers to fish passage along Ebabias Creek.

Why
The Estero Americano and Ebabias Creek are listed as "critical habitat" for winter-run steelhead trout.

How

Step 1 Continue to identify funding sources for stream restoration projects and off-channel water development.

Step 2 Conduct outreach to landowners along riparian corridors.

Step 3 Promote riparian pasture development and riparian pasture grazing plans.

Step 4 Monitor vegetation along stream corridors every 5 years using high-resolution aerial photography.

Step 5 Develop a plan to identify and remove fish passage barriers along Ebabias Creek, which is potentially suitable spawning habitat for steelhead trout.

Lead Agency:
GRRCD with assistance from NRCS

Other Partners:
CDFG, NRCS, State Coastal Conservancy, SWRCB, NMFS.

Anticipated Costs:
Stream Corridor Restoration: range $80,000 to $100,000 per stream mile.

Regulatory Issues:
Endangered Species Act; Clean Water Act

HAB-02

Protect and Enhance Estuarine Habitat

<u>What</u>

Develop a conservation management plan for the Estero Americano that is based on a wetlands functional assessment. Identify and map critical habitat types, and develop species lists. Identify threats, mitigation measures and priority restoration areas. Enhance and protect estuarine habitat through restoration projects and conservation easements.

<u>Why</u>

The Estero Americano is an important nursery area for inshore and estuarine fishes. Forty-four species of fish have been documented in the estuary. It is an important spawning area for many marine species including jacksmelt, topsmelt, Pacific herring and northern anchovy. It serves as a year-round habitat for sizable populations of some estuarine species such as staghorn sculpin and arrow goby. The mudflats, open water, and extensive marsh area of the Estero also provide seasonally important foraging habitat for migratory waterfowl and shorebirds, and resident long-legged wading birds.

<u>How</u>

Step 1 Map all estuarine habitats in the watershed, refining the National Wetlands Inventory (NWI) GIS data layer (RCD and Consultants by 2012).

Step 2 Conduct a Wetlands Functional Assessment for all tidal wetlands (RCD and Consultants by 2012).

Step 3 Conduct avian and aquatic inventory surveys.
(RCD, PRBO and the Bodega Bay Marine Lab by 2014).

Step 4 Develop a conservation management plan identifying and mapping critical habitats; and identifying mitigation measures and priority restoration sites (RCD and Consultants by 2014).

Step 5 Purchase land/easements and/or implement restoration projects on high-priority sites (RCD and land trusts by 2016).

<u>Lead Agency</u>:
RCD with assistance from Bodega Bay Marine Lab and PRBO.

<u>Other Partners:</u>
Marin RCD; NRCS; Partners in Flight; US Fish & Wildlife Service; CDFG; NOAA; SWRCB; ACOE.

<u>Estimated Costs</u>
Wetland Mapping $20,000 - $40,000; Wetland Functional Assessment $40,000 - $60,000
Avian and Aquatic Inventory Surveys $50,000 - $100,000
Conservation Management Plan $50,000 - $80,000
Restoration and Conservation Easements (cost unknown)

<u>Regulatory Issues</u>
Endangered Species Act; Clean Water Act

HAB-03

Protect and Enhance Freshwater Wetland Habitat

What
Protect and/or enhance all significant freshwater wetlands in the watershed. Prioritize wetland sites based on ecological functions and values. Priority sites will include, for instance, wetland sites located in a floodplain; sites that provided habitat for sensitive, threatened or endangered species; sites that provide important habitat connectivity or refuge; and sites that have mitigation benefits to reduce agricultural runoff.

Why
Wetlands provide critical habitat for aquatic organisms, shorebirds and waterfowl. Wetlands also provide important habitat for terrestrial wildlife. More than 70% of all terrestrial wildlife species, including many threatened and endangered species, use wetlands during some portion of their lifecycle. For example, wetlands offer important connecting corridors and refuges for terrestrial species during migration.

Wetlands provide many ecological services. They reduce flooding, filter pollutants, trap sediment, and recharge groundwater. Protecting wetlands is integral to reducing water quality impairments in the watershed, as well as increasing the beneficial uses of the estuary and its tributaries.

How

Step 1 Refine the National Wetlands Inventory GIS data layer for the watershed (RCD by 2012).

Step 2 Prioritize wetlands for protection and/or enhancement using the ACOE's wetlands functional assessment highway methodology (RCD by 2012).

Step 3 Enhance and/or protect significant wetland sites (RCD, ongoing).

Lead Agency
RCD with assistance from NRCS.

Other Partners
Marin RCD; CDFG; SWRCB.

Anticipated costs
Wetland Mapping $10,000 - $20,000
ACOE Wetland Functional Assessment $40,000 - $60,000
Restoration and Conservation Easements (cost unknown)

Regulatory Issues
Endangered Species Act; Clean Water Act

HAB-04

Control Livestock Access to Streams

What

Install fencing along major tributaries to the Estero Americano, and develop off-channel water sources. Work with agricultural landowners to develop riparian pastures and riparian pasture grazing plans, to develop off-channel water sources, and revegetate stream corridors.

Why

Livestock access to streams has severely degraded stream corridors in the watershed, and results in bank erosion, nutrient and fecal contamination of surface water, and loss of riparian vegetation. Based on modeling results, streambank erosion contributes more than 9,000 tons of sediment a year to surface waterbodies in the watershed.

How

Step 1 Work with landowners to adopt riparian management measures (RCD and NRCS, On-going).

Step 2 Continue to fund cross-fencing and off-channel water development (RCD and NRCS, On-going).

Step 3 Provide landowners with information on riparian pasture development and management (RCD and NRCS, On-going).

Step 4 Monitor riparian corridor conditions and management practices (RCD, On-going).

Lead Agency

RCD with assistance from NRCS

Other Partners

UCCE; Marin RCD; SWRCB; CDFG.

Anticipated Costs

Riparian Corridor Restoration: including streambank stabilization, revegetating riparian areas, off-channel water development, and fencing to restrict livestock access during critical times of the year. Estimated minimum costs for the project are $100,000 per stream mile.

Regulatory Issues

Endangered Species Act
Clean Water Act
Federal, State and Regional Conservation Planning Documents

HAB-05

Work with the Agricultural Community to Promote on-Farm Habitat Enhancement Projects

What
Support the agricultural community in enhancing on-farm wildlife habitat, and creating habitat connectivity on both a watershed and regional scale. Methods to improve wildlife habitat include restoring riparian areas, planting hedgerows, constructing grassed waterways, utilizing habitat-orient erosion control methods, improving instream habitat structure and complexity, constructing nesting boxes, protecting freshwater wetlands, eradicating non-native vegetation, planting native vegetation, adopting grazing management plans to promote biodiversity, as well as using non-lethal methods of predator control.

Why
The biggest threat to wildlife in the U.S. and around the world is habitat loss, and the leading cause of habitat loss is fragmentation. When landscapes are developed, it fragments continuous habitats and creates islands of wildlife hemmed in by roads and other forms of urban development. Over 80% of the Estero Americano Watershed is privately owned agricultural land. As open space, rangeland is more compatible with the conservation of natural resources and wildlife habitat than any alternative private land use. Working in partnership with the agricultural community is the best way to enhance habitat at the watershed and regional-scales.

How

Step 1 Develop a Habitat Enhancement Program for the watershed including workshops and education materials (RCD by 2010).

Step 2 Continue to fund riparian restoration projects, and conduct bird surveys as part of project effectiveness evaluations (RCD and NRCS, On-going).

Step 3 Promote participation in NRCS's EQIP and WHIP (RCD and NRCS, On-going).

Step 4 Work with Sonoma County and Marin County land trusts to promote habitat enhancement projects on land trusted properties (RCD and Land Trusts by 2010).

Lead Agency
RCD with assistance from NRCS

Other Partners
UCCE; Marin RCD; SWRCB; CDFG; land trusts; PRBO; Madrone Chapter of the Audubon Society.

Anticipated Costs

Unknown

HAB-06

Develop an Invasive Species Eradication Program

What

Create GIS maps of invasive shrubs and stands of trees in the watershed. In particular, map the extent of gorse and scotch broom growing in the watershed. Create maps of all native coastal prairie in the watershed, and map threats from both invasive plants and successional changes (e.g., successional change from grassland to coyote bush). Work with the Marin-Sonoma Weed Management Area and other stakeholders to develop a management strategy to eradicate or control invasive species and to protect and enhance remnant populations of coastal prairie. Research and promote livestock grazing practices that increase biodiversity.

Why

Coastal prairies are recognized as one of the most endangered ecosystems in the United States. In fact, these grasslands are thought to have the highest amount of plant diversity, and include at least 30 endangered plant and animal species. The biggest threats to northern coastal prairies are habitat loss, fragmentation and invasion. Grasslands like California's coastal prairies are severely impacted by exotic invasive organisms including noxious weeds such as gorse and scotch broom. Protecting and restoring coastal prairie will entail eradicating invasive species, which out-compete native species and reduce biological diversity by creating near monocultures. Invasive plants can also significantly degrade wildlife habitat, and are the second largest threat to endangered species after habitat destruction.

How

Step 1 Map the extent of gorse and scotch broom in the watershed (RCD by 2010).

Step 2 Map remnant populations of native coastal prairie (RCD by 2008).

Step 3 Develop an invasive species management strategy (RCD and Marin-Sonoma Weed Management Area by 2010).

Step 4 Support the agricultural community in adopting grazing management plans that promote biodiversity on rangeland (RCD, NRCS, and UCCE, On-going).

Lead Agency

RCD and NRCS

Other Partners

Marin RCD; UCCE; Marin-Sonoma Weed Management Area; Ocean Song Farm and Wilderness Center; Bodega Bay Marine Lab; NRCS; land trusts.

Anticipated Costs

Mapping gorse and scotch broom - $20,000 to $40,000

Mapping native plant communities- $20,000 to $40,000

Grazing Management Plans - $30,000 to $60,000

Table 6-1. Implementation goals, desired outcomes, milestones and indicators

Plan Implementation Goals	Desired Outcomes	1-3 year Milestone	10-year Milestone	Indicator
Develop a long-term surface water ambient monitoring program for the watershed.	Confirmation of improving trends or maintenance of current water quality conditions. Support decisions for future implementation efforts.	Monitoring plan and implementation of monitoring program for 8 to 10 sampling locations in the watershed. Baseline water quality monitoring data for the watershed.	Long-term monitoring data for the watershed.	Quarterly or annual monitoring reports.
Assist in the wide-spread adoption of conservation ranch planning and conservation management practices.	20 to 50% Reductions in agricultural NPS from pasture & rangeland in the watershed. 50% reduction in sediment loadings from streambanks in the watershed. Prevention of management induced erosion on agricultural land. Educate landowners about erosion control and prevention strategies. Increased participation in USDA, NRCS programs.	A minimum of 12 ranch conservation plans completed and implemented. A minimum of 8 grazing plans. A minimum of 8 rangeland health assessments and monitoring reports. 6 miles of streambank stabilization, revegetation and fencing. Additional USDA, NRCS EQIP contracts. Map and protect sensitive erosional sites on a minimum of 12 high priority conservation parcels in the watershed.	An additional 15 conservation plans completed and implemented. An additional 12 grazing plans completed. An additional 12 rangeland health assessments and monitoring reports completed. An additional 8 miles of streambank stabilization, revegetation, and fencing. Continued USDA, NRCS EQIP participation.	Water quality monitoring data. #of Ranch Plans completed. # of conservation practices adopted. # of stream miles revegetated & protected. Annual Rangeland Health Assessments & Monitoring Reports. # of EQIP contracts. # of acres of erosional sites fenced or otherwise protected.

Table 6-1. Continued

Plan Implementation Goals	Desired Outcomes	1-3 year Milestone	10-year Milestone	Indicator
Conduct watershed erosion assessments & implement erosion prevention and mitigation strategies.	20 to 50% reductions in sediment yields from gullies and ranch roads in the watershed. Identify & quantify sediment loads from gullies, streambanks, and ranch roads. Identify & provide treatment prescriptions and cost estimates for high sediment yield sites in the watershed. Educate landowners about erosion control and prevention strategies for ranch roads and gullies.	Work with UCCE to conduct a Gully Erosion Assessment in the lower sub-watershed and in Ebabias Creek Watershed. Mitigate erosion on a minimum of 4 high priority gullies. Work with Pacific Watershed Associates to assess & quantify sediment loadings from ranch roads in the lower sub-watershed and in Ebabias Creek Watershed. Develop treatment prescriptions and erosion control & prevention plans for individual ranches. Hold a workshop on erosion control and prevention.	Restore/mitigate erosion from high priority gullies identified in the UCCE Gully Erosion Assessment Report. Implement ranch road treatment prescriptions.	# of erosional sites restored or mitigated. Tons/yr of sediment savings from mitigation projects. # of road miles assessed and # of erosion control & prevention plans completed. # of road miles mitigated. # of landowners participating in erosion control and prevention program. Water quality monitoring data.
Assist in the adoption of watershed-wide nutrient management planning and practices.	20 to 50% reductions in nutrient loadings from dairy facilities and pastures. Application of manure fertilizer to farm fields at agronomic rates. CDQAP Environmental Certification for all dairies in the watershed.	A minimum of 8 NRCS-approved comprehensive nutrient management plans completed. Implementation of priority pollution control & prevention measures on a minimum of 8 dairies.	Complete an additional 3 NRCS-approved comprehensive nutrient management plans. Implementation of priority pollution control and prevention measures on an additional 3 dairies.	# of nutrient management plans completed. # of pollution control & prevention measures implemented. # of dairies with CDQAP environmental certifications. Water quality monitoring data.

Table 6-1. Continued

Plan Implementation Goals	Desired Outcomes	1-3 year Milestone	10-year Milestone	Indicator
Protect & enhance riparian and instream habitat	Enhanced beneficial uses for aquatic organisms through improved water quality. Improved habitat for salmonids in Ebabias Creek. Increased riparian cover, structure and species abundance. Improved instream habitat complexity.	6 miles of streambank stabilization, revegetation and fencing. Increase instream habitat complexity on 6 miles of streams. 2 miles of streambank stabilization, revegetation and fencing along Ebabias Creek. Increase instream habitat complexity on 2 miles of Ebabias Creek. Conduct stream habitat typing along Ebabias Creek. Identify all fish passage barriers along Ebabias Creek and develop cost estimates for removal.	An additional 8 miles of streambank stabilization, revegetation, and fencing. Restoration of Ebabias Creek as suitable habitat for salmonids.	# of stream miles revegetated & protected. % riparian cover, structure and species diversity. # of instream habitat structures. Water quality monitoring data.
Protect & enhance estuarine and freshwater wetland habitat	Enhanced beneficial uses of the estuary for aquatic organisms. Improved water quality. Reduce loss of marsh and open water habitat due to sedimentation.	Map all wetlands by National Wetland Inventory standards & classifications. Successfully implement sediment reduction grant program (see above).	Conduct wetland values & functional assessment studies. Identify conservation easement or land acquisition priority sites.	Wetland maps Wetland assessments # of erosional sites restored or mitigated. Tons/yr of sediment savings from mitigation projects. Water Quality Data

Table 6-1. Continued

Plan Implementation Goals	Desired Outcomes	1-3 year Milestone	10-year Milestone	Indicator
Work with agricultural landowners to promote on-farm habitat enhancement projects	Increase terrestrial and wetland habitat values on agricultural land. Increase habitat connectivity on both a watershed and regional scale.	Restore and protect 6 miles of riparian corridor and develop riparian pasture management plans. Increase instream habitat complexity on 6 miles of streams. Hold workshops on enhancing habitat values on agricultural land. Conduct bird surveys along restored riparian corridors. Assist a minimum of 12 agricultural operators to write and implement grazing management plans that identify and enhance habitat values on rangeland.	Work with landowners to develop a watershed habitat conservation plan. Restore and protect an additional 8 miles of riparian corridor and develop riparian pasture management plans. Restoration of Ebabias Creek as suitable habitat for salmonids.	# of stream miles revegetated & protected. % riparian cover, structure and species diversity. # of instream habitat structures. Completion of a watershed habitat conservation plan. # of grazing plans.
Develop an invasive species eradication program	Develop a strategy to control and eradicate gorse in the watershed. Significantly reduce the extent of gorse in the watershed. Create an invasive species list for the watershed.	Map gorse populations in the watershed. Develop a control and eradication strategy for gorse.	Measurably reduce the spread and extent of gorse populations.	Map of gorse populations. Extent of gorse population.

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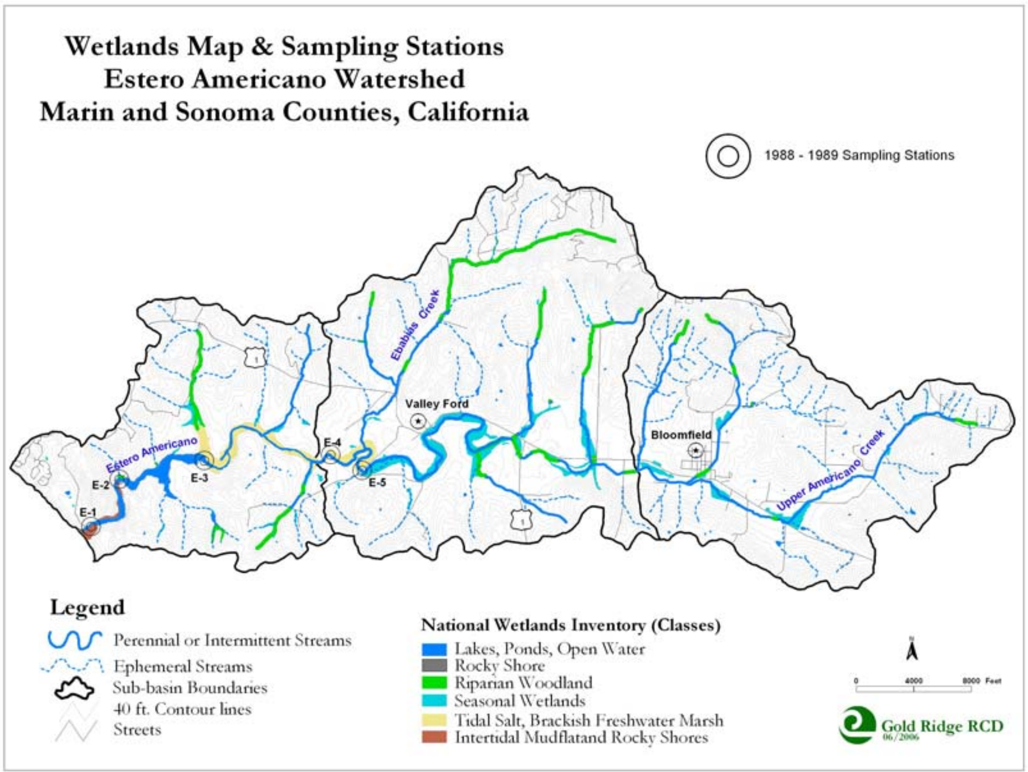
APPENDIX A. BIOLOGICAL DATA

The last fish survey conducted in the Estero Americano occurred between December 1988 and September 1989 for the City of Santa Rosa as part of its Long-term Detailed Wastewater Reclamation Study by Merritt Smith Consulting, Inc. Fish sampling was conducted on five or six separate occasions during that year using otter trawls and gill nets. Five sampling stations (E-1 through E-5) were used for the study (Figure 1). Results from this study can be found in Commins et al, 1990.

Figure 1. Merritt Smith Estero Americano Sampling Stations, 1988-1989



The following tables are presented in this appendix:

Table A-1. Fish Species Caught in the Estero Americano, in Otter Trawls and Gill Nets, 1988-1989.

Table A-2. Gill Net Data by Station, Date, Species and Number

Table A-3. Otter Trawl Data by Station, Date, Species and Number

Table A-1. Fish Species Caught in the Estero Americano, in Otter Trawls and Gill Nets, 1988-1989

Common Name	Scientific Name
Spiny dogfish	*Squalus acanthias*
Leapard shark	*Traikus semifasciata*
Pacific Herring	*Clupea pallasi*
Northern Anchovey	*Engraulis mordax*
Steelhead trout	*Onocorhyncus mykiss*
Surf smelt	*Hypomesus pretiosus*
Longfin Smelt	*Spirinchis thaleichtys*
Plainfin midshipman	*Poricthys notatus*
Pacific tomcod	*Microgadus proximus*
Topsmelt	*Antherinops affinis*
Jacksmelt	*Antherinopsis californiensis*
Threespine stickleback	*Gasterosteus aculeatus*
Bay pipefish	*Sygnathus leptorhynsus*
Striped bass	*Morone saxatilis*
Shiner surfperch	*Cymatogaster aggregata*
Black surfperch	*Embiotoca jacksoni*
Dwarf surfperch	*Micrometrus minimus*
Crevice kelpfish	*Gibbonsia montereyensis*
Arrow goby	*Clevlandia ios*
Tidewater goby	*Eucyclobius newberryi*
Longjaw mudsucker	*Gillichthys mirabilis*
Cheekspot goby	*Ilypnus gilberti*
Rockfish spp.	*Sebastes spp.*
Opaleye	*Girella nigricans*
Lingcod	*Ophiodon elongatus*
Cabezon	*Scorpaenichthys marmoratus*
Staghorn sculpin	*Leptocuttus armatus*
Prickly sculpin	*Cottus asper*
Tidepool sculpin	*Oligocottus maculosus*
Buffalo sculpin	*Enophrys bison*
English sole	*Pleuronectes vetulus*
Starry flounder	*Platichthys melanostictus*
Pacific sanddab	*Citharichthys sordidus*
Speckled sanddab	*Citharichthys stigmaeus*
Diamond Turbot	*Hypsopsetta gutulatta*

Table A-2. Gill Net Data by Station, Date, Species and Number

Station	Date	Species	Number
E-1	12/21/1988	Staghorn sculpin	1
E-1	2/18/1989	Pacific herring	1
E-1	3/7/1989	Pacific herring	1
E-1	6/8/1989	English sole	1
E-1	6/8/1989	Shiner surfperch	1
E-1	6/8/1989	Staghorn sculpin	2
E-1	7/6/1989	Shiner surfperch	2
E-1	7/6/1989	Spiny dogfish	1
E-1	7/6/1989	Staghorn sculpin	1
E-1	7/6/1989	Top smelt	10
E-2	2/18/1989	Pacific herring	1
E-2	3/7/1989	Pacific herring	1
E-2	5/5/1989	Jacksmelt	3
E-2	5/5/1989	Shiner surfperch	1
E-2	5/5/1989	Staghorn sculpin	1
E-2	6/8/1989	Jacksmelt	2
E-2	6/8/1989	Shiner surfperch	2
E-2	6/8/1989	Staghorn sculpin	9
E-2	6/8/1989	Starry flounder	1
E-2	6/8/1989	Top smelt	1
E-2	7/6/1989	Shiner surfperch	1
E-2	7/6/1989	Staghorn sculpin	6
E-2	7/6/1989	Starry flounder	1
E-2	9/19/1989	Leopard shark	1
E-2	9/19/1989	Shiner surfperch	1
E-2	9/19/1989	Surf smelt	1

Table A-2. Continued

Station	Date	Species	Number
E-3	3/7/1989	Starry flounder	1
E-3	5/5/1989	Top smelt	1
E-3	6/8/1989	Shiner surfperch	1
E-3	6/8/1989	Staghorn sculpin	3
E-3	6/8/1989	Top smelt	2
E-3	7/6/1989	Staghorn sculpin	1
E-3	7/6/1989	Top smelt	6
E-3	9/19/1989	Leopard shark	4
E-3	9/19/1989	Shiner surfperch	4
E-4	12/21/1988	Staghorn sculpin	4
E-4	12/21/1988	Starry flounder	2
E-4	2/18/1989	Pacific herring	2
E-4	5/5/1989	Longjaw mudsucker	1
E-4	5/5/1989	Shiner surfperch	5
E-4	5/5/1989	Staghorn sculpin	1
E-4	5/5/1989	Top smelt	29
E-4	6/8/1989	Shiner surfperch	6
E-4	6/8/1989	Staghorn sculpin	6
E-4	6/8/1989	Top smelt	16
E-4	7/6/1989	Striped bass	5
E-4	7/6/1989	Top smelt	30
E-4	9/19/1989	Longjaw mudsucker	1
E-4	9/19/1989	Staghorn sculpin	1
E-4	9/19/1989	Starry flounder	1
E-5	12/21/1988	Stealhead trout	1
E-5	5/5/1989	Shiner surfperch	2
E-5	5/5/1989	Staghorn sculpin	2
E-5	6/8/1989	Shiner surfperch	1
E-5	6/8/1989	Staghorn sculpin	3
E-5	6/8/1989	Top smelt	24
E-5	7/6/1989	Top smelt	106

Table A-3. Otter Trawl Data by Station, Date, Species and Number

Station	Date	Species	Number
E-1	12/20/1988	English Sole	4
E-1	12/20/1988	Pac. Sanddab	2
E-1	2/17/1989	English Sole	1
E-1	3/6/1989	English Sole	19
E-1	4/9/1989	Bay pipefish	1
E-1	4/9/1989	Bufflao Sculpin	1
E-1	4/9/1989	English Sole	9
E-1	5/5/1989	English Sole	12
E-1	5/5/1989	Sebastes "C"	1
E-1	6/8/1989	Cabezon	1
E-1	6/8/1989	English Sole	6
E-1	6/8/1989	Lingcod	1
E-1	6/8/1989	Pac. sanddab	15
E-1	6/8/1989	Penpt. Gunnel	6
E-1	6/8/1989	Prick. Sculpin	1
E-1	6/8/1989	Sand sole	1
E-1	6/8/1989	Staghorn sculpin	1
E-1	7/6/1989	Arrow goby	1
E-1	7/6/1989	Cabezon	1
E-1	7/6/1989	English Sole	2
E-1	7/6/1989	Pac. Sanddab	10
E-1	9/19/1989	Arrow goby	1
E-1	9/19/1989	Spk. Sanddab	6

Table A-3. Continued

Station	Date	Species	Number
E-2	12/20/1988	Arrow goby	4
E-2	12/20/1988	Bay pipefish	1
E-2	12/20/1988	Crevice kelpf.	6
E-2	12/20/1988	English Sole	2
E-2	2/17/1989	Bay pipefish	9
E-2	2/17/1989	Crevice kelpf.	2
E-2	2/17/1989	Staghorn sculpin	1
E-2	3/6/1989	Arrow goby	1
E-2	3/6/1989	English Sole	6
E-2	3/6/1989	Staghorn sculpin	4
E-2	4/9/1989	Bay pipefish	16
E-2	4/9/1989	Longfin smelt	8
E-2	4/9/1989	Sebastes "A"	2
E-2	4/9/1989	Staghorn sculpin	2
E-2	7/6/1989	Threesp. Stck.	1
E-2	7/6/1989	Tidewater goby	1
E-2	9/18/1989	Arrow goby	2
E-2	9/18/1989	Bay pipefish	3
E-2	9/18/1989	Bl. surfperch	1
E-2	9/18/1989	Penpt. Gunnel	1
E-2	9/18/1989	Shiner surfper	2

Table A-3. Continued

Station	Date	Species	Number
E-3	12/20/1988	Arrow goby	1
E-3	12/20/1988	Pac. Sanddab	4
E-3	12/20/1988	Staghorn sculpin	3
E-3	2/17/1989	Arrow goby	1
E-3	2/17/1989	English Sole	3
E-3	2/17/1989	Staghorn sculpin	39
E-3	3/6/1989	goby (larval)	1
E-3	3/6/1989	Staghorn sculpin	25
E-3	3/6/1989	Surf smelt	93
E-3	5/5/1989	Shiner surfper	4
E-3	5/5/1989	Staghorn sculpin	1
E-3	5/5/1989	Starry flounder	1
E-3	5/5/1989	unknown (smlt)	2
E-3	6/8/1989	Bay pipefish	1
E-3	6/8/1989	Hybrid sole	1
E-3	6/8/1989	Staghorn sculpin	14
E-3	7/6/1989	Plainfin midsh	1
E-3	7/6/1989	Shiner surfper	3
E-3	7/6/1989	Staghorn sculpin	8
E-3	7/6/1989	Threesp. Stck.	1
E-3	9/18/1989	Shiner surfper	2
E-4	12/20/1988	Arrow goby	2
E-4	12/20/1988	Pac. Herring	1
E-4	12/20/1988	Pac. Sanddab	2
E-4	12/20/1988	Staghorn sculpin	4
E-4	12/20/1988	Starry flounder	1
E-4	12/20/1988	Surf smelt	19
E-4	2/17/1989	Arrow goby	1
E-4	2/17/1989	Staghorn sculpin	64
E-4	2/17/1989	Surf smelt	24

Table A-3. Continued

Station	Date	Species	Number
E-4	3/6/1989	Staghorn sculpin	9
E-4	3/6/1989	Surf smelt	1
E-4	5/5/1989	Arrow goby	1
E-4	5/5/1989	Bay pipefish	2
E-4	5/5/1989	Diamond turb.	1
E-4	5/5/1989	Hybrid sole	1
E-4	5/5/1989	Pac. Herring	126
E-4	5/5/1989	Shiner surfper	3
E-4	5/5/1989	Staghorn sculpin	42
E-4	5/5/1989	Starry flounder	1
E-4	5/5/1989	Striped bass	2
E-4	6/8/1989	Arrow goby	7
E-4	6/8/1989	Bay pipefish	1
E-4	6/8/1989	Northern anchovy	1
E-4	6/8/1989	Pac. Sanddab	1
E-4	6/8/1989	Shiner surfper	3
E-4	6/8/1989	Staghorn sculpin	6
E-4	7/6/1989	Arrow goby	16
E-4	7/6/1989	Bay pipefish	12
E-4	7/6/1989	Hybrid sole	1
E-4	7/6/1989	Plainfin midsh	24
E-4	7/6/1989	Shiner surfper	6
E-4	7/6/1989	Staghorn sculpin	3
E-4	7/6/1989	Threesp. Stck.	2
E-4	7/6/1989	Top smelt	11
E-4	9/19/1989	Arrow goby	2
E-4	9/19/1989	Bay pipefish	1
E-4	9/19/1989	Plainfin midsh	199
E-4	9/19/1989	Prick. Sculpin	1
E-4	9/19/1989	Shiner surfper	1
E-4	9/19/1989	Staghorn sculpin	15
E-4	9/19/1989	Starry flounder	21
E-4	9/19/1989	Top smelt	1

Table A-3. Continued

Station	Date	Species	Number
E-5	12/20/1988	Arrow goby	2
E-5	12/20/1988	Staghorn sculpin	2
E-5	12/20/1988	Surf smelt	6
E-5	2/17/1989	Chksp. Goby	1
E-5	5/5/1989	Hybrid sole	3
E-5	5/5/1989	Staghorn sculpin	53
E-5	5/5/1989	Threesp. Stck.	1
E-5	6/8/1989	Prick. Sculpin	2
E-5	6/8/1989	Shiner surfper	2
E-5	6/8/1989	Staghorn sculpin	54
E-5	6/8/1989	Threesp. Stck.	1
E-5	7/6/1989	Bay pipefish	22
E-5	7/6/1989	Pac. sanddab	1
E-5	7/6/1989	Plainfin midsh	38
E-5	7/6/1989	Prick. Sculpin	24
E-5	7/6/1989	Shiner surfper	1
E-5	7/6/1989	Starry flounder	1
E-5	7/6/1989	Threesp. Stck.	39
E-5	9/18/1989	Bay pipefish	1
E-5	9/18/1989	Plainfin midsh	387
E-5	9/18/1989	Prick. Sculpin	1
E-5	9/18/1989	Staghorn sculpin	12
E-5	9/18/1989	Starry flounder	17

APPENDIX B. SURFACE WATER MONITORING DATA, 1988-1990

The monitoring data presented in this section was acquired from the Institute for Fisheries Resources' KRIS (Klamath River Information System) West Marin-Sonoma project database. The monitoring program was part of a water quality study of the Estero Americano Watershed conducted by Merritt Smith Consulting for the City of Santa Rosa and the U.S. Army Corps of Engineers. Note that monitoring stations E-1 through E-5 were estuarine. Monitoring stations E-6 through E-8 were located on the mainstem of Americano Creek (Figure 1). The source of this data is:

Commins, M. L., J. C. Roth, M. H. Fawcett and D. W. Smith. 1990. *Estero Americano and Estero de San Antonio Monitoring Program, 1988-1989 Results*. Santa Rosa Subregional Water Reclamation System. Technical Memo E8.

Figure 1-1. Surface Water Monitoring Stations, 1988-1990

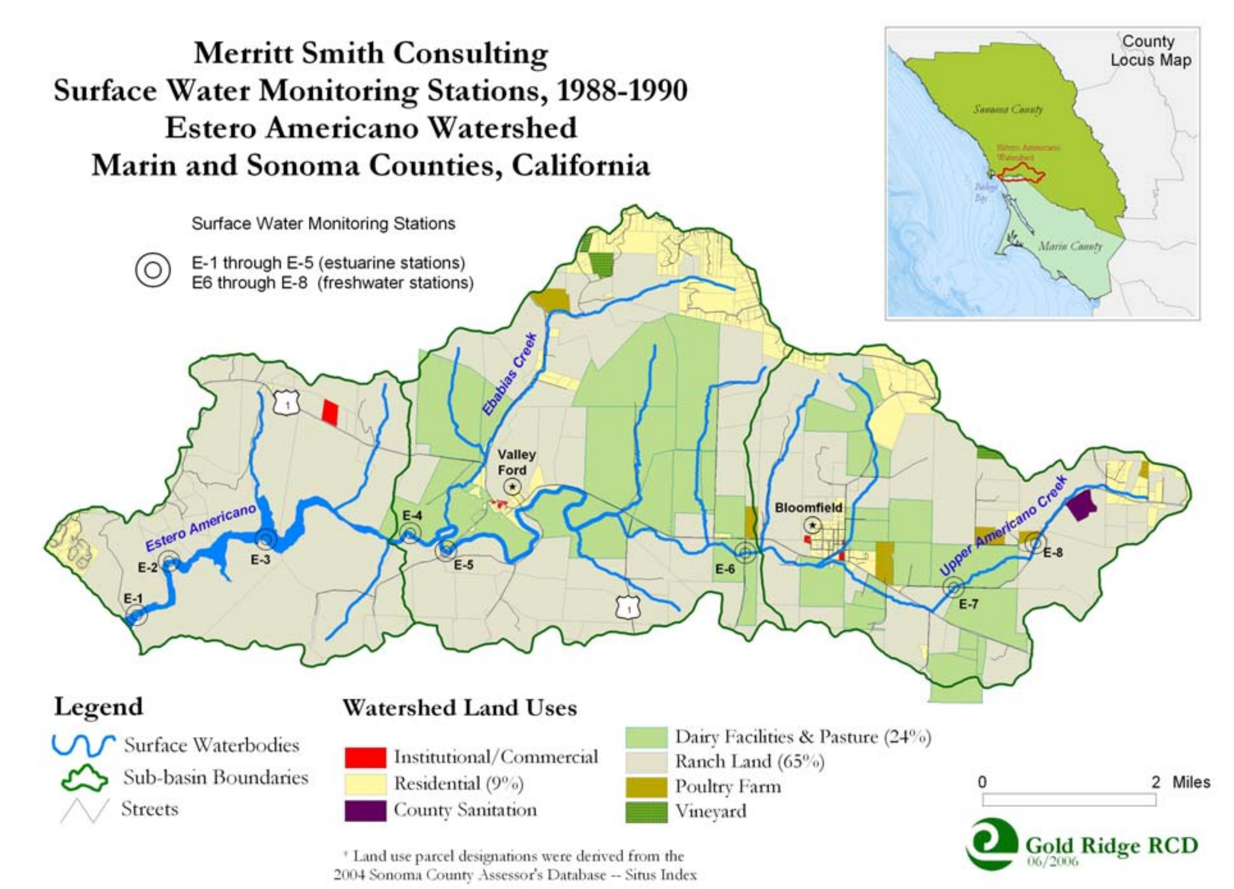


Table 1-1. Surface Water Monitoring Data by Station, 1988-1990

STATION	DATE	TEMP	SALINITY	CONDUCT	DO	PH	TURBID	CHL A
		°C	ppt	µmhos	ppm		FTU	mg/L
E-1	2/29/1988	12	27		9			
E-1	3/30/1988	10.5	32		8.5			0.0623
E-1	4/14/1988	12	32		9.5			0.2432
					9			
E-1	5/16/1988	15.2	33.5		11.2	7.55	3.7	0.047124
E-1	6/15/1988	14.5	33	40000	11.5	7.2	3.6	0.17952
E-1	7/21/1988	15.8	32.6		11	8.39	1.7	
E-1	8/29/1988	15.1	31.8		8.8	7.81	1.8	
E-1	9/28/1988	15.1	32.2		9.75	8	3.6	0.262261
E-1	10/25/1988	13.4	30.4		8.4	7.9	2.4	0.0485
E-1	11/22/1988	12.2	32.3		8.5	7.15	4	0.023053
E-1	12/20/1988	10.2	33		8	7.9	4.5	0.052017
E-1	1/20/1989	9.5	34.1		8.5	7.8	6.3	0.030146
E-1	2/17/1989	9	35.8		12.3	7.9	1.3	0.050243
E-1	3/2/1989	10.8	6.5	8100	9.6	7.3		
E-1	3/6/1989	10	32.7			7.7	2.8	0.010008
E-1	4/9/1989	15	31		9.1			
E-1	5/4/1989	15	32.2		8.6	8	4.3	0.02587
E-1	5/26/1989	15	31.5		8.9	8		
E-1	6/7/1989	13	31.3		9.3	8	2.6	0.037577
E-1	7/5/1989	19	27		8.2	7.8	3.4	0.018663
E-1	9/18/1989	13	34		8.2	7.7	1.7	0.01
E-1	11/28/1989	12	31		8	7.4	4	0.010668
E-1	2/7/1990	8.2	35.1		8.9	7.8	5.2	0.010106
E-1	3/9/1990	8.2	35		8.6	7.8	3.1	0.0517
E-1	4/5/1990	11.2	34.5		8	7.8	2.6	0.0041
E-1	5/24/1990	9.5	34.9		8.5	7.9	4.4	0.0825
E-1	6/25/1990	12	32.5		8.5	7.8	1.9	0.0698
E-1	7/26/1990	11.2	32		7.4	8.1	1.6	0.0341
E-1	9/18/1990	10.3	30.3		8.6	7.5	2.4	0.151
E-1	11/15/1990	11.1	32.3		9.6	7.8		0.172

Table 1-1. Continued.

STATION	DATE	FCOLI	TDS	TSS	DOC	NO3	NH3	UNH3	TOTP
		MPN/100ml			mg/L	mg/L	mg/L	mg/L	mg/L
E-1	2/29/1988	16				0.05	0.05		0.05
E-1	3/30/1988					0.05			0.19
E-1	4/14/1988								0.2
E-1	5/16/1988	2				0.015	0.08		0.16
E-1	6/15/1988					0.05	0.16		2.1
E-1	7/21/1988					0.015			0.15
E-1	8/29/1988					0.03	0.08		0.3
E-1	9/28/1988					0.15	0.05		0.2
E-1	10/25/1988					0.31	0.15		0.1
E-1	11/22/1988	11		7		0.18	0.05		0.34
E-1	12/20/1988					0.19	0.08		0.1
E-1	1/20/1989					0.08	0.09		0.1
E-1	2/17/1989	2			4.2	0.06	0.025		0.1
E-1	3/2/1989								
E-1	3/6/1989				2.1	0.22	0.025		0.4
E-1	4/9/1989								
E-1	5/4/1989				5	0.015	0.06		0.2
E-1	5/26/1989								
E-1	6/7/1989				0.5	0.015	0.025		0.47
E-1	7/5/1989				2.2	0.16	0.06		0.04
E-1	9/18/1989	6.1		4.8	1.4	0.23	0.16		0.07
E-1	11/28/1989			13	0.5	8.7	0.12	0.000438	0.1
E-1	2/7/1990	130		12	0.5	0.24	0.05	0.000331	0.07
E-1	3/9/1990			29	1	0.21	0.025	0.000165	0.1
E-1	4/5/1990			54	1.4	0.05	0.025	0.00021	0.01
E-1	5/24/1990	5		55	0.5	0.22	0.025	0.000235	0.12
E-1	6/25/1990			26	0.5	0.04	0.025	0.000227	0.09
E-1	7/26/1990	2		41	1.3	0.015	0.025	0.000417	0.09
E-1	9/18/1990			11	0.5	0.08	2	0.00784	0.08
E-1	11/15/1990	2		12	3.6	0.096	0.025		0.08

Table 1-1. Continued.

STATION	DATE	TEMP	SALINITY	CONDUCT	DO	PH	TURBID	CHL A
		°C	ppt	µmhos	ppm		FTU	mg/L
E-2	3/30/1988	12	31.5		8.4			0.0813
E-2	4/14/1988	12.5	32.7		10.4			0.1342
E-2	5/16/1988	18.5	33.2		9.8	7.2	12	0.079101
E-2	6/15/1988	16	33	42000	10	7.1	4.2	0.108273
E-2	7/21/1988	17	32.3		9.9	7.04	4.5	
E-2	8/29/1988	15.2	32		8.9	7.72	4.2	
E-2	9/28/1988	15.2	32.3		9.8	8.25	4.4	0.206783
E-2	10/25/1988	13.3	31.2		8.4	8	3.6	0.045391
E-2	11/22/1988	12	33.2		8.3	7.9	5.7	0.020097
E-2	12/20/1988	10	33.5		9	8	2.8	0.031328
E-2	1/20/1989	9.7	33.5		8.2	7.75	5.4	0.04315
E-2	2/17/1989	8.8	33.1		10.3	7.8	1.9	0.029555
E-2	3/2/1989	11	4.8	5500	9.3	6.8	78	0.197427
E-2	3/6/1989	11	17.4			7	37	0.039277
E-2	5/4/1989	18.2	31.7		8.1	8.1	47	0.121164
E-2	6/7/1989	12.8	32.4		9.2	7.8	3.1	0.023037
E-2	7/5/1989	18	28.5		7.7	7.8	4.2	0.01164
E-2	9/18/1989	13	34		8.2		4.2	0.0119
E-2	11/28/1989	11.8	30.2		8.1	7	4.4	0.008983
E-2	2/7/1990	8	35		8.8	7.6	5.2	0.011603
E-2	3/9/1990	9	34.2		9	7.8	3.5	0.0281
E-2	4/5/1990	11.9	33.8		7.5	8	3.7	0.0155
E-2	5/24/1990	11.8	35.4		7.5	8	5.8	0.0314
E-2	6/25/1990	14.3	33.9		6.8	7.6	6.2	0.0519
E-2	7/26/1990	12.7	32		8	8	2.2	0.0359
E-2	9/18/1990	10.4	30		8	7.6	2.2	0.099
E-2	11/15/1990	10.8	32.3		9.6	7.8		0.13

Table 1-1. Continued.

STATION	DATE	FCOLI	TDS	TSS	DOC	NO3	NH3	UNH3	TOTP
		MPN/100ml			mg/L	mg/L	mg/L	mg/L	mg/L
E-2	3/30/1988					0.05			0.13
E-2	4/14/1988								0.06
E-2	5/16/1988					0.015	0.16		0.27
E-2	6/15/1988					0.1	0.14		2.1
E-2	7/21/1988					0.015	0.08		0.1
E-2	8/29/1988					0.03	0.06		0.1
E-2	9/28/1988					0.15	0.025		0.3
E-2	10/25/1988					0.33	0.12		0.1
E-2	11/22/1988			11		0.2	0.06		0.1
E-2	12/20/1988					0.22	0.11		0.1
E-2	1/20/1989					0.27	0.05		0.25
E-2	2/17/1989					0.05	0.025		0.1
E-2	3/2/1989								
E-2	3/6/1989					0.43	0.39		0.47
E-2	5/4/1989					0.015	0.05		0.56
E-2	6/7/1989				1.1	0.015	0.025		0.59
E-2	7/5/1989					0.2	0.025		0.06
E-2	9/18/1989			14		0.16	0.1		0.08
E-2	11/28/1989			14		7.8	0.070	0.000102	0.1
E-2	2/7/1990			13		0.07	0.070	0.000293	0.07
E-2	3/9/1990			28		0.17	0.070	0.000501	0.12
E-2	4/5/1990			16		0.05	0.025	0.000357	0.01
E-2	5/24/1990			36		0.05	0.080	0.001144	0.2
E-2	6/25/1990			32		0.06	0.110	0.000735	0.23
E-2	7/26/1990			53		0.24	0.025	0.000385	0.09
E-2	9/18/1990			9.2		0.09	0.025	0.000388	0.11
E-2	11/15/1990			16		0.11	0.083		0.09

Table 1-1. Continued.

STATION	DATE	TEMP	SALINITY	CONDUCT	DO	PH	TURBID	CHL A
		°C	ppt	µmhos	ppm		FTU	mg/L
E-3	2/29/1988	14	23		7.5			
E-3	3/30/1988	15	31.5		8.4			0.0974
E-3	4/14/1988	13.3	29.3	38900	9.5			0.0261
E-3	5/16/1988	22	33.2		9.5	6	13	0.170544
E-3	6/15/1988	21	33	46500	6.9	7.5	22	0.095931
E-3	7/21/1988	18.1	33		10	7.99	16	
E-3	8/29/1988	16.9	31.3		8	7.54	8.4	
E-3	9/28/1988	15.5	32.5		9.8	8.3	7.3	0.134283
E-3	10/25/1988	13.5	31		8	8.1	3.6	0.039087
E-3	11/22/1988	13.1	32.2		8.2		6.4	0.014777
E-3	12/20/1988	10	33		8.5		3.2	0.016551
E-3	1/20/1989	9.5	32.8		9	7.9	4	0.013595
E-3	2/17/1989	9.5	31.5		8.8	7.8	5.3	0.020097
E-3	3/6/1989	11	0.7	1100	7.8	7.5	62	0.104235
E-3	4/9/1989	21.5	23.4		7.5			
E-3	4/10/1989							0.33275
E-3	4/10/1989							0.070529
E-3	5/4/1989	21.7	28.8		9.2	8.4	11	0.017184
E-3	5/26/1989	18	35		7.3	8.1		
E-3	6/7/1989	16.5	32.4		7.3	7.8	7.4	0.020771
E-3	7/5/1989	21	30		6.1	7.7	25	0.037728
E-3	9/18/1989	13.9	34.2		8.4	7.6	6.8	0.0138
E-3	11/28/1989	11.4	30		8.9	7.5	3.8	0.003743
E-3	2/7/1990	7.5	27.9		8.4	7.6	16	0.025265
E-3	3/9/1990	10	24.2		8.5	7.4	12	0.0284
E-3	4/5/1990	13.1	31.2		7.4	8.1	7.3	0.1447
E-3	5/24/1990	15	35.7		7.7	8.3	22	0.069
E-3	6/26/1990	18	33.8		6.5	8	22	0.0533
E-3	7/26/1990	16.4	32		8.4	8.5	8.8	0.0441
E-3	9/18/1990	14	30.3		7.6	7.3	8.8	0.05
E-3	11/15/1990	10.5	32.6		9.4	7.8		0.071

Table 1-1. Continued.

STATION	DATE	FCOLI	TDS	TSS	DOC	NO3	NH3	UNH3	TOTP
		MPN/100ml			mg/L	mg/L	mg/L	mg/L	mg/L
E-3	2/29/1988	16				0.13	0.05		0.12
E-3	3/30/1988					0.05			0.18
E-3	4/14/1988								0.1
E-3	5/16/1988					0.015	0.025		0.65
E-3	6/15/1988					0.13	0.19		2.2
E-3	7/21/1988					0.015	0.13		0.15
E-3	8/29/1988					0.03	0.08		0.1
E-3	9/28/1988					0.15	0.025		0.1
E-3	10/25/1988					0.15	0.09		0.1
E-3	11/22/1988			8		0.17	0.08		0.29
E-3	12/20/1988					0.21	0.06		0.1
E-3	1/20/1989					0.04	0.1		0.1
E-3	2/17/1989				5	0.06	0.16		0.36
E-3	3/6/1989				28	0.76	1.1		1.1
E-3	4/9/1989								
E-3	4/10/1989								
E-3	4/10/1989								
E-3	5/4/1989				3.3	0.61	0.025		0.53
E-3	5/26/1989								
E-3	6/7/1989				1.8	0.015	0.025		0.15
E-3	7/5/1989				2.5	0.2	0.15		0.17
E-3	9/18/1989			68	0.5	0.14	0.1		0.1
E-3	11/28/1989			18	0.5	0.15	0.130	0.00051	0.1
E-3	2/7/1990			12	8.7	0.41	1.200	0.00486	0.59
E-3	3/9/1990			36	7.1	0.34	0.600	0.001902	0.53
E-3	4/5/1990			41	2.9	0.03	0.090	0.001746	0.63
E-3	5/24/1990			66	1	0.06	0.060	0.002106	0.29
E-3	6/26/1990			180	2.3	0.015	0.110	0.002464	0.78
E-3	7/26/1990			64	1.9	0.015	0.025	0.001475	0.15
E-3	9/18/1990			28	0.5	0.1	0.050	0.000169	0.16
E-3	11/15/1990			8.8	5.5	0.12	0.077		0.08

Table 1-1. Continued.

STATION	DATE	TEMP	SALINITY	CONDUCT	DO	PH	TURBID	CHL A
		°C	ppt	µmhos	ppm		FTU	mg/L
E-4	2/29/1988	15	7		4			
E-4	3/30/1988	16	18		8.8			0.433
E-4	4/14/1988	16	25.7		5.5			0.0843
E-4	5/16/1988	22	23.9		11.6	6.95	22	1.39689
E-4	6/15/1988	24.5	30	45000	8.8	7.6	25	1.27908
E-4	7/21/1988	25	38.8		10.8	7.96	20	0.297565
E-4	8/29/1988	21	34.2		6.05	7.53	20	
E-4	9/28/1988	18.5	34.2		7.2	7.75	18	0.095826
E-4	10/25/1988	13.5	31.8		6.2	7.9	12	0.204891
E-4	11/22/1988	12.5	28		7.9	7.8	12	0.24235
E-4	12/20/1988	9	31.5		10	7.8	12	0.117037
E-4	1/20/1989	8	18.1		6.8	8.2	12	0.028373
E-4	2/17/1989	9	12.4		5	7.4	15	0.062656
E-4	3/2/1989	10.2	0	305	6	7.8		
E-4	3/6/1989	10.7	0	270	4.8	7.5	54	0.40991
E-4	5/4/1989	23	16.9		6.4	7.9	28	0.110917
E-4	6/7/1989	19.4	28.8		7	7.7	34	0.063295
E-4	7/5/1989	26	33.8		8.8	8.1	21	0.366821
E-4	9/18/1989	16	34		6.4	7.7	32	0.0523
E-4	11/28/1989	8.5	20.9		7.9	7.3	8.6	0.020212
E-4	2/7/1990	6	1.4	1120	7.6	7.4	23	0.122427
E-4	3/9/1990	9.2		1210	8.7	7.1	24	0.0653
E-4	4/5/1990	13.4	10.5		5.2	7.7	18	0.1188
E-4	5/24/1990	17.1	26.2		7.3	8.2	28	0.1281
E-4	6/25/1990	22	30		4.9	7.9	92	0.4473
E-4	7/26/1990	21	35		5.7	8.1	50	0.3665
E-4	9/18/1990	16.1	33		8	8	37	0.811
E-4	11/15/1990	9.5	32.8		8.4	7.7		0.021

Table 1-1. Continued.

STATION	DATE	FCOLI	TDS	TSS	DOC	NO3	NH3	UNH3	TOTP
		MPN/100ml			mg/L	mg/L	mg/L	mg/L	mg/L
E-4	2/29/1988	16				1.3	0.55	0.001155	0.59
E-4	3/30/1988					0.05			0.43
E-4	4/14/1988								0.3
E-4	5/16/1988					0.015	0.025	0.00007	1.3
E-4	6/15/1988					0.05	0.73	0.010658	2.1
E-4	7/21/1988					0.03	0.18	0.00594	0.63
E-4	8/29/1988					0.03	0.19	0.001919	0.3
E-4	9/28/1988					0.15	0.08	0.001056	0.23
E-4	10/25/1988					0.15	0.28	0.003612	0.1
E-4	11/22/1988					0.24	0.29	0.002749	0.24
E-4	12/20/1988					0.2	0.17	0.001224	0.1
E-4	1/20/1989					0.55	2.6	0.04472	1
E-4	2/17/1989					0.57	4.8	0.015456	1.9
E-4	3/2/1989								
E-4	3/6/1989					0.82	3.1	0.015593	2.4
E-4	5/4/1989					1.5	0.07	0.001939	0.84
E-4	6/7/1989				6.6	0.42	0.3	0.00369	0.24
E-4	7/5/1989					0.03	0.025	0.001232	0.34
E-4	9/18/1989			42		0.25	0.4	0.003908	0.22
E-4	11/28/1989			16		0.86	0.560	0.001277	0.83
E-4	2/7/1990			10		0.9	2.800	0.00812	2.1
E-4	3/9/1990			25		0.72	3.300	0.006105	2.4
E-4	4/5/1990			52		0.7	0.160	0.001398	1.1
E-4	5/24/1990			58		0.34	0.290	0.009657	0.73
E-4	6/25/1990			460		0.27	1.400	0.03374	1.5
E-4	7/26/1990			240		0.015	0.240	0.008376	0.57
E-4	9/18/1990			110		0.015	0.060	0.001158	0.38
E-4	11/15/1990			18		0.015	0.01		0.16

Table 1-1. Continued.

STATION	DATE	YEAR	TEMP	SALINITY	CONDUCT	DO	PH	TURBID	CHL A
			°C	ppt	µmhos	ppm		FTU	mg/L
E-5	2/29/1988	1988	15	6		3			
E-5	3/30/1988	1988	17	12.5		14			2.79
E-5	4/14/1988	1988	17	19.2		3.5			0.0594
E-5	5/16/1988	1988	23	18.8		16.8	6.9	26	5.5539
E-5	6/15/1988	1988							1.42494
E-5	7/21/1988	1988	24	38.5		12	8.53	17	
E-5	8/29/1988	1988	22.5	37.3		9.2	7.94	23	
E-5	9/28/1988	1988	19.7	36.3		12.5	8.4	20	0.832174
E-5	10/25/1988	1988	14	31.7		8.2	8.15	17	0.060522
E-5	11/22/1988	1988	12.3	25.5		8.6	8	24	2.116129
E-5	12/20/1988	1988	8	26.5		10.5	7.8	36	0.508344
E-5	12/21/1988	1988	7	13.9			7.5		
E-5	1/20/1989	1989	8	10.9		6.4		17	0.100487
E-5	2/17/1989	1989	10	5.5		4.9	7.5	17	0.078025
E-5	3/2/1989	1989	10.5	0	332	4.7	7.6	66	0.93157
E-5	3/6/1989	1989	11	0	315	4.2	7.5	52	0.434022
E-5	4/10/1989	1989							0.049474
E-5	5/4/1989	1989	21.5	6.3	9500	6.1	7.8	33	0.258002
E-5	5/26/1989	1989	23	16		7	8.1		
E-5	6/7/1989	1989	19.5	24.8		5.5	7.5	34	0.067515
E-5	7/5/1989	1989	25	31		8.3	8	41	0.359767
E-5	9/18/1989	1989	17	35.2		5.4	7.5	60	0.3687
E-5	10/23/1989	1989	15.5	29.2		7.9	7.6		
E-5	11/28/1989	1989	10	17.3		7.5	7.4	20	0.056316
E-5	1/16/1990	1990	11	0.5	820	6.2	6.8		
E-5	2/7/1990	1990	7	1	900	7.2	7.5	16	0.090596
E-5	3/9/1990	1990	9		1020	8.1	7.2	14	0.0948
E-5	4/5/1990	1990	14	5	5800	5.6	7.5	32	0.2525
E-5	5/24/1990	1990	17.5	22.5		4.7	7.9	31	0.1053
E-5	6/25/1990	1990	21.2	24.3		3.3	7.8	120	0.5499
E-5	7/26/1990	1990	21.7	34.3		11.1	8.7	35	1.3532
E-5	9/18/1990	1990	16.2	34.5		10.4	7.9	37	2.706
E-5	11/15/1990	1990	9.5	33.7		9	7.8		0.09
E-5	5/6/1994	1994	18.5	6	9000	3.2	8		0.014

Table 1-1. Continued.

STATION	DATE	FCOLI	TDS	TSS	DOC	NO3	NH3	UNH3	TOTP
		MPN/100ml			mg/L	mg/L	mg/L	mg/L	mg/L
E-5	2/29/1988								
E-5	3/30/1988		14516			0.2			0.77
E-5	4/14/1988		23256			0.14	1.1	0.002266	0.64
E-5	5/16/1988	26	21000			0.06	0.09	0.000248	1.5
E-5	6/15/1988		29000			0.05	0.67		4.3
E-5	7/21/1988		45000			0.015	0.21	0.02352	0.79
E-5	8/29/1988	11	41000			0.03	0.22	0.006116	0.78
E-5	9/28/1988		4400			0.15	0.025	0.00157	0.76
E-5	10/25/1988		37000			0.15	0.15	0.003795	0.58
E-5	11/22/1988	2400	28000	27		0.36	0.71	0.010366	3.3
E-5	12/20/1988		29000			0.58	0.36	0.002434	0.29
E-5	12/21/1988		16000			0.67	1.1	0.003652	0.92
E-5	1/20/1989		13000			0.64	6	0.02244	2.6
E-5	2/17/1989	2400	7500		20	0.39	10	0.0459	3.7
E-5	3/2/1989					1.4	5	0.0341	3.7
E-5	3/6/1989		360		42	0.85	3.6	0.020304	2.9
E-5	4/10/1989								
E-5	5/4/1989	1010	1200		17	1.3	0.38	0.008208	1.4
E-5	5/26/1989								
E-5	6/7/1989		16800		9.3	0.47	0.21	0.00173	0.68
E-5	7/5/1989		38400		11	0.015	0.025	0.000928	0.53
E-5	9/18/1989	3300	39000	96	5.2	0.21	0.92	0.006146	1.3
E-5	10/23/1989			58		0.55	0.15	0.001131	0.42
E-5	11/28/1989		19000	49	14	1.3	0.50	0.001675	0.29
E-5	1/16/1990		680	22		1.4	3.30	0.00363	3.5
E-5	2/7/1990	540	900	7.4	23	0.93	3.10	0.012276	2.7
E-5	3/9/1990		700	14	20	0.72	2.40	0.00569	2.6
E-5	4/5/1990		4900	47	6.2	0.09	0.26	0.001625	1.7
E-5	5/24/1990	920	25000	100	7.9	0.27	0.43	0.007676	0.7
E-5	6/25/1990		30000	730	19	0.15	2.20	0.04004	2.8
E-5	7/26/1990	11	48000	270	14	0.015	0.03	0.00315	0.86
E-5	9/18/1990		47000	130	7.3	0.015	0.06	0.000924	1.1
E-5	11/15/1990	17	39000	12	7.1	0.11	0.08		0.29
E-5	5/6/1994		6100	42		0.35	0.21		0.96

Table 1-1. Continued.

STATION	DATE	TEMP	SALINITY	CONDUCT	DO	PH	TURBID	CHL A
		°C	ppt	µmhos	ppm		FTU	mg/L
E-6	2/29/1988	14			1.6			
E-6	3/30/1988	17	0.2		9.6			6.198
E-6	4/14/1988	15	0.7	900	10.8			8.638
E-6	5/16/1988	15.8	1.1	1700	2.1	7.55	62	4.711875
E-6	6/15/1988	16	1.5	2320	3.5	8		7.6296
E-6	7/21/1988	25.5	3.2	4230	20	9.35		
E-6	11/22/1988	13		650	5.1	7.35	14	0.174374
E-6	12/20/1988	8.9			4		41	1.702361
E-6	12/21/1988		1.2	1700	1.2			6.058749
E-6	1/20/1989	10.8	0	700	2.3	7.65	27	0.359387
E-6	2/17/1989	13.9	0.2	700	11.2	7.5	15	0.546174
E-6	3/2/1989	11	0	462	5.7	7.5		
E-6	3/6/1989		0	250	5.1	7.4	46	0.605219
E-6	5/4/1989	23.5		800	9	8.3	30	0.868044
E-6	6/7/1989	17	0.3	620	10.4	8.3	26	5.714622
E-6	7/6/1989	19	0.2	900	19	8.8		32.73172
E-6	9/18/1989	16.8	1	1120	2.7	7.7	20	0.1534
		19.1	0.5	860	10.3	8.3	25	
E-6	10/23/1989	14.9		700	5	7.7		0.710077
E-6	11/28/1989	10		900	3.5	7.6	51	
E-6	1/16/1990	11.7	0.2	415		7		0.170174
E-6	2/8/1990	7		457	9.4	7.8	22	0.1879
E-6	3/9/1990	13		530	8.3	7.9	25	0.9237
E-6	4/5/1990	15.3		720	8	7.3	22	3.0665
E-6	5/24/1990	12.8		590	4.1	7.3	50	36.279
E-6	6/25/1990	16	0.8	1140	19	9.1	57	109.532
E-6	7/26/1990	20.5		1920	20	9.8		
								0.017
E-6	5/6/1994	16.6		700	3.2	7.8		

Table 1-1. Continued.

STATION	DATE	FCOLI	TDS	TSS	DOC	NO3	NH3	UNH3	TOTP
		MPN/100ml			mg/L	mg/L	mg/L	mg/L	mg/L
E-6	2/29/1988	16				0.1	11	0.07788	5.2
E-6	3/30/1988		888			0.5	6.7	0.057553	5
E-6	4/14/1988		2160				268	1.85992	13
E-6	5/16/1988	2400000	1100			0.015	41	0.36285	13
E-6	6/15/1988		2000			0.05	61	1.4213	10
E-6	7/21/1988		4100			0.98	5.7	1.8069	44
E-6	11/22/1988	2400	610	13		1.3	2.7	0.012582	3.4
E-6	12/20/1988		1100			0.59	24	0.348	9.4
E-6	12/21/1988		1500			0.015	110	0.9823	19
E-6	1/20/1989		640			0.03	18	0.14292	7.2
E-6	2/17/1989	2400	560		31	0.05	14	0.09912	5.9
E-6	3/2/1989								
E-6	3/6/1989		350		38	1.4	2.5	0.0112	3.2
E-6	5/4/1989	20900	570		30	0.31	7.5	0.62475	5.2
E-6	6/7/1989		440		28	0.45	0.49	0.026215	
E-6	7/6/1989		770		64	3.2	4.2	0.7098	7.6
E-6	9/18/1989	2400000	950	28	49	2.1	9.6	0.12864	8.5
			683			1.52	5.45	0.372	7.1
E-6	10/23/1989		580	86	100	2.6	4.70	0.056	5.5
E-6	11/28/1989		1000	110		7.8	15.00	0.094	7.9
E-6	1/16/1990		400	17	28	2.3	4.90	0.009	4.8
E-6	2/8/1990	9200	440	40	24	0.95	4.30	0.035	3.1
E-6	3/9/1990		410	33	20	0.26	4.80	0.078	4
E-6	4/5/1990		520	36	26	0.72	5.40	0.026	5.6
E-6	5/24/1990	350000	450	130	74	0.015	2.70	0.011	3.2
E-6	6/25/1990		1100	270	150	0.08	1.50	0.302	4.9
E-6	7/26/1990	35000	1700	1200		0.015	3.60	0.918	15
E-6	5/6/1994		530	11		0.03	2.10		3.6

Table 1-1. Continued.

STATION	DATE	TEMP	SALINITY	CONDUCT	DO	PH	TURBID	CHL A
		°C	ppt	µmhos	ppm		FTU	mg/L
E-7	2/29/1988	13			5.5			
E-7	3/30/1988	16	0		7.6			0.374
E-7	5/16/1988	14	1	1600	2.3	7.75	11	14.8665
E-7	6/15/1988	14.9	3.2	35210	2.7	7.9		168
E-7	12/20/1988	9			10.5		7.5	0.0863
E-7	1/20/1989	11.8		412	15.2	8.7	3.5	0.047879
E-7	2/17/1989	12.9		620		7	6.2	0.088074
E-7	3/2/1989	11.2	0	221	9.8	7.7		
E-7	3/6/1989		0	218	8.8	7.5	13	0.054761
E-7	5/4/1989	21.8		500	10.5	8.6	14	0.344806
E-7	6/7/1989	15.1	0.5	890	5.8	7.8	25	1.085055
E-7	7/6/1989							
E-7	9/18/1989							
E-7	10/23/1989	16.1		770	8.2	7.5		
E-7	11/28/1989	10.9		520	8.4	7.5	18	0.299946
E-7	1/16/1990	11.5	0.1	298	10.4	7		
E-7	2/8/1990	7		360	12.8	7.4	8	0.023581
E-7	3/9/1990	13		383	12	8.1	6.5	0.0616
E-7	4/5/1990	14.2		520	5.2	7.5	27	0.5727
E-7	5/24/1990	10.8		570	5	7.2	8.3	0.3387
E-7	6/25/1990	11.5	0.9	1120	0.7	7.2	93	5.63

Table 1-1. Continued.

STATION	DATE	FCOLI	TDS	TSS	DOC	NO3	NH3	UNH3	TOTP
		MPN/100ml			mg/L	mg/L	mg/L	mg/L	mg/L
E-7	2/29/1988	16				0.05	0.05		0.38
E-7	3/30/1988		468			0.3	1.4	0.0182	1.8
E-7	5/16/1988		1100			0.015	86	1.032	8.6
E-7	6/15/1988		3200			0.05	170	2.822	18
E-7	12/20/1988		440			0.06	0.06	0.00072	0.41
E-7	1/20/1989		390			0.09	0.15	0.013275	0.1
E-7	2/17/1989		330			0.015	0.12	0.000258	0.5
E-7	3/2/1989								
E-7	3/6/1989		300			0.81	0.24	0.00145	2.1
E-7	5/4/1989		380			0.58	0.14	0.0196	1.1
E-7	6/7/1989		630			0.09	32	0.4736	
E-7	7/6/1989								
E-7	9/18/1989								
E-7	10/23/1989		600	32		0.2	0.68	0.005596	2.2
E-7	11/28/1989		530	19		8.7	2.60	0.014664	2.9
E-7	1/16/1990		290	5.2		1.1	0.14	0.000269	1.7
E-7	2/8/1990			12		0.41	0.08	0.00027	1
E-7	3/9/1990		330	12		0.08	0.07	0.001848	0.97
E-7	4/5/1990		400	60		0.07	0.44	0.00312	1
E-7	5/24/1990		440	16		0.015	1.20	0.003396	1.7
E-7	6/25/1990		930	380		0.015	49.00	0.13867	9.7

Table 1-1. Continued.

STATION	DATE	TEMP	SALINITY	CONDUCT	DO	PH	TURBID	CHL A
		°C	ppt	µmhos	ppm		FTU	mg/L
E-8	2/29/1988	12			6.4			
E-8	3/30/1988	15	0		9.8			0.0493
E-8	5/16/1988	16.6	0.2	650	4.5	6.99	6.1	0.088638
E-8	11/22/1988	13.2		600	7.25		12	0.039012
E-8	12/20/1988	8.6			9.5	7.6	5.4	0.041377
E-8	1/20/1989	9		405	11.8	7.65	4.1	0.047879
E-8	2/17/1989	11.5	1.8	700	11.4		3.1	0.046697
E-8	3/2/1989	10.5	0	221	10.2	7.8		
E-8	3/6/1989	11.5	0	220	9.8	7.7	16	0.020583
E-8	5/4/1989	19.2		490	7.4	8.3	5.7	0.039277
E-8	6/7/1989	15.5	0.3	560	4.2	7.5	11	0.347218
E-8	7/6/1989							
E-8	9/18/1989							
E-8	10/23/1989	14		620	7.5	7.2		
E-8	11/28/1989	8.4		520	9.6	7.5	6.9	0.027698
E-8	1/16/1990	10.5		292	10.2	6.8		
E-8	2/8/1990	6		312	11.8	7.3	11	0.008609
E-8	3/9/1990	10		340	12.5	7.9	6.4	0.0088
E-8	4/5/1990	12.5		500	7.6	7	4	0.016
E-8	5/24/1990	11.9		510	6.8	7.3	4.2	0.0271
E-8	6/25/1990	13.3	0.2	580	5.2	7.4	4	0.1129

Table 1-1. Continued.

STATION	DATE	FCOLI	TDS	TSS	DOC	NO3	NH3	UNH3	TOTP
		MPN/100ml			mg/L	mg/L	mg/L	mg/L	mg/L
E-8	2/29/1988	16				0.82	0.05		0.44
E-8	3/30/1988		380			0.1	0.18	0.000443	0.45
E-8	5/16/1988		75000			0.015	0.52	0.00104	0.8
E-8	11/22/1988		600			1.4	1.2	0.0099	1.5
E-8	12/20/1988		510			1.5	0.12	0.000728	0.77
E-8	1/20/1989		410			0.63	0.13	0.000884	0.1
E-8	2/17/1989		340		8.2	0.16	0.025		0.29
E-8	3/2/1989								
E-8	3/6/1989		320		21	1.1	0.38	0.003629	0.88
E-8	5/4/1989		390		8.3	1.7	0.025	0.001538	0.56
E-8	6/7/1989		390		17	0.06	3	0.02418	
E-8	7/6/1989							0.015007	
E-8	9/18/1989							0.003008	
E-8	10/23/1989		640	55		6.5	4.30	0.000235	6.4
E-8	11/28/1989		670	6.8	24	5.8	0.69	0.000174	1.5
E-8	1/16/1990		300	7.2		1.5	0.21	0.000335	1.3
E-8	2/8/1990		350	18	11	0.57	0.07	0.00005	0.43
E-8	3/9/1990		310	11	9.1	0.34	0.03	0.0001	0.43
E-8	4/5/1990		390	2	7.1	0.04	0.03	0.014616	0.3
E-8	5/24/1990		440	10	8.2	0.26	0.03	0.000	0.77
E-8	6/25/1990		510	19	9.2	0.03	2.80	0.015	1.5

APPENDIX C. WATERSHED MODELING METHODS AND RESULTS

The following section details the modeling methods used to estimate nutrient and sediment pollutant loadings in the Estero Americano Watershed. To determine the load reductions necessary to meet environmental targets in the watershed, sediment loading estimates were determined using two standardized loading models. Models selected for this study were chosen based on recommendations in EPA's (2005) *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. Sheet and rill erosion was estimated using *STEPL*, a public domain simplified spreadsheet tool (Tetra Tech, Inc., 2005). The model relies on a standardized Curve Number (CN) and the Universal Soil Loss Equation (USLE) to estimate runoff and loadings from various land use/land cover classes. Sediment loadings from streambank and gully erosion were estimated using the *Channel Erosion Equation (*Michigan Department of Environmental Quality, 1999*)*, which uses the direct volume method to calculate annual average sediment loadings and reductions. Nutrient loads were estimated using the STEPL model. Modeling results for estimated average annual sediment loadings by source are presented in Table 1.

Table 1. Estimated Average Annual Sediment Loadings tons/yr by Source

Source	Subwatershed			Total	
	Lower (tons)	Middle (tons)	Upper (tons)	(tons)	(percent)
Blueline Streams:	499	5,147	2,523	8,169	**34%**
Seasonal Streams:	342	535	654	1,531	**6%**
Gullies:	**1,972**	**4,695**	**2,723**	**9,390**	**39%**
Sheet & Rill	740	2,294	1,797	**4,831**	**20%**
Subtotal	**3,553**	**12,671**	**7,697**	**23,921**	**100%**

Estimating Nutrient Loads and Sediment Loads from Sheet and Rill Erosion:

Watershed modeling of nutrients and sediment loads from sheet and rill erosion used for this watershed management plan (refer to Chapters 3 and 4 of this document for a discussion of results) utilized the *Spreadsheet Tool for the Estimation of Pollutant Load*, *Version 3.1* (STEPL). This model, developed for the EPA provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. The model employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs). The model computes surface runoff; nutrient loads, including nitrogen, phosphorus, and

5-day biological oxygen demand (BOD_5); and sediment delivery based on various land uses and management practices (Table 6 and Table 7).

The land uses considered in the model are urban land, cropland, pastureland, feedlot, forest, and a user-defined type. The pollutant sources include major nonpoint sources such as cropland, pastureland, farm animals, feedlots, urban runoff, and failing septic systems. The types of animals considered in the calculation are beef cattle, dairy cattle, swine, horses, sheep, chickens, turkeys, and ducks. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (from sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies (not used for modeling for this watershed management plan).

Figure 1 shows the spreadsheet structure of STEPL. It is composed of worksheets for input and output interaction. The input data include state name, county name, weather station, land use areas, agricultural animal numbers, manure application months, population using septic tanks, septic tank failure rate, direct wastewater discharges, irrigation amount/frequency, and BMPs for simulated watersheds. Data input for the USLE are based on default values for soil conditions in Sonoma County. Precipitation data are based on San Francisco weather data. Pollutant loads and load reductions are automatically calculated for total nitrogen, total phosphorus, BOD_5, and sediment.

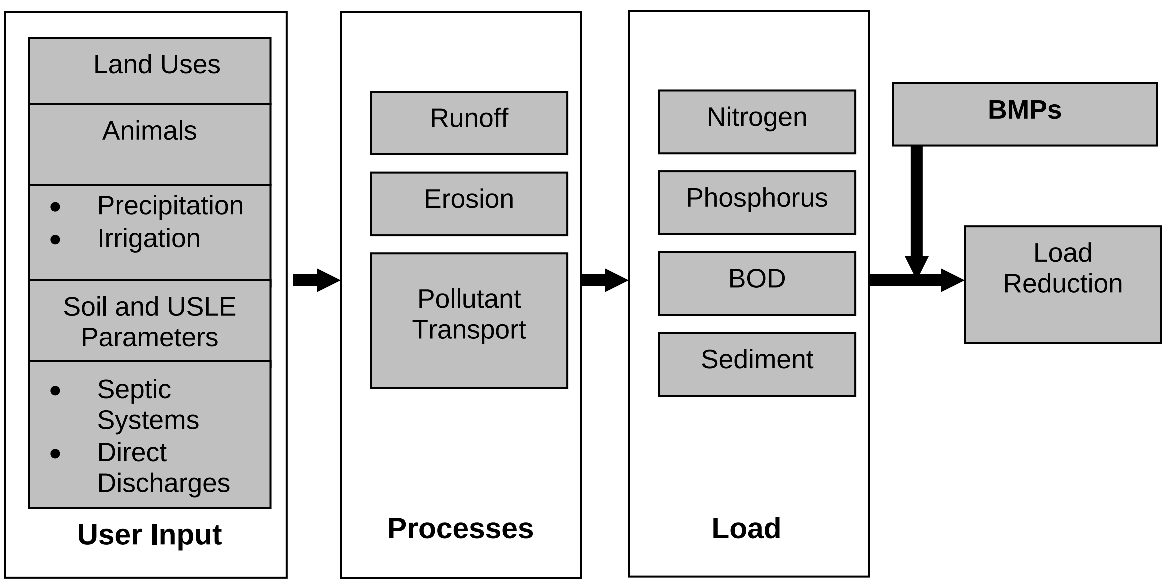


Figure 1. Spreadsheet structure.

Watershed modeling parameters and results used in this study are presented in the six tables below. Estimates of the acreage of various land uses in the watershed were derived from Sonoma County's spatial data layer of parcel boundaries and the *Sonoma County Assessor's Situs Index Database, 2004* (Table 2). Estimates for the number and type of livestock operation and the number and type of animals per operation are based on local knowledge of the agricultural community (Table 3). Estimates for the number of septic systems were derived from the county parcel data and Situs Index (Table 4). Estimates of failure rate of septic systems are "best guess estimates," and should not be cited or used to inform other planning studies.

Table 2. Input watershed land use area (ac) and precipitation (in)

Watershed	Urban	Cropland	Pasture Land	Forest	Feedlots	Feedlot Percent Paved	Total	Annual Rainfall	Rain Days	Avg. Rain/Event
Lower	186	0	5778	40	10	0-24%	6014	36	70	1.060
Middle	536	75	9477	600	17	25-49%	10705	36	70	1.060
Upper	868	40	6754	40	18	25-49%	7720	36	70	1.060

Table 3. Input agricultural animals

Watershed	Beef Cattle	Dairy Cattle	Sheep	Horse	Chicken	# of months manure applied
Lower	750	0	600	20	0	2
Middle	750	2400	1500	20	0	2
Upper	900	2400	300	0	84500	2
Total	2400	4800	2400	40	84500	

Table 4. Input septic system

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %
Lower	259	2.43	10
Middle	271	2.43	30
Upper	219	2.43	30

Table 5. Modify the Universal Soil Loss Equation (USLE) parameters					
Watershed	**Cropland**				
	R	**K**	**LS**	**C**	**P**
Lower	116.884	0.370	1.561	0.200	1.000
Middle	116.884	0.370	1.561	0.200	1.000
Upper	116.884	0.370	1.561	0.200	1.000
Watershed	**Pastureland**				
	R	**K**	**LS**	**C**	**P**
Lower	116.884	0.370	1.561	0.010	1.000
Middle	116.884	0.370	1.561	0.020	1.000
Upper	116.884	0.370	1.561	0.020	1.000
Watershed	**Forest**				
	R	**K**	**LS**	**C**	**P**
Lower	116.884	0.370	1.561	0.003	1.000
Middle	116.884	0.370	1.561	0.003	1.000
Upper	116.884	0.370	1.561	0.003	1.000

Sheet and rill erosion produces roughly 20 percent of the predicted total annual sediment yield in the watershed, an estimated 4,831 tons per year. Most of this sediment originates in the middle and upper sub-watersheds. Close to 96 percent of sediment from sheet and rill erosion derives from pastureland in the Estero Americano Watershed (Table 1).

Table 6. Total load by subwatershed(s)				
Watershed	**N Load lb/year**	**P Load lb/year**	**BOD Load lb/year**	**Sediment Load t/year**
Lower	75662.3	10604.5	178038.8	739.8
Middle	152207.2	24413.3	342090.4	2294.0
Upper	138555.4	23334.1	293281.9	1796.7
Total	366424.9	58351.8	813411.0	4830.5

Table 7. Total load by land uses				
Sources	**N Load (lb/yr)**	**P Load (lb/yr)**	**BOD Load (lb/yr)**	**Sediment Load (t/yr)**
Urban	11203.3	1726.7	43504.7	256.9
Cropland	2558.4	593.8	4682.9	253.0
Pastureland	155776.3	15947.2	489079.6	4298.4
Forest	230.5	107.1	540.8	22.1
Feedlots	191281.2	37871.7	253654.4	0.0
Septic	5375.2	2105.3	21948.5	0.0
Total	366424.9	58351.8	813411.0	4830.4

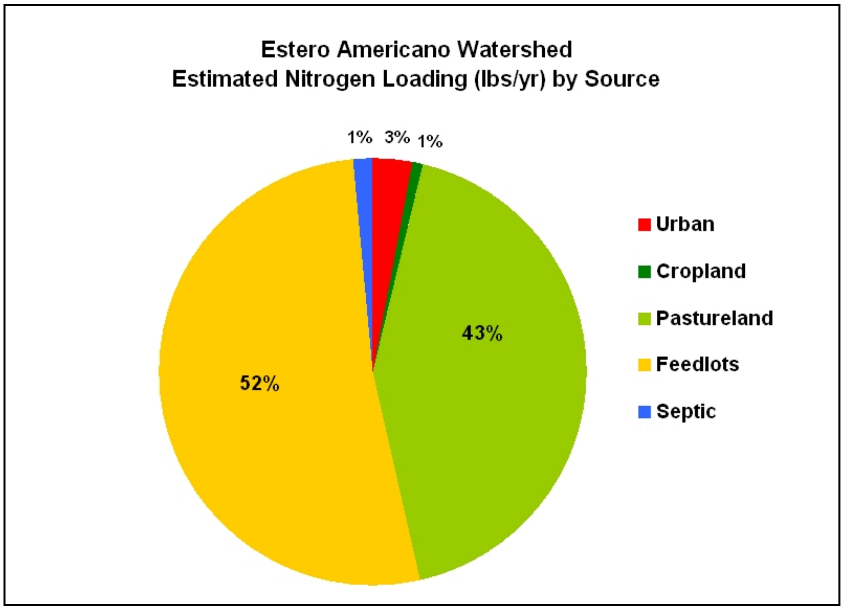


Figure 2. N Loading (lbs/yr) by Source

Agricultural operations account for 96 percent of estimated annual nitrogen loads in the larger Estero Americano Watershed. Septic systems and urban land uses account for 4 percent of total loadings.

Estimating Sediment Loads from Gully and Streambank Erosion:

Sediment loadings from streambank and gully erosion were estimated using the *Channel Erosion Equation (CEE) (*Michigan Department of Environmental Quality, 1999*)*, which uses the direct volume method to calculate annual average sediment loadings and reductions.

CEE = Length (ft.) x Height (ft.) x LRR (ft./yr.) x Soil weight (ton/ft3)

The method assumes 100% delivery of the eroded soil to the stream. This calculation contrasts the original bank slope with the existing repose. The rate at which bank deterioration has taken place is an important variable to determine. The Lateral Recession Rate (LRR) is the thickness of soil eroded from a bank surface (perpendicular to the face) in an average year. Recession rates are measured in feet per year. However, a channel bank may not erode for a period of years when no major runoff events occur. When a major storm does occur, the bank may be cut back tens of feet for a short distance. It is necessary to assign recession rates to banks with such a process in mind. If ten feet of bank has been eroded, the ten feet must be adjusted to an average annual lateral recession rate rather than a recession rate for one storm.

Selecting the lateral recession rate is the most critical step in estimating channel erosion using the direct volume method. A historical perspective is required in many instances. However, in most cases, such information is lacking and field observations and professional judgment are needed to estimate recession rates. Table 8 provides guidance on estimating lateral recession rates that were used for this study.

Table 8. Lateral Recession Rates of Streambanks and Gullies as Estimated Using Field Observations

Lateral Recession Rate ft/yr	**Category**	**Description**
0.01 - 0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang. No exposed tree roots.
0.06 - 0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang.
0.3 - 0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and stream course or gully may be meandering.

Source: Michigan Department of Environmental Quality, 1999

Estimates for determining lateral recession rates for gullies and streambank erosion in the Estero Americano Watershed relied on two methods of assessment. First, high-resolution 2004 aerial photographs were used to map the location and length of gullies visible in the aerial photographs and to assess riparian conditions throughout the watershed (refer to Appendix X Riparian Assessment). Two hundred and eighty-three gullies were mapped using this method; of these, 166 occur on soils with a high erosion hazard (close to 60% of gullies mapped). Aerial photo-interpretation identified 14 gullies directly adjacent to the estuary, and 42 gullies that drain into Ebabias Creek. Although aerial photo-interpretation can provide valuable information on the location and extent of large gullies in the unwooded portions of the watershed, the type of erosion (landslide, sheet, channel bank) and erosion activity levels of individual gullies cannot be determined from aerial photographs.

In order to estimate the severity of erosion, and the general characteristics of gullies in the watershed, we utilized findings from an earlier gully erosion assessment conducted in 1986 as part of *The Sonoma Coastal Wetlands Restoration Program* funded by the State Coastal Commission (Circuit Rider Productions, Inc., 1987). The 1986 field survey identified 112 gullies and 66,480 feet of channel bank erosion. We used the general characteristics of these 112 field surveyed gullies (Table 9) to extrapolate on a percentage basis the characteristics (width and depth) of the 283 gullies identified using aerial photography. The length of each of the 283 gullies were measured as mapped. To estimate erosion severity or LLR in ft/yr, the 112 gullies from the earlier study were grouped into erosion severity categories based on the recorded average width of each gully surveyed (Table 10). An average soil density weight of .0525 for sandy loam was used for the *Channel Erosion Equation*. Potential sediment loadings from gully erosion are shown in Table 1.

Table 9. Summary of 1986 Gully Assessment

Range width'	Number of Gullies	% of Gullies	Av width	Av depth	Av length
1 to 8'	62	55	6'	4'	148
10 to 15'	23	21	11'	7'	106
20 to 100'	27	24	32'	13'	202
Totals	*112*	*100%*			

Table 10. Selected Lateral Recession Rates based on Gully Width

Width (ft)	Severity	LLR
2 to 8	Moderate	0.1 to 0.2
10 to 15	Severe	0.5
>20	Very Severe	0.7

In order to model potential sediment loading from streambank erosion using the *Channel Erosion Equation*, we relied on a riparian corridor assessment conducted as part of this watershed management plan (see Appendix D). The riparian corridor assessment was conducted to identify needed restoration along stream corridors in the watershed. Stream segments were coded in a Geographical Information System (GIS) based on abundance of riparian vegetation (minimal vegetation, partial vegetation, or abundant vegetation) and location in the watershed, using high-resolution aerial photography.

Lateral recession rates and bank height were assigned for each stream segment based on the amount of riparian vegetation and the location of the stream segment (mainstem, main tributary or seasonal stream) in the watershed. Later recession rates and bank heights were considered greatest along the unvegetated segments of the mainstem of Americano Creek, Bloomfield Fork and Ebabias Creek (Table 13). Vegetated tributaries or ephemeral streams in the upper portions of the watershed were assigned the lowest lateral recession rates and bank heights (Table 11). Soil weight was determined based on the location of the stream segment in the watershed (floodplain or upland location).

The assessment found that over 14 stream miles have minimally vegetated riparian corridors, with approximately 104 acres of riparian area in need of restoration. In addition, there is an estimated 7.1 stream miles that have only partially vegetated stream corridors, needing 51.4 acres of riparian area restoration. Modeling results of estimated average annual sediment yields in the watershed found that erosion from streambanks was the second largest source of sediment discharged to surface waterbodies (Table 1). Modeling parameters and results of this portion of the study are presented in tables 11-13.

Table 11. Sediment Loading Estimates from Small Seasonal Stream Segments

Upper Watershed	**Length ft.**	**Height ft.**	**LRR**	**Soil Weight**	**Tons/yr**
Minimally Vegetation	49312.1	3	0.06	0.0525	466
Partially Vegetated	30212.78	2	0.03	0.0525	95.17
Vegetated	44327.42	2	0.02	0.0525	93.09
Total	***123852.3***				***654.26***
Middle Watershed					
Minimally Vegetation	40889.19	3	0.06	0.0525	386.4
Partially Vegetated	23849.57	2	0.03	0.0525	75.13
Vegetated	34872.47	2	0.02	0.0525	73.23
Total	***99611.23***				***534.76***
Lower Watershed					
Minimally Vegetation	22587.58	3	0.06	0.0525	213.45
Partially Vegetated	21074.26	2	0.03	0.0525	66.38
Vegetated	29693.49	2	0.02	0.0525	62.36
Total	***73355.33***				***342.19***

Table 12. Sediment Loading Estimates from USGS Small Tributary Stream

USGS Smaller Tributary Streams					
Upper Watershed	**Length ft.**	**Height ft.**	**LRR**	**Soil Weight**	**Tons/yr**
Minimally Vegetated	9866.17	3	0.30	0.0525	466.18
Partially Vegetated		3	0.20	0.0525	
Vegetated	1969.43	3	0.04	0.0525	6.20
Total	***11835.6***				***472.38***
Middle Watershed					
Minimally Vegetated	29337.68	3	0.30	0.0525	1386.21
Partially Vegetated	2586.24	3	0.06	0.0525	24.44
Vegetated	12698.46	3	0.02	0.0525	40.00
Total	***44622.38***				***1450.65***
Lower Watershed					
Minimally Vegetated	9151.52	3	0.30	0.0525	432.41
Partially Vegetated	3071.30	3	0.06	0.0525	29.02
Vegetated	11906.19	3	0.02	0.0525	37.50
Total	***24129.01***				***498.94***

Table 13. Sediment Loading Estimates from USGS Large Tributary Stream Segments

USGS Larger Tributary Streams					
Upper Watershed					
Americano Creek and Bloomfield Fork	**Length ft.**	**Height ft.**	**LRR**	**Soil Weight**	**Tons/yr**
Minimally Vegetated	16783.57	4	0.40	0.0425	1187.26
Partially Vegetated	16783.57	4	0.20	0.0425	824.70
Vegetated	5026.11	4	0.04	0.0425	39.04
Total	***38593.24***				***2051.00***
Middle Watershed					
Americano Creek and Ebabias Creek					
Minimally Vegetated	9054.40	4	0.40	0.0425	3176.84
Partially Vegetated	8906.39	4	0.20	0.0425	347.11
Vegetated	21336.62	4	0.04	0.0425	172.26
Total	***39297.42***				***3696.21***

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APPENDIX D: RIPARIAN ASSESSMENT (March 2005)

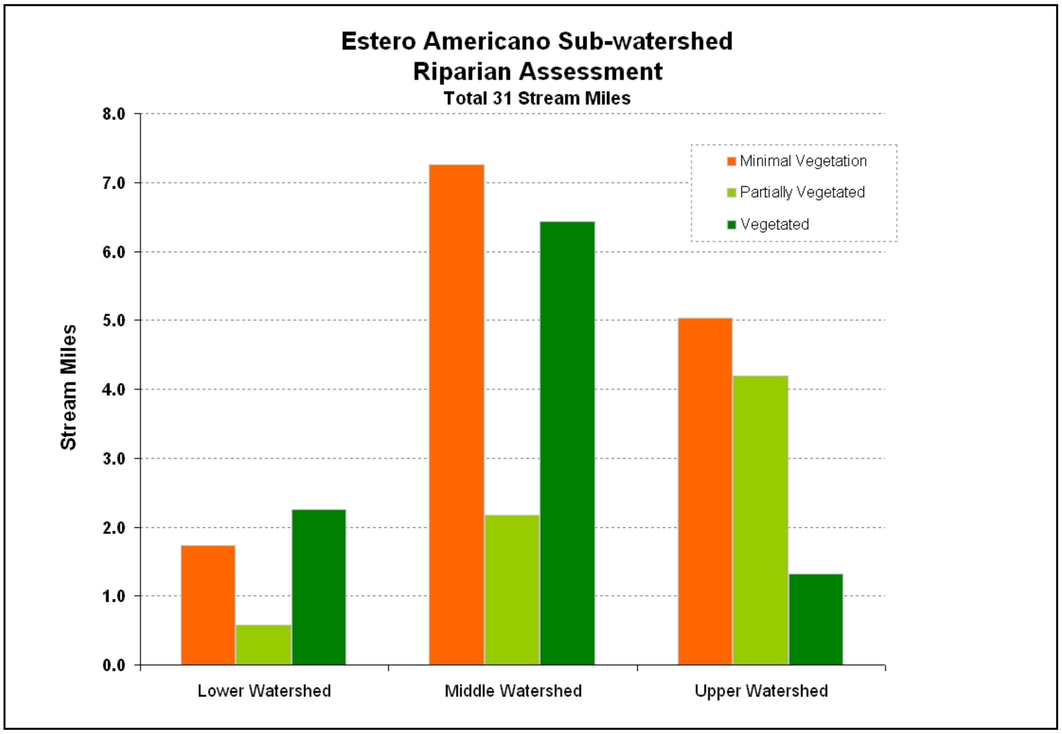

Figure 1-1. Riparian Conditions by Sub-watershed for USGS blue-line streams.

The watershed for the Estero Americano and its main tributary Americano Creek is 39 sq. miles. In total, there are approximately 31 miles of blue-line ephemeral or intermittent streams in the watershed, and an additional 56 miles of smaller seasonal streams draining into these larger tributaries. For the purposes of this management plan, the larger Estero Americano watershed was assessed using three sub-watershed boundaries: Upper Americano Creek sub-watershed, Estero Americano Middle sub-watershed, and Lower Estero Americano sub-watershed. The three areas have a number of distinct topographical, hydrologic, vegetative, and land use characteristics.

Methods

A riparian corridor assessment was conducted on all U.S. Geological Survey (USGS) blue-line streams in the watershed using high-resolution aerial photographs taken in the spring of 2004. Stream segments were coded in a GIS based on abundance of riparian vegetation (minimal vegetation, partial vegetation, or abundant vegetation). The assessment found that 45 percent of streams in the Estero Americano watershed had minimal riparian vegetation; 22 percent are partially vegetated; and 32 percent of stream miles are abundantly vegetated (see Table 1-1). Coding of stream segments was done on a desktop computer; qualitative assessments of the actual condition of riparian vegetation were not conducted. However, an earlier study that included field assessments found that even were there were willows and Eucalyptus trees, soil was compacted and banks sloughed due to livestock access (Buell, 1988).

Table 1-1. Watershed Riparian Corridor Assessment for USGS blueline streams

Condition	Stream Miles	Percent of Stream Miles
Minimally Vegetated	14	45%
Partially Vegetated	7	22%
Vegetated	10	32%
Total	**31**	

Americano Creek is roughly 7.6 miles in length and drains the upper third of the larger watershed before flowing into the tidal estuary at Valley Ford. The creek's sub-watershed encompasses 11.9 sq. miles. There are two ephemeral or intermittent streams that drain into Americano Creek from upland areas above the village of Bloomfield. Americano Creek and its tributary streams and their associated riparian areas are in a degraded state. Close to 90 percent of riparian corridors are either minimally or partially vegetated. Six dairies are located either directly on the creek or on one of its tributaries. Water quality monitoring data show spikes of nutrient pollution along the creek in this sub-watershed.

The Middle sub-watershed is 17.1 sq. miles and includes the Town of Valley Ford. Ebabias Creek is the largest tributary in the sub-watershed, and is the only stream with restoration potential for salmonids in the larger Estero Americano watershed. Ebabias Creek flows 5.4 stream miles from its headwaters off Burnside Road to the Estero just north of the Town of Valley Ford. Four ephemeral streams drain into the Estero from upland areas in this sub-watershed, totaling 15 stream miles. Sixty percent of riparian corridors are either minimally or partially vegetated. The riparian corridor for the mainstem of Ebabias Creek, alternatively, is 60 percent vegetated. There are five dairies located in the Middle sub-watershed.

The Lower Estero Americano sub-watershed encompasses 9.8 sq. miles. There are three ephemeral streams that drain into the estuary. Approximately 50 percent of the 4.5 stream miles in the Lower sub-watershed have riparian vegetation; 38 percent of the riparian corridor is minimally vegetated; and 13 percent is partially vegetated. Land use in the lower estuary sub-watershed is primarily open rangeland.

Americano Creek

Americano Creek was once a perennial stream. The creek is now ephemeral in all or nearly all years and supports no fish resources above tidewater (Beull, 1988).
Flowing water persists only during the rainy season. Soil compaction and denuded stream banks due to livestock presence are almost universal throughout the stream system. Functional riparian plant communities are either nonexistent or are highly degraded. In most areas, even where willows are present, stream banks are sloughed.

Table 1-2. Americano Creek Riparian Corridor Assessment for USGS blueline streams

Americano Creek		
Condition	**Stream Miles**	**Percent of Stream Miles**
Minimally Vegetated	3.2	42%
Partially Vegetated	3.2	42%
Vegetated	1.2	16%
Total	**7.6**	

Stream erosion in the mainstem of Americano Creek and the lower reaches of tributaries is high. Scour/deposition patterns are predominately lateral in the valley floor since the stream is alluvial and the average stream gradient is low (less than 1%). The hydraulic geometry of Americano Creek is predominantly rectangular and much wider in most areas than it would be naturally, due to trampled, sloughed, and denuded banks. Fine sediment (sand, silt) deposition in the channel bottom is excessive, and resulting aggradation of the stream channel relative to bank height is reported to exacerbate local flooding problems near Bloomfield and Valley Ford (Madrone Associates, 1977).

Sediment transport during periods of high runoff is obviously high, but judging from deposition patterns in the stream channel bottom, the supply of fine sediment to Americano Creek significantly exceeds the carrying capacity of the stream. The overall condition of the aquatic (freshwater) environment and its fringe (riparian) areas and associated wetlands is poor, and this condition is pervasive (Buell, 1988).

Riparian Restoration:

Numerous riparian corridor restoration studies have been conducted on streams in arid and semi-arid areas incorporating controlled livestock access to riparian areas. In most areas, very little else was needed to affect substantial recovery, although rates of recovery vary (Buell, 1988). Restoring riparian corridors has important benefits for reduction in peak runoff and flood routing. Increased water retention capabilities of soils and presence of perennial and wet meadow grasses retards runoff from upland areas spreading runoff events over a longer time period and reducing flood peaks. Changes in hydraulic geometry of stream channels associated with riparian recovery (deepening, narrowing) assist in this process of natural runoff management.

Recovery of riparian areas as extensively damaged as those in the Americano Creek watershed can be greatly accelerated by a judicious planting program using selected successional and climax species. Strategic plantings of various herbaceous and woody species may eliminate the necessity of actively "treating" the entire riparian corridor by acting as seed stock for downstream areas (ibid).

In the Americano Creek watershed, runoff control will be greatly enhanced if riparian recovery can extend up tributary areas, even small ravines, to establish vegetation belts from potential spring areas on surrounding hillsides. The more natural water retention which can be developed in upper watershed water courses, the greater will be the resulting reduction in runoff peaks in the Bloomfield and Valley Ford areas. The restoration of riparian plant communities, including wetland plant species, serves a number of valuable water quality functions. Riparian vegetation traps and utilizes excess inorganic nutrients (nitrate and phosphate). Riparian areas also serve as relief floodways and water and sediment retention areas during periods of very high runoff.

The inorganic nutrient removal function has several potential benefits. First, lowering nutrient levels in water flowing into Americano Creek will reduce the potential for problematic algae blooms in the creek and associated oxygen depletion events. Second, nutrient loading of the upper portion of the estero will be reduced, ameliorating the present problem of extremely low dissolved oxygen concentrations in this part of the system.

Estimating the number of landowners, stream miles and acres that need to be addressed

To estimate the costs of riparian restoration of minimally and partially vegetated stream segments in the Estero Americano and its sub-watersheds, a 30 foot buffer along both sides of stream segments was generated in a GIS to derive restoration area in acres. The stream segments were also coded with parcel APN numbers so that landowners could be identified for outreach purposes. The analysis found that over 14 stream miles have minimally vegetated riparian corridors, and there are approximately 104 acres in need of riparian restoration (Table 1-3).

In addition, there are approximately 7.1 stream miles that have only partially vegetated stream corridors, needing 51.4 acres of riparian restoration (Table 1-4).

Table 1-3. Minimally Vegetated Riparian Corridors

Location	Landowners	Acres	Stream Miles
Upper Watershed	**20**	**37.1**	**5**
Upper Americano Creek	9+	19.4	2.6
Upper Tributaries	11	17.7	2.4
Middle Watershed	**14+**	**53**	**7.3**
Middle Americano Creek	4	3.6	0.6
Middle Tributaries	5+	31.1	4.3
Ebabias Creek	5	18.3	2.4
Lower Watershed	**3**	**12.7**	**1.7**
Totals	**37+**	**103.7**	**14**

Table 1-4. Partially Vegetated Riparian Corridors

Location	Landowners	Acres	Stream Miles
Upper Watershed	**19**	**31.2**	**4.3**
Upper Americano Creek	12	19	2.6
Upper Tributaries	7	12.2	1.7
Middle Watershed	**10**	**15.9**	**2.23**
Middle Americano Creek	2	4.8	0.64
Middle Tributaries	3	3.7	0.49
Ebabias Creek	5	7.4	1.1
Lower Watershed	**2**	**4.3**	**0.58**
Totals	**31**	**51.4**	**7.1**

Table 1-5. Estimating costs per stream mile

Restoration Practice Components	Unit	Number of Units	Unit Cost	Total
Fencing, barbed 4-strand	ft	5280 ft	5	26,400
Fencing, high tensile 4-strand	ft	5280 ft	5	26,400
Off-channel Water Development		1 ea		
Pipeline, 1.5"	ft	1200 ft	5	6,000
Tank, 2000 gal	ea	1 ea	2,000	2,000
Trough, 600 gal	ea	2 ea	600	1,200
Pump, solar	ea	1 ea	3,400	3,400
Livestock Crossing, rock	ea	1 ea	2,500	2,500
Revegetation, multiple species	ac	2 ac	2,200	4,400
Trickle system	ac	2 ac	1,200	2,400
Bio-revetment (willow wall)	ea	2 ea	5,000	10,000
Trickle system	ac	1 ac	1,200	1,200
Grade Stabilization Structure, rock	ea	4 ea	6,000	24,000
Total Riparian Restoration Cost per Mile ***Costs are variable and do not include labor, design or permittting.** ***Cost estimates for line-items were derived from USDA, NRCS cost sheets for Sonoma County as well as recent RCD project cost accounting.**				**83,500**

Table 1-6. Summary of Costs for Riparian Restoration.

Riparian Restoration Needs	Stream Miles	Acres	Estimated Restoration Costs
Minimally Vegetated Riparian Corridors	14	103.7	1,169,000
Partially Vegetated Riparian Corridors	7.1	51.4	592,850
Total Riparian Restoration Costs	21.1	155.1	1,761,850

Appendix E. Fisheries Enhancement Report

Limiting Factors for Estuarine and Freshwater Fisheries in the Estero Americano Watershed

Anecdotal reports from watershed residents claim that the Estero Americano and Americano Creek once supported runs of coho salmon and steelhead trout. Both of these species require year-round, cold freshwater habitat of relatively high quality during a portion of their life cycle. Steelhead trout and other anadromous salmonids spawn in freshwater, spend various lengths of time in an estuary before migrating to the ocean, and then return to their natal streams to complete their life cycle.

The Estero Americano and its tributary, Ebabias Creek, are designated as *Critical Habitat* for "winter run" steelhead trout by the National Oceanic and Atmospheric Administration (NOAA) (50 CFR 226). However, due to conditions in the estuary and its tributaries such as the absence of perennial freshwater flow, siltation of former spawning areas, denuded stream corridors, fish passage barriers, and poor water quality the system does not currently support salmonids.

Unfortunately, there is no reliable information on the historic abundance of salmonids in the Estero Americano and its tributaries. NOAA's National Marine Fisheries Service (NMFS) recommends stream surveys be conducted on four of the estuary's tributaries to assess restoration potential. California Department of Fish and Game (CDFG) staff biologist, Bill Cox, believes that Ebabias Creek may be the only restorable freshwater habitat left in the system for salmonids (personal communication).

The State of California has also designated the estuary and its main tributaries as potential spawning and cold freshwater habitat for fish species. The intended or desired "fisheries" beneficial uses of the Estero Americano Hydrologic Unit as determined by the State of California include:

- Cold Freshwater Habitat
- Estuarine Habitat
- Marine Habitat
- Commercial and Sport Fishing
- Migration of Aquatic Organisms,
- Spawning, Reproduction, and/or Early Development Habitat
- Rare, Threatened, or Endangered Species Habitat

Limiting Factors for Salmonids

Although there remains some debate on specific habitat thresholds necessary for productive salmonid populations, there is broad consensus that salmonids require the following:

- Cool, clean, well oxygenated water;
- Clean spawning gravel;
- Complex stream channel structure (e.g., riffles, pools, and glides);

- Adequate summer stream flows and deep pools;
- Diverse, well-established riparian vegetation;
- Complex instream habitat elements such as large woody debris;
- Abundant food supply;
- Free, unobstructed migration for juveniles and adults to and from the stream of origin; and
- Estuarine conditions that support production of prey organisms for juvenile out-migrants as well as for rearing and returning adults.

Fisheries biologists assess habitat suitability based on an evaluation of *limiting factors* or habitat requirements for specific species. Limiting factors for salmon and steelhead trout can be defined as conditions that limit the ability of habitat to fully sustain healthy populations. Table 1 lists the potential limiting factors for fisheries in the watershed.

Table 1. Potential Habitat Limiting Factors for Freshwater Streams in the Estero Americano watershed.

Stream Segment	**Fish Passage**	**Riparian Vegetation**	**Instream Habitat**	**Substrate**	**Flow**	**Water Quality**			
						Nutrients	**Temp.**	**DO**	**Turbidity**
Upper Americano Creek	**X**	**X**	**X**	**X**	**X**	**?**	**?**	**?**	**?**
Americano Creek		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Upper Ebabias Creek	**X**				**?**				
Ebabias Creek	**X**	**X**	**X**	**X**	**X**	**?**	**?**	**?**	**?**

Although comprehensive stream habitat surveys have not been conducted in the Estero Americano Watershed, a number of watershed assessments over the last few decades have concluded that there is a lack of suitable habitat for salmonids (Madrone Associates, 1977; Commins et al., 1990). A two-year fish sampling survey conducted in the Estero Americano between 1988 and 1990 found only one steelhead trout in the estuary (Commins et al., 1990).

Americano Creek

Americano Creek is roughly 7.6 miles in length and drains the upper third of the Estero Americano Watershed before flowing into the tidal estuary at Valley Ford. There are three USGS blueline ephemeral streams draining into Americano Creek, Bloomfield Fork and two unnamed tributaries. Each tributary is approximately 14,000 feet in length. Denuded, eroding streambanks are almost universal throughout the system due to historic riparian vegetation clearing, changes in sediment transport and hydrology, and ongoing livestock access to stream corridors. Functional riparian plant communities are either nonexistent or are highly degraded. In most areas, even where willows are present, stream banks are unstable.

The hydraulic geometry of Americano Creek is predominantly rectangular and much wider in most areas than it would be in an undisturbed system; reflecting channel response to changes in land cover and use. Fine sediment deposition in the channel bottom is excessive, and has resulted in aggradation of the stream channel relative to bank height. Channel scour and sediment deposition patterns lead to lateral movement and widening, as the stream is alluvial and the average stream gradient is less than 1% (See Appendix A).

Flow: Flow in Americano Creek, the estuary's main tributary, is very low between May and December, with surface flow disappearing within this period in most years. Although pools fed by subsurface flow remained into summer months, they were heavily polluted with animal waste. An aquatic resources assessment conducted in the late 1980s to evaluate the potential for development of freshwater resident and anadromous fisheries in Americano Creek concluded that the lack of year-round flow precludes a fishery in the creek (Smith and Horne, 1990).

Instream Habitat: Over 85 percent of the land in the Americano Creek sub-basin is used for agriculture. Vegetative cover is predominantly range or pastureland, riparian vegetation is sparse, and there are no mature forests in the watershed. According to a 1988 stream assessment and report, deposition patterns in the stream channel bottom indicate that the supply of fine sediment to Americano Creek significantly exceeds the carrying capacity of the stream; and, that the overall condition of the aquatic environment and its riparian areas and associated wetlands is poor (Beull, 1988). No fish resources were found in Americano Creek or its smaller tributaries at the time of this earlier study (Smith and Horne, 1990).

Water Quality: Surface water monitoring conducted between 1988 and 1990 found that high ammonia levels, high temperatures, and low dissolved oxygen levels preclude the re-establishment of healthy fish populations in Americano Creek.

Un-ionized Ammonia: Water quality monitoring data from the late 1980s found that the average concentration of un-ionized ammonia in Americano Creek is between 0.1 and 1 mg-N/L, depending on season and location. Un-ionized ammonia can be lethal to aquatic life at concentrations of 0.025 mg/L. Over a two-year period, about 40 percent of the ammonia observations in Americano Creek exceeded the acute criterion.

Dissolved Oxygen (DO): Dissolved oxygen levels in Americano Creek and the upper estuary fluctuates diurnally. In spring, following animal waste loading during winter, DO declines to near 0 ppm each night. DO optimal attainment levels for cold water fisheries should be around 5 ppm in the estuary and 6 ppm in the tributaries. Dissolved oxygen levels in the upper Estero Americano and Americano Creek fall below these attainment levels. Seasonal minimum DO levels are sufficiently low to be fatal to most fish.

Temperature: Temperature is important because it directly affects aquatic organisms, and also influences the physical characteristics of water and pollutants such as dissolved oxygen and ammonia discussed above. Cool water contains higher levels of dissolved oxygen than warmer water and has lower levels of toxic un-ionized ammonia.

Primary environmental or human factors influencing surface water temperatures in the Estero Americano Watershed include heat loadings from direct sunlight due to lack of riparian vegetation and high turbidity levels due to high rates of erosion in the watershed. The Estero Americano watershed is considered critical habitat for salmonids (steelhead trout). The upper optimum temperature for salmonid rearing is 15.6 °C; the lower optimum temperature is 10 °C. During summer months, temperatures in Americano Creek can reach 25 °C.

Ebabias Creek

The sub-basin for Ebabias Creek is approximately 4,200 acres in size. The creek flows 5.3 stream miles from its headwaters near Burnside Road down through the valley paralleling the Freestone-Valley Ford Road, and then into the estuary below the Town of Valley Ford. There is one USGS blueline ephemeral stream flowing into Ebabias Creek, as well as a number of smaller seasonal streams in the upper portion of the watershed. Most of the land in this sub-basin is open rangeland, however, some portions of the upper sub-basin are heavily wooded.

According to a CDFG staff biologist, Ebabias Creek is likely the only potentially restorable freshwater habitat for steelhead trout in the larger Estero Americano Watershed. Based on a riparian corridor assessment conducted for this management plan, there are approximately 2.5 stream miles in the upper Ebabias Creek sub-basin that meet some of the spawning and rearing habitat requirements for steelhead trout. There are, however, at least three significant fish passage barriers between the estuary and spawning habitat in the upper watershed. An extensive stream survey and cost-benefit analysis should be conducted for Ebabias Creek to determine restoration potential and feasibility.

There is currently no surface water or aquatic resources monitoring data for Ebabias Creek.

Estuarine Habitat Factors

Tidal circulation in the Estero Americano extends over four miles inland.
There are approximately 300 acres of open water habitat and 240 acres of tidal and brackish marsh habitat in the estuary. The Estero Americano provides food, shelter and nursery habitat for many marine and estuarine fish species. Thirty-five species of fish were identified in the estuary during a biological assessment conducted between 1988 and 1990. During this study, only a single steelhead trout was identified.

Excessive sedimentation entering the estuary over the last 120 years has raised the elevation of the estuary's bottom and lowered the volume of tidal exchange. This has resulted in the reduction of tidal scouring, particularly at the mouth of the estuary, and is a factor in the periodic closure of the estuary's mouth. The seasonal formation of a sandbar across the mouth of the estuary and the lack of perennial freshwater flow in the system leads to hypersaline and hypoxic conditions in the upper estuary during summer months. These estuarine conditions are considered to be inconsistent with the establishment of an anadromous fishery in the watershed according to some fisheries biologists (Buell, 1988).

Recommendations

- Work with the agricultural community to employ agricultural best management practices to reduce nutrient and sediment pollution entering the estuary and its tributaries.
- Work with the agricultural community to protect and restore riparian corridors.
- Conduct stream habitat surveys along Ebabias Creek and its tributary streams.
- Conduct a biological assessment of aquatic organisms in the estuary and Ebabias Creek.
- Identify all fish passage barriers along Ebabias Creek and its tributaries and assess costs of removal.

APPENDIX F. MONITORING NEEDS & GUIDELINES

Tracking Watershed Management Plan Objectives

The assessment and monitoring programs presented in this chapter were selected to address existing data gaps, to assist landowners and natural resource managers in their efforts to protect and enhance the natural resource base of the watershed, and to provide guidance in the implementation of this watershed management plan.

Assessment and monitoring programs recommended within the Estero Americano Watershed Management Plan are designed to answer the two following questions:

1) Are the Estero Americano and its tributaries currently achieving the water quality objectives established by the North Coast Regional Water Quality Control Board?

2) Are the beneficial uses of the Estero Americano and Americano Creek being maintained and protected, and if not, what are the limiting factors?

Monitoring is a technical term that denotes collecting a series of observations over time in order to detect changes or trends. Monitoring programs can be very expensive and labor intensive. Due to the lack of public funding for extensive monitoring, only one monitoring program is addressed in this chapter.

The repetition of measurements over time for the purposes of detecting change distinguishes monitoring from *inventory* and *assessment*. Although inventories and assessments can be based on a single measurement or observation, they can also incorporate a series of observations to either gauge conditions before and after some management action or change, or, to gain a more accurate estimate of a specific parameter. Often, an assessment or inventory will serve as a first step towards developing a longer term monitoring program. Assessments and inventories can provide important information on baseline or current conditions if conducted properly.

Priority Monitoring & Assessment Programs:

Ambient Surface Water Monitoring Program
Riparian Assessments
Ranch Roads Surveys and Assessment
Gully Erosion Assessment
Residual Dry Matter Assessment
Manure Land Application Tracking and Assessment

AMBIENT SOURCE WATER MONITORING

Program Objective

To measure water quality background conditions and long-term trends, and to document watershed-scale responses to the implementation of best management practices recommended in this watershed management plan.

Watershed Management Plan Objective

Achieve water quality standards for nutrients and sediment in the estuary and its tributaries by 2016.

Program Description

Develop a surface water ambient monitoring program for the Estero Americano Watershed. To determine whether or not the Estero Americano is meeting established water quality objectives, eight monitoring locations will be selected within the watershed. Monitoring sites will be selected along the mainstem of Americano Creek, Ebabias Creek, and the estuary itself. Frequency of sample collection and analyses will vary by season, with higher frequency sampling (bi-weekly) in the winter and decreased frequency (monthly) in the summer.

Sampling and analysis will include field measured and laboratory analysis for selected parameters. Field measured parameters will include stream discharge, temperature, dissolved oxygen, conductivity and pH. Collected water samples will be preserved and transported at 4^{o} C to the appropriate water quality analytical laboratory. Samples will be analyzed for turbidity, pH, conductivity, suspended sediment concentration, total nitrogen, ammonium/ammonia (NH_4/NH_3), nitrate ($N0_3$). If warranted, samples will also be analyzed for total phosphorus and orthophosphate. Values of ammonium/ammonia combined with instream measurements of pH and temperature will be used to calculate the concentration of un-ionized ammonia (NH_3).

A State Water Resources Control Board (SWRCB) approved Monitoring and Assessment Plan (MP) and a Quality Assurance Project Plan (QAPP) will be developed for the program. The MP and QAPP will guide monitoring activities. All data will be stored and compiled in a manner that is consist with SWAMP program protocols thus allowing integration of the projects data into the SWAMP database.

RIPARIAN ASSESSMENT

Program Objective

Track the abundance and distribution of riparian vegetation in the Estero Americano Watershed at least once every 5 years.

Watershed Management Plan Objective

Stabilize streambanks and revegetate 6 miles of degraded stream corridor in the watershed by 2010.

Stabilize streambanks and revegetate an additional 8 miles of degraded stream corridor by 2014.

Enhance habitat values and habitat connectivity on private lands.

Program Description

Assessing, protecting, and enhancing riparian habitat is a stated goal of this watershed management plan. Over half of the stream miles in the watershed currently lack healthy riparian vegetation. Riparian areas in the watershed will be periodically assessed to measure the achievement of this goal. Restoring and protecting riparian vegetation along streams will improve water quality, instream and riparian habitat, and will significantly reduce sediment loading to the estuary and its tributaries from streambank erosion.

Riparian area assessments will be conducted using high-resolution aerial photography. Stream segments will be coded based on the abundance of vegetation in the riparian zone, approximately 50' on each side of the stream. This information will be added to an existing riparian assessment GIS data layer. In addition, the GIS data layer will be updated each time a stream segment is stabilized and revegetated.

Streambank stabilization projects will use bioengineering techniques and native plantings. Photo-monitoring will be conducted for all restoration projects.

RANCH ROAD EROSION ASSESSMENTS

Program Objective

Quantify and reduce erosion caused by improperly designed or maintained ranch roads.

Watershed Management Plan Objective

Upgrade 15 miles of ranch roads in the watershed by 2010

Program Description

Road surfaces, cut and fill slopes, and ditches are common sources of sediment in the watershed. Failures of road crossing fills or cut and fill slopes produce episodic sediment runoff, usually during large precipitation events. Better road maintenance, design and upgrading of ranch roads will reduce chronic sediment loading to the estuary and its tributaries.

A systematic field inventory of a maximum of 40 miles of roads will be conducted to delineate all sites that are currently delivering sediment or pose a risk of sediment delivery to nearby streams in the lower Estero Americano Watershed and in the Ebabias Creek sub-basin. For each identified site, a data form will be filled out that includes detailed information on the nature and magnitude of existing and potential erosion problems; the likelihood of erosion or slope failure; the recommended treatment immediacy; the volume of future erosion; the percentage of delivery to the stream system; and recommended treatments to eliminate or drastically reduce each site as a future sediment source.

A tape and clinometer survey will also be completed on almost all stream crossings in order to develop reproducible volume estimates for future erosion, and for road upgrading and road decommissioning treatments. Sites will be mapped using either mylar overlays over 1:12,000 scale aerial photographs or on GIS base maps created from existing data layers and from the results of the aerial photograph analysis. Future sediment delivery volumes will be computed utilizing one of several methods, depending on the type of site. These volumes will be included on the data form for each site. For stream crossings, the tape and clinometer method described above will be used to calculate erosion and sediment delivery volumes for crossings that are not properly constructed (where culverts are not appropriately sized and/or installed, for example). This method utilizes double-end-area calculations to quantify the fill volume that will be delivered to the stream if the crossing washes out.

GULLY EROSION ASSESSMENT

Program Objective

Identify and quantify potential sediment yields from high priority gullies.

Watershed Management Plan Objective

Restore or mitigate erosion from a minimum of 8 gullies in the watershed by 2010.

Program Description

The gully erosion assessment program will build on a recently completed watershed assessment for the Estero Americano. High-resolution 2004 aerial photographs were used to map gullies throughout the watershed. Two hundred and eighty-three gullies were mapped; of these, 166 occur on soils with a high erosion hazard (close to 60% of gullies mapped). Although aerial photo-interpretation can provide valuable information on the location and extent of large gullies in the unwooded portions of the watershed, the type of erosion and erosion activity levels cannot be determined from aerial photographs.

A gully erosion assessment will be conducted on the 14 gullies located directly adjacent to the estuary, the 42 gullies that drain into Ebabias Creek, and any gully located above a dairy or livestock high-use area that is also located along the mainstem of Americano Creek as identified in the recently completed watershed assessment. The inventory and monitoring methods used for this erosion assessment will be based on UC Cooperative Extension's *Sediment TMDL Site Inventory and Monitoring User Guide* (1998).

Final site selection will be based on a sediment delivery inventory using the following criteria: 1) potentially deliverable sediment that is actually delivered to a watercourse; 2) potential sediment delivery that is management induced; 3) potential sediment delivery that is reasonably responsive to mitigation; and 4) potentially deliverable sediment that is greater than an established volume threshold. Treatment levels selected for individual sites will range from fencing out and revegetating the area to grade stabilization structures and reshaping. Treatment methods will be based on cost effectiveness and sediment volume thresholds.

RESIDUAL DRY MATTER (RDM) ASSESSMENTS

Program Objective

Conduct RDM assessments on priority conservation parcels, and increase RDM values by 15% using conservation management measures and practices.

Watershed Management Plan Objective

Enhance rangeland and pasture on 20 livestock ranches and dairy operations in the watershed to reduce streambank erosion and sheet and rill erosion by 2010.

Program Description

Grazing management practices influence sheet and rill erosion on rangeland. Overgrazing can result in low RDM, reducing site fertility and infiltration rates, and exposing soil to more rainfall—increasing erosion and runoff. Treatment for low RDM includes better site preparation, seeding and fertilization, and increased grazing management.

The program will work with a potential 20 livestock ranches and dairies in the watershed to update Ranch Plans and to conduct RDM assessments, and to to develop and implement better grazing management practices. Conservation-oriented ranch plans will include an inventory of existing resources and resource conditions; operational goals; water quality management issues and objectives, along with a prioritized list of conservation management practices and measures that will reduce soil loss and agricultural runoff. It is anticipated that most of the ranches will develop and implement grazing plans as part of the ranch planning process. Grazing plans will be based partially on RDM assessments and monitoring.

Guidelines used for the program will be based on a number of conservation planning documents, including *The California Rangeland Water Quality Management Plan* (1995) and USDA, NRCS conservation planning guidelines and *Technical Office Field Guide* (TOFG). Monitoring protocols will be based on UCCE, *Guidelines for Residue Management on Annual Range*.

TRACKING LAND APPLICATION OF MANURE

Program Objective

Assist dairy operators in the watershed to better track land application of manure, and to promote application at agronomic rates based on soil, manure and vegetation sampling.

Watershed Management Plan Objective

Have all dairies adopt nutrient budgeting and management planning by 2010.

Develop a manure land application tracking system for the entire watershed by 2012.

Document reductions in nutrient concentrations in Americano Creek and the Estero Americano, with apparent trends by 2010.

Program Description

The District, in collaboration with UCCE and USDA, NRCS, will design and promote the adoption of a manure land application tracking system as part of a larger nutrient budgeting and nutrient management planning program. Soil, vegetation, and manure sampling will be conducted to evaluate nutrient content and fertilization requirements for individual dairies. A land application tracking system will be implemented to record current waste loads applied on a per field basis. Sampling results will be used to calibrate land application rates and timing the following year.

Program effectiveness will be measure by the adoption of on-farm nutrient management plans, nutrient budgets, land application tracking, and reductions in nutrient waste loads applied to farm fields in excess of soil requirements and crop nutrient demand.

The end goal of these efforts is to have dairy operators quantify and better manage on-farm nutrient production and consumption. Through this process, operators will be able to assess and calculate potential excess nutrient loads, and address any nutrient imbalance through export of nutrients from the watershed, composting strategies, or other effective management strategies.