SAN GERONIMO VALLEY SALMON ENHANCEMENT PLAN

A Guidance Document

Prepared for

Marin County Department of Public Works

Prepared by

Prunuske Chatham, Inc.

with assistance from
Stillwater Sciences

December 23, 2009

Prunuske Chatham, Inc. is very grateful to the Salmon Advisory Committee and Technical Advisory Committee members for their thoughtful and thorough review of the Draft Enhancement Plan. We also wish to acknowledge the residents of San Geronimo Valley who participated in public meetings and provided their comments and ideas, including detailed implementation suggestions. Although we could not address all of the comments under the scope of this document, we trust they will continue to inform the next steps in sustaining San Geronimo's salmon and steelhead runs.

We would like to the Marin County Department of Public Works for their technical review and formatting of the final Draft Plan. A special thanks to Alekzander Pang and Laurie Williams with Public Works for producing many of the report graphics and photos and to Margaret Young and Justin Bodell at PCI for producing the graphics in the appendices.

Final Draft – December 23, 2009

Executive Summary

The Salmon Enhancement Plan presents science-based recommendations to improve and maintain habitat conditions that will support viable populations of salmon and steelhead trout in San Geronimo Valley. The Lagunitas Watershed, which includes San Geronimo Valley, is the largest and most stable population of the endangered coho salmon south of Fort Bragg and presents one of the best opportunities to preserve and restore coho in central California. In addition to coho salmon, San Geronimo also supports threatened steelhead trout and a fall run of Chinook salmon.

This Plan is not a regulatory document. It is not being presented to the County for approval. Any new policies or ordinances informed by the Plan would require a full public process and approval by the Board of Supervisors.

The Plan is based on four core strategies. The first is to **preserve and improve habitat conditions for all salmonid life stages that occur in San Geronimo Valley**. Other than collective efforts to address climate change and better care for ocean ecosystems, there is little Marin County and San Geronimo Valley residents can do to directly improve ocean conditions. However, residents can provide habitat that supports sufficient spawning, rearing, and over-wintering habitat to deliver healthy smolts into the ocean. The second core strategy is to **promote ecosystem resiliency through rehabilitating natural processes.** By protecting and restoring processes such as the delivery of sufficient quantities of cool, clean water and the development of diverse instream conditions, San Geronimo's fish and other wildlife will be better able to survive future environmental changes. The third strategy is to **correct and avoid activities that degrade habitat** wherever possible. In recognition that any measures to enhance habitat take place within a long-established community, the fourth core strategy is to **sustain the character and quality of life in San Geronimo Valley.**

The Plan process began in the summer of 2008 with the Existing Conditions Report (ECR) completed in February 2009 (Stillwater Sciences 2009a.) A Salmon Advisory Committee (SAC) and a Technical Advisory Committee (TAC) comprised of public agency representatives, technical experts, and watershed landowners was formed to guide the process. In addition, five public meetings were held in the San Geronimo Valley from August 2008 through October 2009. Substantial input was received from the San Geronimo Valley community and considered in the final draft. The Plan will be presented to the Marin County Board of Supervisors as a draft set of recommendations in February 2010 when the building moratorium is scheduled to end. .It is recommended that the County develop an implementation plan in conjunction with the community after the Board accepts this guidance document. The implementation plan, environmental compliance documents, and the necessary budget request would be presented to the Board of Supervisors at a future date . Workshops and community outreach are planned following February's Board meeting.

The total estimated cost for implementation of the recommended measures by the County is approximately $1,536,500. This amount includes costs to develop community outreach and landowner incentive programs, planning and monitoring but not actual construction of any proposed improvements. Many of these recommendations depend upon voluntary implementation by homeowners with support from Marin County and other agencies. Ideas for homeowner incentives include low-cost assessments from engineers and other technical experts, free green waste disposal for invasive plant material, and conservation corps work days to help with planting, relocating small structures away from streambanks, and other labor-intensive actions. Strategies for simplifying environmental compliance and suggestions for funding sources are also included. The Plan also includes recommendations for a monitoring strategy that would inform regular review and modification of the recommended actions.

The recommendations and scientific background in the Plan provide guidance for:

- Enhancing instream and riparian habitat, and the watershed conditions that support them
- Providing outreach and assistance to homeowners to encourage voluntary implementation of enhancement measures
- Design review, and land use permitting that support healthy streams
- Advancing long-term, collaborative stewardship of the Valley's natural resources
- Supporting state and federal coho population recovery efforts currently underway in this and other coastal watersheds
- Securing grant funding to assist homeowners, the County, and other agencies and organization in implementing enhancement projects

The ECR synthesized information on the biological and physical characteristics of the Valley and identified restoration and enhancement priorities. With the ECR as its scientific foundation, the Plan identifies the habitat elements needed for successful spawning and rearing of salmonids and summarizes the current state of the populations and their habitat. The Plan includes an evaluation of the Federal National Oceanic and Atmospheric Administration (NOAA) coho recovery team targets for spawner population and properly functioning conditions (PFC) to the existing and potentially restorable salmonid habitat in San Geronimo Creek and its tributaries is included. The Plan relies on the assumption that addressing coho habitat needs will also benefit steelhead trout and Chinook salmon as well as many other species of native wildlife.

The recommendations present prioritized actions to conserve, enhance, and monitor critical habitat elements and functions needed to support viable salmon and steelhead populations. They address four primary focus areas: 1) protect and restore riparian habitat; 2) enhance instream habitat structure through adding large woody debris, gently sloping back and planting eroding banks, and establishing inset floodplains where safe and feasible; 3) achieve and maintain high water quality; and 4) achieve and maintain sufficient water quantity. Recommendations, summarized in the table below, include watershed-wide, reach-scale and parcel based measures. Data gaps important for refining and implementing the recommendations are also identified.

Plan Recommendations

Recommen-dation Focus	Salmonid Habitat Supported		Recommendation	Priority
Applies to all	All salmonid life stages	1	Establish and support a community outreach process to guide implementation	High
Protect and restore riparian habitat	**Rearing Habitat**: Tall, dense riparian vegetation keeps water cool, provides food in the form of nutrient input and detritus for insects that nourish fish and their prey, and contributes undercut roots and large pieces of wood to help create the habitat variety salmonids need to thrive. Riparian plants also help filter fine sediments and excessive nutrients from entering streams. **Spawning Habitat**: Trees and large branches that fall into streams help trap and sort gravel. **Winter/Spring High Flow Habitat**: Fallen wood and living plants on flooded stream terraces provide direct shelter for fish during storms and also help form pools.	2	Protect and enhance the riparian corridor to create healthy, self-sustaining habitat.	High
		3	Develop a riparian vegetation management strategy with fire officials to allow fire-safe practices while preserving riparian habitat.	Medium
		4	Apply policies, regulations, and guidelines to protect salmonid habitat and the ecological functions that sustain it to all new development and redevelopment currently allowable in the SCA.	High
		5	Consider conservation of key undeveloped streamside parcels through easements or purchase of fee title	Medium
		6	Consider development of a process to promote the replacement, removal, and modification of unpermitted structures in the SCA that adversely effect fish habitat.	Medium - Low
Enhance instream habitat structure	**Rearing Habitat**: Juvenile salmonids need a complex set of habitat features to provide optimal foraging and resting conditions; riffles to support aquatic insects; places under rocks, roots, undercut banks, or large pieces of wood to rest and hide from predators; and deep pools with cool water temperatures.	7	Develop plan to increase channel complexity to improve habitat quantity, value, and resiliency for all life stages.	High
		8	Promote removal of barriers to fish migration.	Medium - High
		9	Promote instream gravel delivery and retention.	Medium

Recommen-dation Focus	Salmonid Habitat Supported		Recommendation	Priority
	Spawning Habitat: Salmonids need access to clean, pea-to-orange size gravel for successful spawning and hatching. **Winter/Spring High Flow Habitat**: Over-wintering fish need places with-slower flowing water during storms. High-flow refugia are created by large pieces of wood, backwater areas where tributaries join the main stream, and low, vegetated terraces next to the stream channel.	10	Minimize and reduce streambank armoring.	Medium - High
		11	Develop an Instream Habitat Implementation Plan.	High
Achieve and maintain high water quality.	**All salmonid life stages**: Salmon and steelhead need cool, well-oxygenated water to thrive. Excess levels of suspended particles in the water (i.e., turbidity or total suspended solids) can also cause stress, including reduced growth, feeding, and reproduction. Heavy metals, pharmaceuticals, and other chemicals can affect fish health and behavior, which in turn affects their ability to survive and reproduce. **Spawning Habitat**: Fine sediments can impair oxygen flow to eggs and impede the emergence of fry from the gravel. Cool water temperatures are also critical to the survival of the eggs.	12	Promote increased watershed-wide stormwater retention and disconnection.	High
		13	Develop a community-supported program to assist homeowners with addressing leaking septic systems. Give highest priority to systems within SCA and in reaches with higher nutrient levels.	Medium
		14	Promote minimal usage and proper disposal of chemicals, nutrients, and toxic materials.	Medium
		15	Reduce fine sediment delivery from roads and upland erosion.	Medium - High
Achieve and maintain sufficient water quantity.	**Rearing Habitat**: Sufficient summer baseflow is elemental to fish survival. It is also key to maintaining water quality. **Spawning Habitat**: Salmonids need sufficient flows during spawning season to move up into the tributaries and again in the early summer when young fish begin their out-migration to the ocean.	16	Protect and enhance summer streamflow.	High
Applies to all	All salmonid life stages	17	Develop and implement a coordinated monitoring program.	High

TABLE OF CONTENTS

Page

Chapter 1. Introduction 1-1

1.1 Overall Goal and Core Strategies 1-2

1.2 Plan Objectives 1-5

1.3 Plan Overview 1-6

1.4 Plan Process 1-7

Chapter 2. Recommendations for Mitigation, Protection, and Enhancement 2-9

2.1 Watershed-wide Recommendations by Focus Area 2-9

2.2 Prioritization System for Watershed-wide Recommendations 2-12

2.3 Watershed-wide Recommendations by Numerical Order 2-15

2.4 Data Gaps 2-59

2.5 Reach-specific Priorities and Recommendations 2-60

Chapter 3. Summary of Salmonids and their Habitat in San Geronimo Valley 3-70

3.1 The Fish 3-70

3.2 Populations and Survival Indicators 3-74

3.3 The Habitat 3-76

3.4 Human Impacts 3-78

3.5 Threat - Climate Change 3-81

3.6 Threat - Disturbance Regimes 3-82

Chapter 4. Targets for Recovery and Habitat Rehabilitation 4-85

4.1 Salmonid Life-stage Population Goals 4-85

4.2 Habitat Elements and Components Required to Support Population Targets 4-91

4.3 Rehabilitation of Physical Conditions and Processes to Support Critical Habitat Elements 4-99

Chapter 5. Policies and Regulations that Protect Salmonids and their Habitat 5-104

5.1 2007 Marin Countywide Plan 5-104

5.2 Marin County Ordinances 5-110

5.3 State and Federal Regulations 5-112

Chapter 6. Recommended Implementation Strategies 6-115

6.1 Recommendations for Implementation 6-115

6.2 Recommended Implementation Measures and Cost Estimates 6-121

6.3 Incentives and Resources for Homeowners 6-123

6.4 Funding options 6-124

6.5 Coordinated Environmental Compliance Strategies 6-128

6.6 Monitoring for Adaptive Management 6-130

6.7 Plan Oversight 6-133

Chapter 7. References 7-134

FIGURES AND TABLES

Figure 1. Location of San Geronimo Valley in the context of the Lagunitas Watershed. 1-2

Table 1. Summary of Plan recommendations for San Geronimo Valley residents. 1-8

Figure 2. Functions of riparian habitat 2-17

Table 2. Summary of existing riparian protection for streams in Marin County. 2-19

Figure 3. Channel cross-section. 2-34

Table 3. Reach vegetation recommendations. 2-67

Figure 4. Extent of salmonids in San Geronimo Valley (ECR Figure 3-17). 3-72

Figure 5. Timing of life stages for the anadromous salmonids present in San Geronimo Valley..... 3-73

Figure 6. Number of coho redds observed in the San Geronimo watershed during the spawning periods 1997/8 through 2007/8 (data from ECR, Table 3-16). 3-74

Figure 7. Population estimates of steelhead and coho in San Geronimo Valley in late summer, 1995-2008 (data from ECR, Table 3-17). 3-75

Figure 8. Comparison of coho juvenile abundance in the fall and the following spring, indicating apparent winter survival and habitat carrying capacity of the San Geronimo Valley (data from ECR, Table 3-18)..... 3-76

Figure 9. Habitat components that support salmonid life stages. 3-77

Figure 10. Existing development pattern as shown by impervious surfaces in San Geronimo Valley (ECR Figure 3-2). 3-79

Figure 11. Cumulative percent TIA in reaches of San Geronimo Valley as an indicator of level of urbanization (ECR Figure 3-4). 3-80

Figure 12. Conceptual approach summarizing the estimation of habitat area needs and life-stage density goals to support a minimum viable coho population in the San Geronimo Creek watershed. 4-86

Table 4. Targets for critical habitat elements of salmonid over-wintering habitat to support emergent fry survival and juvenile survival to smolting. 4-94

Table 5. Targets for critical elements of salmonid summer rearing habitat to support optimal juvenile growth and survival. 4-96

Table 6. Targets for critical elements of salmonid spawning habitat to support returning adults, successful egg hatching, and emergence..... 4-98

Table 7. Targets for the restoration of a sustainable and resilient riparian zone..... 4-102

Table 8. Targets for tracking hydrologic function in San Geronimo Valley. 4-103

Figure 13. Map of parcels within San Geronimo Valley with additional potential development units and number of units..... 5-106

Figure 14. Comparison of development in San Geronimo Valley using existing conditions, original zoning criteria, and the application of the combined 1994 and 2007 CWP policies. 5-107

Figure 15. Comparison of existing cumulative TIA and projected cumulative TIA based on 2007 CWP allowable buildout units for each subwatershed. 5-107

Table 9. 2007 Marin Countywide Plan policies – Natural Systems & Agriculture element. 5-108

Table 10. Marin County ordinances. 5-110

Table 11. State and federal permits required for actions that affect stream habitat..... 5-113

Table 12. Summary of Recommended Implementation Items. 6-116

Table 13. State, federal, and foundation grant sources. 6-125

Table 14. Monitoring types for restoration or enhancement projects. 6-131

Table 15. Example of implementation monitoring components for restoration projects anticipated in the San Geronimo Creek watershed. 6-132

Chapter 1. Introduction

San Geronimo Valley is a rare place. Despite examples of nearly every major root cause of watershed degradation—past logging, small dams and direct summer pumping, dense development tucked close to stream channels, even historic mining—it is one of the last places along the central California coast to still have a coho salmon population and one of the few where people and salmon exist so closely together. In addition to cool water and relatively dense cover, San Geronimo has residents who are deeply committed to maintaining the character of their Valley, including the salmon and steelhead at its core.

Yet San Geronimo Valley's salmonids are struggling. Coho salmon are listed as endangered and steelhead as threatened under the federal Endangered Species Act within the Central California Coast Evolutionarily Significant Unit (ESU). This designation represents a genetically unique salmon population on our central coast, between Santa Cruz and Fort Bragg. Chinook salmon in the San Geronimo Valley watershed are considered a Species of Concern by federal and state agencies.

- Between the winters of 1995/96 and 2007/2008, an average of 108 coho salmon redds (nests) were counted each year in San Geronimo Valley.
- Based on the NOAA recovery planning process (Chapter 4), 222 redds are needed to support a viable population.
- Overall, the Central California Coast ESU once produced 50,000 to 125,000 spawning coho salmon.
- Now the Central California Coast ESU produces about 5,000 adult fish.

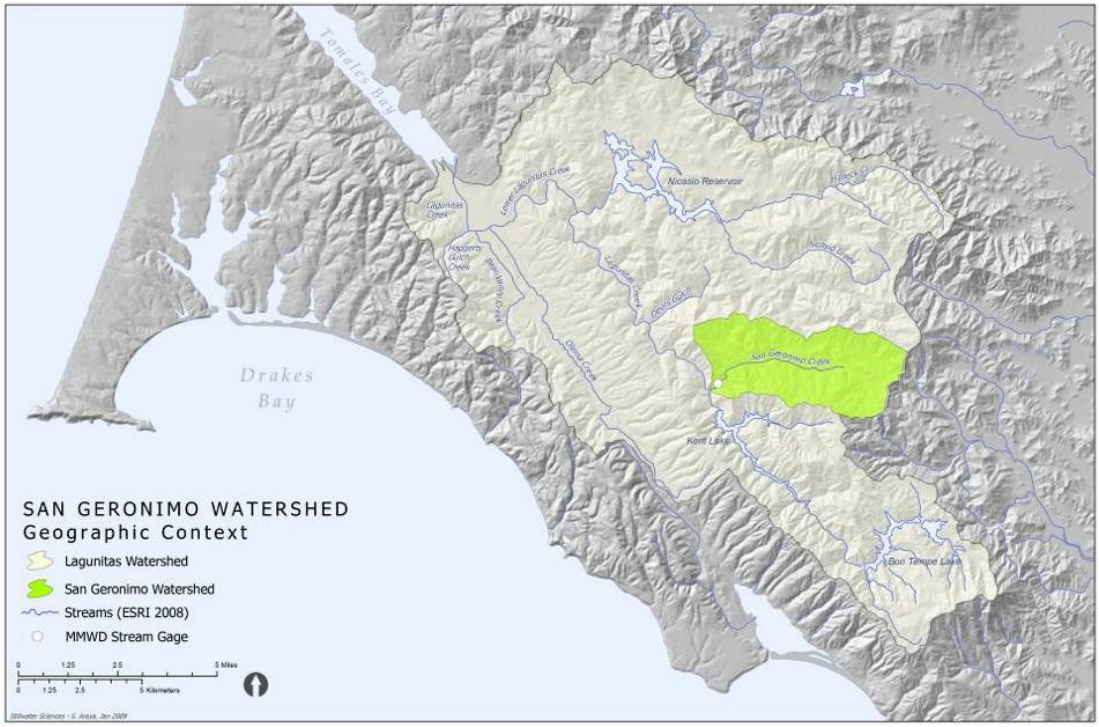
Spawning adult coho return to the Lagunitas watershed. Photo by John Green.

As impacted as it is, the Lagunitas Creek watershed population, which includes San Geronimo Valley (Figure 1), is the largest and most stable south of the Noyo River in Fort Bragg (Stillwater Sciences 2008). The need to protect and enhance habitat in the Lagunitas system, including San Geronimo Valley, is urgent.

Although we don't have estimates of the average number of returning adult steelhead to San Geronimo Valley, populations throughout the state are estimated to be about half of what they were in the 1960s (Stillwater Sciences 2008). Chinook salmon have only recently

colonized the Lagunitas Creek watershed, and a handful return most years to spawn in mainstem San Geronimo Creek.

Figure 1. Location of San Geronimo Valley in the context of the Lagunitas Watershed.



1.1 Overall Goal and Core Strategies

The overall goal of the San Geronimo Valley Salmonid Enhancement Plan (Plan) is to provide science based recommendations to increase salmon and steelhead survivorship in the San Geronimo Creek watershed. The companion report to this Plan, the San Geronimo Valley Enhancement Plan Existing Conditions Report (ECR), synthesized information on the biological and physical characteristics of the Valley and identified restoration and enhancement priorities. The Plan uses the findings of the ECR, NOAA's National Marine Fisheries Service (NOAA) coho recovery planning process, and other scientific analyses to establish habitat targets and make recommendations to achieve them.

The Plan is based on four core strategies:

- Preserve and improve habitat conditions for all salmonid life stages that occur in San Geronimo Valley.
- Promote ecosystem resiliency through rehabilitating natural processes.
- Correct and avoid habitat activities that degrade habitat.

- Sustain the character and quality of life of San Geronimo Valley.

Preserve and improve habitat conditions for all salmonid life stages that occur in San Geronimo Valley

Salmon and steelhead are anadromous fish; they spend most of their adult life in the ocean and return to the streams where they were born to spawn. San Geronimo Creek and its tributaries provide habitat for spawning for all three species, and for summer rearing and over-wintering for juvenile steelhead and coho before they leave the watershed in early summer as smolts headed for the ocean.

Ocean conditions depend on levels of predation, food web dynamics, habitat quality, and ecological interactions that respond to changes in ocean currents and long-term variations known as "decadal oscillations." Except for long-term action on arresting climate change, these mechanisms are beyond our control. Our best shot at assuring that salmon and steelhead will return to spawn in the San Geronimo watershed is to optimize production of healthy smolts. This Plan acknowledges the urgency of first addressing the most critical habitat needs identified in the ECR and promotes protection and enhancement of the whole stream system to support salmonids throughout their entire span in the Valley.

Protecting what works is the most effective and efficient conservation tool. In San Geronimo Valley, this includes keeping existing riparian habitat intact, maintaining streamflows, preventing fine sediments from degrading spawning areas, and protecting areas that provide excellent habitat or opportunities for significant restoration.

Healthy stream habitat in San Geronimo Creek.
Photo by Laurie Williams

Improving habitat conditions is the other primary instrument to maximize the Valley's potential to grow healthy salmonids. The ECR identified a lack of instream high-flow habitat as the primary issue for salmon in the Valley.

During storm events, adult and juvenile fish need places to shelter from high storm flows. With large trees in the creek, undercut banks, or with floodplains that allow water to spread out instead of up, salmon would have places to wait. Establishing these instream conditions can be done at the site scale through revegetation and rehabilitation of stream complexity. Clean, cool water and enough of it for summer rearing are other key issues for salmon and steelhead in San Geronimo.

Promote ecosystem resilience through rehabilitating natural processes

Resilience is the ability to adapt to environmental change. Salmon and steelhead are masters of resiliency and have survived extreme climatic events over their evolutionary history. Their genetic diversity, levels of abundance, and adequate freshwater habitat cushioned them from droughts, floods, and changes in ocean conditions. However, as runs disappear in small coastal watersheds, remaining populations dwindle, and habitat is lost behind dams or degraded beyond usability, salmonid resilience is severely threatened.

A central tenet of this Plan is that by protecting the processes that create and maintain salmonid habitat, we promote the ability of San Geronimo Creek and its wild fish to respond to future environmental changes. These processes include an adequate supply of clean water all year; a healthy, sustainable riparian corridor to moderate water quality, support the stream food web, and supply critical structural elements that can be moved and shaped by flowing water to create a variety of instream habitats; enough room for the stream channel to adapt to watershed changes; access to all useable habitat; and natural sorting of sediment.

Over millennia, salmon have responded to a diversity of environmental changes, including ice ages. The resilience of these animals to adapt to change has allowed the re-population of huge continental areas where salmon had been extirpated. Straying and life history variation are considered vital facets of the resiliency that have allowed salmon to survive extreme climatic events that surely included ocean food web variation as well.

However, previous climatic events were counterbalanced by healthy watersheds and functional ecosystems that allowed salmon from the lower latitudes to repatriate the entire Pacific salmon range. Society now faces the challenge of attempting to manage salmon scarcity at a time of unprecedented human-induced change, not only in the rate, but also in the degree and scale of change. When these cumulative impacts of human-induced change (including low salmon biodiversity) are compounded by stressors of ocean variability and climate change, then how humans manage the watersheds will assuredly determine the fate of these animals.

Paul Siri, SAC Member
Ocean Policy and Science Consultant

Correct and avoid activities that degrade habitat

San Geronimo Valley has changed profoundly in the past 150 years. Most of the stream channels are deeply incised and disconnected from their floodplains. Few mature redwoods and Douglas-firs remain to provide deep, continuous shade and large pieces of wood. Roads and roofs collect rainwater, along with fine sediment, pesticides, oil, and a host of other pollutants, and dump it all into the streams instead of letting it soak into the soil. As houses were built close to streams, banks were covered with rock and concrete to protect property from erosion. Understanding how these changes affect salmonid habitat is fundamental to preventing further degradation and to designing enhancement measures that address causes instead of symptoms.

Sustain the character and quality of life of San Geronimo Valley

Resilience derives not only from the physical characteristics of the ecosystem, but from the social and economic relationships that sustain the physical environment. Part of the reason that salmon and steelhead populations are worth enhancing in San Geronimo Valley is that residents and their neighbors have taken extraordinary measures on behalf of their fish. Sustaining and strengthening this community support is vital to keeping fish in the Valley.

Implementation of the Plan recommendations would rely heavily on voluntary actions by San Geronimo residents. The Plan acknowledges that residents would need strong support from Marin County, other public agencies, and community organizations through education, technical advice, and cost assistance. Although the Plan also provides guidance for planning and permitting new development, the bulk of the work of protecting and enhancing habitat needs to occur on existing developed land throughout the watershed, not just along streams. Upland residents could support streamside landowners through increasing rainwater infiltration, addressing erosion, and keeping pollutants out of stormwater and groundwater. While salmon are at the forefront of this study, most of the improvements made for salmonids also benefit people. Stable streambanks, sufficient clean water, properly-maintained roads, and a beautiful riparian corridor where people and wildlife co-exist contribute value to residents as well as habitat for fish.

1.2 Plan Objectives

The objectives of the Plan are to:

- Support coho population recovery efforts with science-based planning and watershed based recommendations.
- Present policy guidance, programmatic strategies, and recommendations to enhance instream and riparian habitat.
- Encourage voluntary implementation of recommended enhancement measures by watershed residents.

- Support and advance long-term, collaborative stewardship of the Valley's natural resources.
- Support requests for grant funding to assist homeowners, Marin County, and other agencies and organizations in implementing enhancement projects.

This Plan is not a regulatory document. Any new policies or ordinances informed by the Plan would require a full public process and approval by the Board of Supervisors.

1.3 Plan Overview

The Plan is organized into five primary chapters. Chapter 2 presents the Plan recommendations. It includes watershed-wide recommendations to achieve the targets in Chapter 4, studies to fill data gaps, and reach-specific priorities. The watershed-wide actions are organized by four primary focus areas: protect and restore riparian habitat, enhance instream habitat structure, achieve and maintain high water quality, and achieve and maintain sufficient water quantity. Conceptual plans for riparian planting, site layout for streamside property, and stormwater infiltration are included in Appendix H. Key recommendations that rely on implementation by residents are shown in Table 1. Recommendations also include guidance for; outreach, education, and monitoring; and maintenance and enhancement of public lands and roads.

Chapter 3 summarizes the state of salmon, steelhead, and their habitat in San Geronimo Valley. It briefly describes how salmon and steelhead use the watershed, the habitat elements that support them, and human impacts on that habitat. Key issues for San Geronimo Valley include the decline in vegetation cover along streambanks and the scarcity of large, mature trees along valley streams; lack of complex instream habitat, particularly high-velocity refugia for over-wintering fish; and compromised water quality. Water temperatures and dissolved oxygen levels exceed optimal levels in some locations.

Chapter 4 describes how the population goals set by the NOAA salmonid recovery team for Lagunitas Creek have been translated into estimated target numbers of coho salmon at different live stages for San Geronimo Creek and its tributaries. Part 2 of Chapter 4 presents targets for the habitat elements that support coho salmon and steelhead during summer rearing, over-wintering, and spawning. Part 3 presents targets for riparian and hydrologic processes that are fundamental to all life stages. The targets are intended to guide restoration and to track overall watershed health. For the restoration and hydrology indicators, we present both science-based goals and targets that we believe are achievable in San Geronimo Valley to enhance and sustain salmonid habitat.

Chapter 5 identifies current policies and regulations that protect salmonids and their habitat in San Geronimo Valley. Chapter 6 addresses Plan implementation. It includes cost estimates for short-term actions, recommendations for incentives and other resources to support homeowners, permit coordination strategies, funding ideas, and a description of monitoring for adaptive management. Chapter 6 also recommends an ongoing advisory committee to oversee implementation.

1.4 Plan Process

This plan was preceded by the 2009 Existing Conditions Report (ECR), which included new assessments of riparian habitat, geomorphic conditions, and watershed imperviousness. A public outreach plan would be developed as part of the proposed implementation program. The process has been guided by a Salmon Advisory Committee (SAC) and a Technical Advisory Committee (TAC). Public agencies, watershed landowners, and technical experts participated in many meetings of these committees. Members are listed in Appendix A. In addition to meetings and workshops of the SAC and TAC, the process included five public meetings held in San Geronimo Valley.

Community members, organizations, SAC members, and TAC members contributed a wealth of thoughtful and extremely helpful comments to the Draft Plan. We have tried to incorporate as many as we could under the work scope. Many of the comments that we received addressed specific implementation measures and should be considered during the next stage of this process. Appendix K contains the comments received on the Draft Plan.

As with any watershed planning process, the Plan represents guidance based on the best information available at the time. A critical element to the success of this Plan would be an ongoing community process to periodically assess the habitat and population targets in light of new information and to revise and reprioritize recommendations as needed.

Table 1. Summary of Plan recommendations for San Geronimo Valley residents.
(Recommendation number follows in parentheses)

All residents	If you live adjacent to a stream in the Valley	If you plan to build a new home or make improvements along a stream in the Valley
Participate in community implementation process. (1) Use rainwater capture and Low Impact Development practices to retain stormwater. (12) Participate in community program to address leaking septic systems. (13) Use fish-friendly products; store compost, animal and yard waste away from streams; properly dispose of toxic materials. (14) Disperse runoff from private roads and driveways to prevent it from directly entering streams. (12) Repair erosion from roads, gullies, and other upland sources. (15) Volunteer for collecting monitoring data. (17)	Keep existing riparian trees and shrubs, plant more to restore continuity and increase canopy cover, incorporate native plants into bank stabilization and erosion control. Control invasive plants. (2) Follow revised fire-safe guidelines to protect property and help preserve riparian habitat. (3) Consider moving or modifying small outbuildings adjacent to streams. Relocate animal pens, compost piles, and other nutrient sources out of the riparian buffer. (6) Leave fallen trees and woody debris in stream channels when safe to do so. (8) When repairing eroding banks, use techniques that will enhance instream habitat. (8, 10) Participate in grant-supported, collective stream enhancement projects with neighbors. These could include replacing existing hard bank armoring with fish friendly techniques, establishing small inset floodplains, adding large woody where safe and feasible, and revegetation. (8, 10)	Maintain a vegetated riparian buffer to protect habitat and safeguard structures and landscaping from erosion and flooding. (1, 4) Use Low Impact Development practices to retain stormwater on-site. (4) Use MMWD water when available. If not, locate new wells outside of SCA. (4) Use the most effective septic treatment permittable by Marin County Environmental Health Services for replacement of existing systems and installation of new systems. Locate drainfields as far from streams as possible. (4) Use clear-span bridges or arch culverts to span creeks. Restore canopy density and continuity. (4) Size culverts so that gravel and cobble can move downstream. (4, 9)

Chapter 2. Recommendations for Mitigation, Protection, and Enhancement

The recommendations are divided into watershed-wide measures, studies to address data gaps, and reach-specific priorities. These recommendations are consistent with state and federal plans for salmon recovery and are intended to support work towards achieving the targets described in Chapter 4. Recommendations include actions that homeowners can take on their own, and programs for public agencies to rehabilitate stream habitat and better manage public resources.

Because of existing land use in the watershed and the need for long-term, committed stewardship, the watershed-wide recommendations rely heavily on voluntary activities by watershed residents with substantive technical and financial support from Marin County, other public agencies, and non-profit organizations. Recommendations are also included for management and enhancement of public lands and roads. Marin County and other regulatory agencies play a critical role through land-use permitting and enforcement to ensure that voluntary actions are supported by policies and practices that protect salmonid habitat for new development and re-development. A list of existing ordinances and policies to protect salmon habitat is provided in Chapter 3.

2.1 Watershed-wide Recommendations by Focus Area

Most of the watershed-wide recommendations fall into four overarching efforts to:

1) protect existing riparian habitat and restore it wherever possible;

2) reestablish the structural complexity within the stream channel to support salmonids throughout the year;

3) achieve and maintain water quality that supports salmonids throughout their life cycles; and

4) achieve and maintain sufficient water quantity to successfully rear enough salmon and steelhead to sustain the San Geronimo runs.

Two recommendations, 1 (Establish and support a community process to guide implementation) and 17 (Develop and implement a coordinated monitoring program) apply to all four focus areas.

The recommendations included in each focus area are listed below.

Section 2.3 includes detailed descriptions of each recommendation, identifies priority rankings, provides the scientific reasoning, and identifies who would participate in the implementation.

Protect and Restore Riparian Habitat

Healthy riparian habitat is fundamental to well-functioning streams. It keeps water cool and clean, protects streambanks from erosion, moderates flood flows, and provides roots and wood that are vital to creating the diverse habitat that salmonids and many other aquatic creatures need. In San Geronimo Valley, riparian habitat has been impacted by many years of development. The ECR identified an insufficient number of trees over 12 inches in diameter to supply woody debris and complex root structures for instream habitat, declining density and continuity of riparian vegetation, and the displacement of native vegetation with invasive and ornamental plants (ECR Sections 3.6 and 5.3, Appendix A2).

Total impervious area (TIA) in the SCA ranges from 7.3% along the North Fork of San Geronimo Creek to 20.8% along Montezuma Creek in representative study reaches (ECR Section 3.3.2). This measurement of impervious area estimates the amount of riparian habitat that has been replaced by hard, impervious structures, such as buildings and driveways, and is an indicator of development impacts to riparian zone health and functioning. However, TIA underestimates the amount of riparian habitat lost because lawns, landscaping, vegetable gardens, outbuildings, and are not included in the TIA analysis, yet they all can have significant impacts on the riparian zone.

A recent analysis was conducted by Marin County to supplement the ECR riparian vegetation survey with quantitative data on land use and cover within the SCA (ECR Appendix G). The study was limited to 29 parcels where landowners gave permission for access. The parcels included equestrian centers, the Marin Municipal Water District (MMWD) pump station, large residential and undeveloped property. Even in this sample of parcels with less development than typical in the San Geronimo SCA, 12% of the SCA area surveyed was covered with buildings, decks, pools, driveways, and other impervious structures—above the 10% percent imperviousness associated with decline in stream habitat quality (Center for Watershed Protection 1998). Another 25% of the SCA area was in lawn, bare earth, and nonnative vegetation. The average riparian canopy width was 44 feet, and, in most cases, it ended abruptly with not even isolated riparian trees in the remaining width of the SCA, well below the proposed target of an 80-150 ft wide woody riparian zone with 75% cover.

The recommendations below are intended to protect existing habitat and to increase width, continuity, and species diversity.

The recommendations to protect and restore the riparian zone are:

1) Establish and support a community outreach process to guide implementation

2) Protect and enhance the riparian corridor to create healthy, self-sustaining habitat.

3) Develop a riparian vegetation management strategy with fire officials to allow fire-safe practices while preserving riparian habitat.

4) Apply existing policies, regulations, and guidelines to protect salmonid habitat and the ecological functions that sustain it to all new development and redevelopment currently allowable in the SCA.

5) Consider conservation of key undeveloped streamside parcels through easements or purchase of fee title.

6) Consider development of a process to promote the replacement, removal, or modification of unpermitted structures in the SCA that adversely affect fish habitat.

Enhance Instream Habitat Structure

Salmon and steelhead require a complex set of habitat elements to support them through all of their freshwater life stages. Agriculture, logging, and urbanization contribute to the simplification of creeks and degradation of habitat (ECR Sections 2.3.1.2 and 2.3.4). Vegetation clearing, soil compaction, changes in sediment delivery, and increased flood frequency and magnitude cause channels to incise. When stream incision occurs, creeks become disconnected from their floodplain, banks are often steep and raw, and bed topography simplifies. Removal of downed trees contributes to channel bed simplification and the loss of critical shelter habitat. The ongoing practices of removing large wood, encroaching on the riparian zone, and stabilizing steep, eroding banks with rock or other hard armoring precludes the rehabilitation of channel processes that form and maintain high-quality habitat.

Recommendations to *protect and restore riparian habitat*, *achieve and maintain high water quality*, and *achieve and maintain sufficient water quantity* would all contribute to improving instream habitat. Recommendations to enhance the physical structure of instream habitat components are:

7) Develop plan to increase channel complexity to improve habitat quantity, value, and resiliency for all life stages.

8) Promote the removal barriers to fish migration.

9) Promote instream gravel delivery and retention.

10) Minimize and reduce streambank armoring.

11) Develop an Instream Habitat Implementation Plan to coordinate, prioritize, and design efforts to increase channel complexity.

Achieve and Maintain High Water Quality

Suitable water quality conditions are critical to the development, growth, and survival of juvenile salmonids; they include cool temperatures, high dissolved oxygen, and low

quantities of fine sediment. Similar criteria also support adult migration and spawning. High nutrient levels can cause algal blooms, further reducing dissolved oxygen concentrations. Emerging research indicates that common contaminants in urban and agricultural runoff (e.g., pesticides, herbicides, and metals) can have deleterious effects on aquatic organisms, including salmonids..

The recommendations outlined in *protect and restore riparian habitat* and *achieve and maintain sufficient water quantity* would improve water quality. Additional recommendations to achieve and maintain high water quality are:

12) Promote watershed-wide stormwater retention and disconnection from waterways.

13) Develop a community-supported program to assist homeowners with addressing leaking septic systems. Give highest priority to systems within SCA and in reaches with higher nutrient levels.

14) Promote minimal usage and proper disposal of chemicals, nutrients, and toxic materials.

15) Reduce fine sediment delivery from roads and upland erosion.

Achieve and Maintain Sufficient Water Quantity

Sufficient water is fundamental for salmonid survival. This may seem obvious, yet habitat protection and restoration plans rarely address it. Water is where the needs of humans and fish most strongly collide. Established water sources and rights, usage habits, and our ever-growing need for water, especially in water-scarce areas such as west Marin County, make water management for natural resources difficult. To add even more challenges, the impacts of human usage are difficult to quantify because of the complexity of groundwater and surface water interactions. The Plan contains one recommendation with multiple implementation approaches:

16) Protect and enhance summer streamflow.

2.2 Prioritization System for Watershed-wide Recommendations

Each recommendation is given a priority of high, medium, or low based on a cumulative score of three different criteria:

Direct Effect on Salmonid Habitat

The habitat score reflects the impact of the recommendation on one or more of the habitat goals. Scores are assigned based on how effectively actions address habitat issues specifically identified either in the ECR or in other San Geronimo assessments, or issues for

which specific San Geronimo data may be either lacking or insufficient, but a strong correlation to salmonid habitat has been convincingly established in the scientific literature. An example of the first category is Recommendation 7 to increase channel complexity. Recommendation 14 to promote minimal usage and proper disposal of chemicals and toxic materials is an example of an impact that has not been assessed in the San Geronimo watershed but has strong support through research in other salmonid populations (ECR Section 2.3).

5 Known strong effect based on San Geronimo-specific data

4 Presumed strong effect based on scientific literature applied to San Geronimo conditions

3 Known moderate effect

2 Presumed moderate effect

1 Minimal effect on salmonids (may have stronger effect on other species)

Urgency for Stabilizing Salmonid Populations in San Geronimo Valley

The urgency score reflects the precariousness of the coho salmon population in the Central California Coast ESU and the importance of San Geronimo Valley in producing healthy smolts. Recommendations with a high urgency rating are immediately critical for salmon survivorship. Recommendations with a lower urgency rating may be vitally important for sustaining populations, but their implementation is not quite as pressing.

3 Immediately critical

2 Should start soon (within two years)

1 Important, but action should not impede efforts to initiate high and medium urgency actions.

Feasibility of Implementation.

The feasibility score is based on ease of implementation and cost. Low hanging fruit—recommendations that are relatively simple and affordable—are given the highest score. Recommendations that require significant changes to how owners can use their property, extensive planning and technical design, or are very expensive rate the lowest.

3 Very feasible

2 Feasible, but will be more difficult and expensive to implement

1 Implementation of action faces significant challenges

Prioritization Ranking

The overall priority ranking is calculated by adding the three scores.

High	9-11
Medium	6-8
Low	5 or less

2.3 Watershed-wide Recommendations by Numerical Order

Recommendation 1:
Establish and support a community process to guide implementation of the Plan

Priority:

High

Salmonid lifestage affected:

All

Description:

Future refinement and implementation of this Plan depends upon support from the residents of San Geronimo Valley. The formation of effective implementation programs for some of the recommendations, such as repairing leaking septic systems and encouraging riparian re-vegetation, requires community participation. Suggested methods for strengthening community participation include continuation of an advisory committee with greater community representation, regular public forums for discussion and information sharing, and community working groups for specific actions or neighborhoods. Regular State of the Watershed conferences, similar to the State of Tomales Bay conferences held biennially for many years, could give the County, landowners and other agencies an opportunity to present monitoring data and report on progress. This process would allow residents to report on successes and challenges, to identify needs for resources; and assist stakeholders with the prioritization process

Who would implement Recommendation 1:

- **Marin County** through coordination of ongoing public participation process
- **Residents** through participation on advisory committee or working groups
- Marin County, residents, community organizations, and other resource agencies through regular State of the Watershed conferences or similar forums

Recommendation 2:
Protect and enhance the riparian corridor to create healthy, self-sustaining habitat.

Priority: **HIGH**

5 Effect on salmonids or their habitat
3 Urgency
2 Feasibility/Ease

Salmonid lifestage affected:

Summer rearing, over-wintering, spawning

Summary of recommended approach:

- Provide educational materials, technical

support, workshops, and incentives to support homeowners.
- Protect and care for existing native riparian plants.
- Increase the width, canopy cover, diversity, and continuity of riparian habitat through planting.
- Leave fallen trees where it's safe to do so.
- Protect riparian functions by maintaining riparian habitat.
- Reduce invasive plant populations to make room for native plants and discourage planting certain species in SCA.
- Design streambank rehabilitation to maximize riparian vegetation function and success.

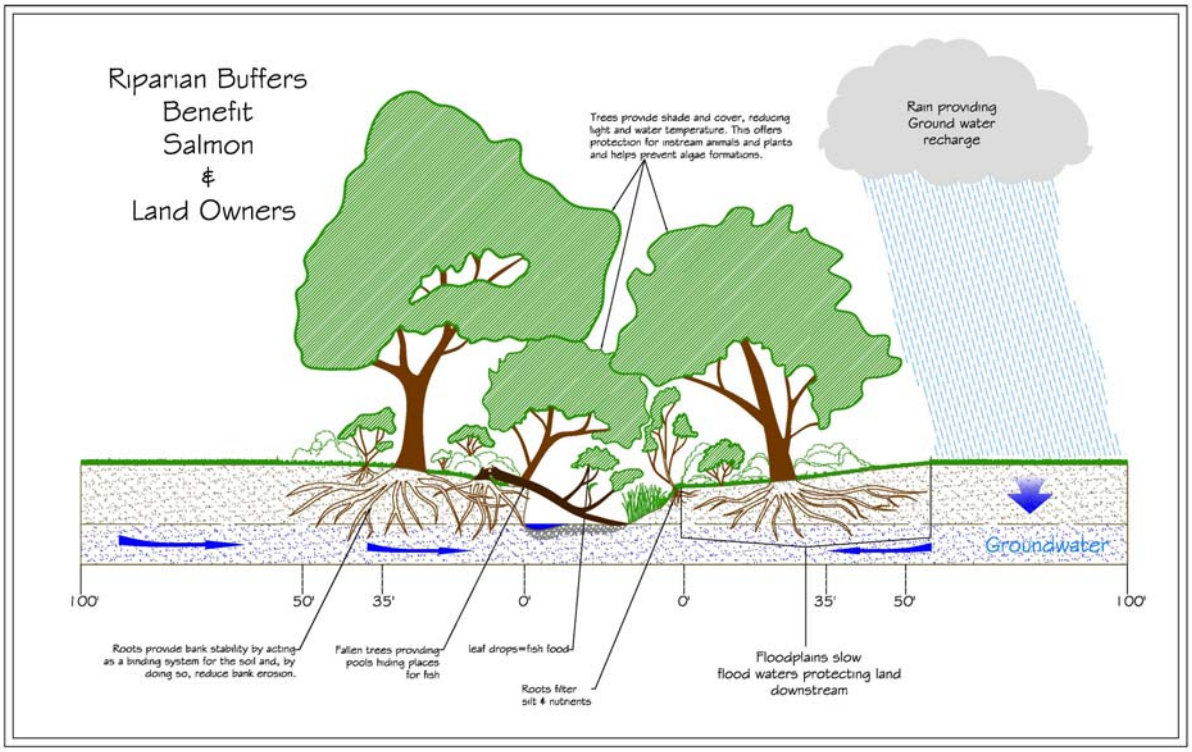
Scientific reasoning:

Riparian habitat with dense, native, mature vegetation is vital to creating and maintaining high quality habitat for salmonids in San Geronimo Valley. Shade helps to maintain the cool water temperatures that salmon and steelhead need to thrive. Cooler water holds more oxygen. Leaves dropping into the streams are a major food source for the aquatic insects that in turn feed fish. Large wood, in the form of downed dead or live trees, traps and sorts gravels used for spawning, redirects flows to form deeper pools, and provides shelter. During high winter storm flows, densely vegetated banks and floodplains dissipate energy and provide safe havens for fish by creating low-velocity areas.

Although this Plan is focused on steelhead and salmon, riparian habitat is critical for many other wildlife species. It connects upland habitats to water sources and provides travel corridors, cover, and food. Many species spend much of their lives in or close to riparian habitat. Over 135 species of California birds and 90 species of mammals, reptiles, invertebrates, and amphibians either completely depend upon riparian habitats or use them preferentially at some stage of their life history (RHJV 2009).

Healthy riparian habitat also provides many benefits for people. Grasses, other herbaceous plants, and low shrubs filter fine sediment, nutrients, and other pollutants from runoff before it enters streams. Trees, with their extensive, deep root structures hold banks in place to protect property from erosion. Vegetated banks slow and hold water to reduce flooding and increase recharge into the stream during the summer months. Appendix E summarizes the science behind the recommended buffer widths to protect riparian functions for the San Geronimo Creek watershed

Figure 2. Functions of riparian habitat



The Existing Conditions Report identifies the following conditions as directly degrading instream habitat conditions for salmonids or supporting that degradation (ECR Chapter 5):

- Lack of existing instream large woody debris and complex root structures to support deep, low velocity pools and backwaters;
- Low dissolved oxygen concentrations and increased water temperatures during summer and early fall;
- High concentrations of fine sediments in the channel bed in the upper reaches of the channel network (i.e., North Fork San Geronimo and Woodacre Creek);
- Cleared, compacted, and/or impervious areas throughout the contributing watershed and along the streams, leading to increased erosion, sediment, nutrients, and toxins to the streams;
- An overall low number and density of large trees (more than 12 inches in diameter at breast height) in the riparian corridor that is not sufficient to support a long-term supply of large woody debris or complex root structure in the stream channel;
- Substantially altered riparian vegetation community with widespread displacement of native understory species by invasive and ornamental species (e.g., lawns) that do not support comparable ecosystem functions;
- Discontinuous and declining riparian canopy and bank cover that may not provide adequate shade to maintain cool water temperatures during summer rearing.

Description:

Reach-specific recommendations for protecting and enhancing riparian habitat are described in Section 2.5. Following are general guidelines that apply throughout the watershed:

Provide educational materials, technical support, workshops, and incentives to support homeowners.

A community outreach program is recommended to increase awareness and make it easy for interested landowners to enhance their streamside property. Homeowner support could include free consultation with revegetation experts; workshops on native plant use in residential areas, invasive plant removal, and coping with Sudden Oak Death; free or low-cost plants; voluntary participation in grant-funded revegetation projects; and free green-waste disposal boxes. Support for MCSTOPPP's efforts to educate landscapers, nurseries, and other vendors about the ecological dangers of aggressive invasive plants should be continued and strengthened. Outreach to residents should also include information about the impacts of releasing exotic animals such as bullfrogs and non-native fish. Coordination between public agencies, local organizations and homeowner groups, to provide education through a variety of venues and sources is important to reach out to a wide range of Valley residents.

Protect and care for existing native riparian plants.

Preserving existing native plants is the first and most urgent step in protecting riparian habitat. Native trees within the SCA should be protected unless they are an immediate threat to safety. Native shrubs and herbaceous species are also important for riparian function and should be encouraged to grow throughout the SCA.

Increase the width, canopy cover, and continuity of riparian habitat through planting.

Riparian planting in San Geronimo Valley is critical at all scales. An individual homeowner or a group of neighbors working together to plant clusters of trees or shrubs can close gaps in the canopy along the stream and increase cover throughout the riparian zone. Larger-scale restoration opportunities, such as those in Larsen Creek and the North Fork San Geronimo reaches, should be considered a high priority for restoration grant funds. Appendices H and I contain information on selecting, installing, and maintaining riparian plants for San Geronimo Valley.

Leave fallen trees.

Downed wood is a fundamental ingredient of both terrestrial and aquatic ecosystems. It returns nutrients back into the soil and streams, provides food for insects and other invertebrates, and shelters wildlife. Consultation with Fish and Game (CDFG) staff is required when considering removal or movement of large wood in the channel. If CDFG allows removal, a Streambed Alteration permit (1602 permit) is required. Recommendation 7 provides more information on handling wood in streams.

Photo by Prunuske Chatham, Inc.

Protect riparian functions by maintaining or enhancing a riparian buffer

Several existing County policies and ordinances prescribe stream setbacks for new development in Marin County (Table 3). This recommendation complements these policies and ordinances and is applicable to existing developed areas as well as proposals for new development.

Table 2. Summary of existing riparian protection for streams in Marin County.

Measure	Provisions
Marin Countywide Plan (CWP) through the Stream Conservation Area (SCA) policies	The CWP policies establish a development setback of at least 100 feet from the top of the bank. Exceptions to full compliance with all SCA criteria and standards may be allowed only if the following is true: 1. A parcel falls entirely within the SCA; or 2. Development of the parcel entirely outside the SCA is either infeasible or would have greater impacts on water quality, wildlife habitat, other sensitive biological resources, or other environmental constraints than development within the SCA. In addition, the CWP allows the following uses in the SCA where they conform to zoning and all relevant criteria and standards for SCAs: 1. Existing permitted or legal nonconforming structures or improvements, their repair, and their retrofit within the existing footprint; 2. Projects to improve fish and wildlife habitat;

Measure	Provisions
	3. Driveway, road, and utility crossings, if no other location is feasible; 4. Water- monitoring installations; 5. Passive recreation that does not significantly disturb native species; 6. Necessary water supply and flood control projects that minimize impacts to stream function and to fish and wildlife habitat; 7. Agricultural uses that do not result in any of the following: a. The removal of woody riparian vegetation; b. The installation of fencing within the SCA that prevents wildlife access to the riparian habitat within the SCA; c. Animal confinement within the SCA; and d. A substantial increase in sedimentation
Marin County Public Works Title 24.04	This ordinance requires that all structures be set back from streams at least 20 feet from the top of bank or 20 feet plus twice the channel depth, whichever is greater to protect structures from erosion and flood hazards.
Title 22.42	This Community Development Agency ordinance requires that any proposed development within the Countywide Plan's Stream Conservation Area that adjoins a mapped anadromous fish stream is subject to Design Review

A minimum 35-foot buffer is recommended to guide enhancement on parcels that are already developed and to guide enhancement of riparian habitat on parcels proposed for new or re-development. This buffer is measured from the edge of the creek bed or active channel and provides the following benefits

- protects water quality,
- preserves riparian vegetation,
- allows for restoration where riparian vegetation is patchy or non-existent,
- allow natural stream adjustments and protects property from erosion,

- supports stormwater infiltration

*The Department of Fish and Game defines the **active channel** level as the "elevation delineating the highest water level that has been maintained for a sufficient period of time to leave evidence on the landscape." (DFG 2003). In the field, it can be determined by one or more of the following indicators:*

- *The point where cleanly scoured rocks and gravel transition to smaller-sized particles such as silt and sand, or directly to terrestrial vegetation*
- *A break in rooted vegetation or moss growth on rocks along stream margins*
- *Natural line impressed on the bank*
- *Shelving or terracing*
- *Changes in soil character*
- *Natural vegetation changes from predominantly aquatic to predominantly terrestrial*

To support a naturally regenerating riparian forest and a sustainable source of large woody debris 100 feet or more is recommended by the scientific literature and by many other local and state governments for the conifer and hardwood riparian forests that naturally occur in San Geronimo Valley (Appendix E). Such a buffer is called for in the Countywide Plan, with certain practical exceptions, as noted above. Because of existing development in San Geronimo Valley, it is critical to protect existing habitat and promote the restoration of wider and more diverse riparian forests on public lands or with willing, private landowners. Valley residents can markedly improve the diversity and connectivity of these riparian buffers through voluntary actions.

In areas constrained by existing development or in areas where SCA exceptions might allow new development, a minimum 35-foot setback from the active channel for new activities that would reduce riparian vegetation or function can make a crucial contribution to filtering most sediment and sediment-attached pollutants, and providing shade and root structure close to the channel (Figure 2). Trees growing within the setback would eventually contribute to large wood in the stream as they mature and fall over. Based on measurements of mainstem San Geronimo Creek and major tributaries collected as part of this planning process (ECR, Appendix A), a 35 ft setback would allow construction of a 3:1 slope in most reaches as part of stream stabilization and restoration projects. It would also allow natural erosion processes as the stream adjusts to changes in the watershed and runoff patterns without jeopardizing structures, gardens, or other infrastructure. In areas where people are already living, this zone is the key area to focus riparian enhancement activities.

An undisturbed buffer is most critical along perennial and intermittent streams in the Valley. Steep, ephemeral, first order streams also play a crucial role in stabilization, infiltration, and filtration functions necessary to protect downstream habitat. Protection of these functions is addressed in Recommendation 12.

Reduce invasive plant populations overall and discourage planting certain species in SCA.

The ECR identifies English ivy, Himalayan blackberry, and French broom, all rated as having a high negative ecological impact on native plant communities, as common in the riparian shrub layer. Periwinkle or vinca, ranked as a moderate threat to native communities, represented 37% of the herbaceous cover in the sites sampled (ECR Section 3.6.1). Cherry plums were found near Montezuma Creek and Forest Knolls, but they are considered a limited threat according to the California Invasive Plant Council. Giant reed (*Arundo donax*), a highly invasive riparian species, also occurs in the watershed. Guidelines for removing exotic invasive plants are included in Appendix I.

Design streambank rehabilitation to maximize riparian vegetation function and success.

Gently-sloped banks and inset floodplains where appropriate and feasible facilitate the establishment of native riparian vegetation (Recommendations 7 and 11). When banks are sloped back to a gentler slope, the top of bank moves landward. County planners should have the option to preserve the landward SCA boundary at the location that existed before work begins as an incentive to encourage the most effective restoration

Biotechnical bank stabilization using gently-sloped banks and a small, inset floodplain protected with a willow wall. The floodplain and bank were later planted with native plants.
Photo by Prunuske Chatham, Inc.

Who would implement Recommendation 2:

- **Landowners** through voluntary practices to enhance the riparian corridor
- **Public agencies, SPAWN and other organizations** through demonstration projects, workshops, technical assistance, and grant funding to support landowners
- **Marin County Community Development Agency** through ordinances and permit requirements that are consistent with this action on all new development and redevelopment
- **All regulatory agencies** through enforcement of existing regulations that currently protect riparian habitat

Recommendation 3:
Develop a riparian vegetation management strategy with fire officials to allow fire-safe practices while preserving riparian habitat.

Priority: **MEDIUM**

3 Effect on salmonids or their habitat
3 Urgency
2 Feasibility/Ease

Salmonid lifestage affected:

Summer rearing, over-wintering, spawning

Scientific reasoning:

See Recommendation 1 for a discussion of the importance of protecting riparian habitat in San Geronimo Valley.

Description:

Fire is a genuine threat in San Geronimo Valley, not only to homes and public safety, but also to the natural habitat. Major fires occurred in the Valley in 1878, 1904, 1923, and 1945. The 1923 fire burned mature redwoods along the mainstem and the 1945 fire destroyed 30 square miles in the Carson Creek watershed (Tolson 2007, ECR Section 3.2).

Current fire regulations require maintaining a 30 ft perimeter around each home with no combustible material and no continuous tree canopy, and a 100 ft zone (an additional 70 ft) of reduced fuel (Marin County Fire Department 2009). In San Geronimo Valley where many homes are within 100 ft or even 30 ft of streams, these measures can be in direct conflict with protecting and maintaining a vital, sustainable riparian corridor. Coordination between County agencies is needed to modify fire regulations to meet both fire protection and enhancement goals.

The following guidelines promote riparian health while providing fire protection:

1. Protect and maintain healthy native vegetation as much as possible. Well-maintained, healthy riparian plants are likely to be less flammable than unhealthy or diseased plants.
2. Plant low-flammable species in the reduced fuel zone. Research on flammability of particular plant species is incomplete and somewhat controversial. However, it is generally agreed that plants that have a high moisture content (typically broad, supple leaves), a low resin content (i.e., without strong-smelling oils), and that do not accumulate much dead material are likely to be less flammable. Low-growing species are also less likely to contribute to a wildfire. The following native riparian species are just a few examples of those that have less-flammable characteristics:
    - redwoods, bigleaf maple, alder, Oregon ash
    - ferns (e.g. western sword fern, lady fern, giant chain fern)
    - sedges, rushes
    - low-growing forms of some native shrubs (e.g. snowberry)

3. When removing plants to create "defensible space," prioritize invasive non-native species. Many non-native invasive species in San Geronimo Valley are also among the more flammable plants; removing these can provide both fire protection and habitat improvement benefits. These plants include eucalyptus, acacia, broom, and pampas grass.
4. Maintain canopy cover, which is important to riparian health, where possible. In some cases, pruning lower limbs of native riparian trees may be a reasonable alternative to thinning the trees themselves. For conifers, limbs should not be pruned up more than 2/3 of the tree's total height. For deciduous trees, such as oaks and bays, prune no more than ¼ of the tree's crown.
5. Leaf litter is an important element of the forest ecosystem and should not be removed completely. Bare soil will be more susceptible to erosion and invasion by invasive species, and is less likely to support the regeneration of native species. Defensible Space Guidelines from the Marin County Fire Department (www.marincountyfire.org/defensiblespace) allow up to three inches of litter within 30-100 feet of a house.
6. Where possible, allow denser vegetation to remain on the north-facing slopes (i.e., the southern side) of a creek. Shading on the south side is especially important for moderating creek temperatures for fish, and north-facing slopes tend to be cooler and moister.
7. Instead of removing all downed wood, prune off small branches and clear away flammable grasses or brush from around them.

Additional sources of information on fire-safe landscaping are in Appendix I.

Fire officials should also work with Valley residents, CDFG, San Francisco Regional Water Quality Control Board (Regional Board), and DPW to prepare procedures and an outreach strategy to reduce avoidable negative impacts to salmonids during and after fires.

PG&E regularly clears vegetation around its poles for fire protection and prevention. Many of these poles are close to streams in San Geronimo Valley. Alternatives to clearing should be investigated and used whenever possible, these include maintaining low, herbaceous cover with mowing or weed-eating to at least protect soil and filter sediment and some pollutants; using low-growing fire resistant plants in the outer area of the maintained radius; and replacing old fuse mechanisms with newer, spark-resistant fuses.

Who would implement Recommendation 3:

- **Marin County Fire Department and DPW** in consultation with **California Fish and Game, Regional Board**, and **NOAA**
- **PG&E** for fire management around utility poles.

Recommendation 4:
Apply policies, regulations, and guidelines to protect salmonid habitat and the ecological functions that sustain it to all new development and redevelopment currently allowable in the SCA.

Priority: **HIGH**

4 Effect on salmonids or their habitat
3 Urgency
2 Feasibility/Ease

Salmonid lifestage affected:

Summer rearing, over-wintering, spawning

Summary of recommended approach:

- Maintain riparian vegetation and increase buffer whenever possible.
- Reduce invasive plant populations and discourage planting of highly invasive plants.
- Allow no net increase in effective (connected) impervious area (EIA).
- Use only bank stabilization methods that enhance instream and riparian habitat.
- Prohibit water withdrawals that may impact summer streamflows.
- Use clear span bridges or arched culverts at road crossings over perennial and intermittent streams.
- Restore canopy density and continuity.
- Use the most effective septic treatment permittable by Marin County Environmental Health Services for replacement of existing systems and installation of new systems..
- Upsize culverts whenever possible to improve transport of gravel, cobble, and, where practical, large woody debris.
- Use fire resistant building materials.

Scientific reasoning:

New development and improvements on already developed parcels in the SCA have the potential to diminish riparian habitat and function through direct removal of native vegetation, an increase in the area of hardened surfaces and subsequent reduction in the capacity of riparian soils to hold and slowly release water. Development next to the stream can also increase the amount of sediment, nutrients, and other pollutants generated close to the waterways. See Recommendation 1 for a discussion of the importance of protecting riparian habitat in San Geronimo Valley.

The amount of impervious area, especially effective or connected impervious area, is strongly correlated to degraded stream condition (ECR, Section 2.3). Connected impervious area speeds rainfall from rooftops, driveways, and streets along with sediment, spilled oil, brake dust, and many other pollutants, and then delivers the polluted water directly into storm drains or streams. Percent imperviousness over 10% is associated with unstable banks, decline in physical habitat, and the disappearance of sensitive fish and insects (Center for Watershed Protection, 1998). The percent cover of impervious surface in the SCA

study reaches ranges from 7-21% (ECR Section 3.3.2). Montezuma Creek with 21% and Woodacre Creek with 19% had the highest percentages.

Potential future impacts of development along streams include the need to harden banks to protect property as the stream channel changes over time, the removal of diseased or aging trees for safety reasons, and failing septic systems.

The quality of summer rearing habitat is dependent upon sufficient streamflow to maintain pool connectivity, low water temperatures, and sufficient dissolved oxygen levels. Water supply wells adjacent to creeks have been shown to lower the groundwater table and locally impact summer streamflows, especially in drought years (PCI 2006). Riparian pumps lower pool levels during critical summer conditions.

Recommendation 3 addresses all riparian, hydrologic function, and water quality targets. Retention of trees close to streams would ultimately contribute towards achieving the channel bed form and food availability targets.

Description:

Preliminary analysis based on data provided by the Marin County Assessors office indicates there are 203 unimproved single-family residential parcels that include portions of the SCA in San Geronimo Valley. Of those, 58 are wholly in the SCA. Of the 203 parcels, approximately 108 cannot contain 3,000 sq. feet[1] of development outside of the SCA. The analysis does not consider additional restrictions such as inadequate percolation for septic systems or lack of access that would reduce the total number of buildable parcels. Building within the SCA may be permitted if the entire parcel is within the SCA providing that development does not adversely alter hydraulic capacity; cause a net loss in habitat acreage, value, or function; or degrade water quality. (CWP, Policy Bio-4.1).

In addition, replacement, repair and maintenance of existing permitted or legal nonconforming structures within their existing footprint can occur in the SCA. The following guidelines should be used to select and shape projects that have minimal impact on salmonid habitat, and to guide any ordinances that may be drafted to implement the policies of the 2007 CWP. Where policies for these guidelines or portions of them have been adopted in the CWP, the policy or program number is indicated. The Conceptual Plans in Appendix H demonstrates development that complies with these guidelines.

[1] The 3000 sq. ft. estimate is based on 2000 sq.ft home, 500 sq.ft. septic system, and 500 sq.ft. driveway.

Maintain a vegetated riparian buffer

The Plan recommends enhancement occur within a minimum 35-ft riparian buffer for new development and re-development to protect riparian and instream functions, and to safeguard structures from erosion and flooding. See Recommendation 2.

Retain native riparian trees and shrubs within the remaining SCA (BIO-4.f, 4.i)

As mandated in the County's Native Tree Preservation and Protection Ordinance, native trees and shrubs should be retained within the remaining SCA unless they are an immediate threat to human safety (Marin County Code, Chapter 22.27). The Plan recommends that the threat determination within the SCA be made by a professional, third-party assessment. Trees smaller than the thresholds identified in the Tree Ordinance are also important to protect along streams because they will eventually maintain the canopy cover as existing larger trees mature and die.

Reduce invasive plant populations and prohibit planting of highly invasive plants (BIO-4.6)

The Plan target is to reduce invasive species to less than 25% of the total vegetative cover. Progress toward this target can be made through two strategies: 1) reducing the number of invasive plants through removal; and 2) increasing the number of native plants through revegetation or landscaping with site-specific, native plants (Action 2). The invasive plants identified in the text box in Action 1 should not be used in any new development or re-development landscape plans.

These plants should not be used in the SCA:

Acacia
Bamboo
Broom (French, Scotch, Spanish)
Ivy (English, Algerian, German/Cape)
Capeweed
Eucalyptus
Giant Reed
Gorse
Harding grass
Himalayan blackberry
Pampas grass
Periwinkle

Follow Plan guidelines for new planting

Native plant revegetation within the SCA should follow the guidelines in this Plan (Action 1 and Reach-Specific Recommendations) and in the Woody Debris Management and Recruitment Plans once they are completed (Action 11).

Allow no net increase in effective (connected) impervious area (EIA) (Bio-4-19)

Low Impact Development (LID) techniques, including pervious pavements and path surfaces, raingardens, and bioswales, interrupt the flow and allow it to percolate into soil. New development in the SCA should be designed, constructed, and maintained to result in no increase in runoff. Conceptual Plan 3 in Appendix H shows LID and rainwater capture practices for a residential parcel. More resources are listed in Appendix I.

Use only bank stabilization methods that enhance instream and riparian habitat (Bio-4.4, Bio-4.5, Bio-4.19)

Applicants should be informed at the time of building permit issuance that site layout needs to take into account unstable creek banks and allow room for the creek to meander. The Marin County Drainage Setback Ordinance already requires that all structures be set back at least 20 ft from the top of bank or 20 ft plus twice the channel depth, whichever is greater (Marin County Code, Chapter 24.04). Driveways, parking areas, and permanent landscaping are also vulnerable to changing streambanks and should be placed outside of the buffer area.

If bank stabilization is part of a development proposal, the stabilization should follow the practices in Action 18 and in reach-specific recommendations. Only biotechnical measures incorporating vegetation and/or large woody debris should be permitted unless other measures are clearly demonstrated to have a benefit to salmonid habitat, creek morphology, or the riparian zone (e.g., saving heritage trees). Where creation or restoration of an inset floodplain or a gently-sloped bank is feasible and appropriate (Action 7), County planners should have the option to preserve the landward SCA boundary at the location that existed before work begins as an incentive to encourage the most effective restoration.

Avoid water withdrawals that may impact summer streamflows

Depending on their depth and location, new wells can have an immediate impact on surface water during critical summer months. It is recommended that until a comprehensive investigation is available to guide County planners and MMWD reviewers, new wells be avoided in the SCA. Recommendation 16 and Data Gap 10 call for a comprehensive investigation of groundwater availability and its relationship to surface water in areas with development potential above MMWD supply tanks. A policy should be considered to prohibit the new development of springs within the SCA, as they directly contribute to dry season flows.

Rainwater catchment systems should be encouraged throughout the watershed in place of wells or as augmentation to MMWD water for irrigation and other non-potable uses. (See Recommendation 16).

Use clear span bridges or arch culverts at road crossings.

Providing that they meet all existing environmental regulations and would cause no net loss in riparian vegetation and no increase in effective impervious area, road or driveway crossings should use clear span bridges or culverts. It is recommended the footings or other supporting structures be located outside the stream channel. Unless the bridge is located in an herbaceous-dominated reach, canopy density and continuity should be preserved through careful sitting or restored through tree planting along the roadway.

Use the most effective septic treatment permittable by Marin County Environmental Health Services for replacement of existing systems and installation of new systems. Locate drainfields as far from streams as possible.

Construction of new systems where the leachfields can be located 100 ft from perennial streams, 75 ft from intermittent streams, and 50 ft from ephemeral streams is currently allowed under Marin County Code (Chapter 18.06). Exceptions to the setbacks can be made to replace existing systems, if the field is preceded by a pretreatment system such as a sand filter or AdvanTex media filter, or through the variance procedure. Variances may be provided if it can be demonstrated that the reduction of requirements would not present a threat to water quality or public health. Given that levels of fecal coliform in San Geronimo Creek, particularly in Woodacre Creek and the mainstem, exceed criteria set by the Regional Board (ECR, Section 3.5.3), water quality standards should be rigorously adhered to in the variance procedure. All waivers are currently subject to review by the Regional Board.

Require that all culverts transport naturally moving gravel, cobble, and, where practical, LWD

New and replacement culverts throughout the watershed should be designed to allow movement of gravel, cobble, and woody debris from the upper watershed to larger tributaries and the mainstem. See Action 9.

Use fire resistant materials

Preventing fire protects riparian habitat, human safety, and reduces the need for extreme clearing.

Who would implement Recommendation 4:

- **CDA and DPW** through permitting of new development and redevelopment.
- **EHS** through permitting of wells and septic systems.
- **MMWD** and the County through review of well applications.
- **Regional Board** through review of requests for waivers to Marin County septic system regulations.

Recommendation 5:
Consider the conservation of key undeveloped streamside parcels through easements or purchase of fee title (CWP Policy Bio-1.2, Program Bio-2.b).

Salmonid lifestage affected:

Summer rearing, over-wintering, spawning

Priority: **MEDIUM**	
3-5	Effect on salmonids or their habitat
2	Urgency
1	Feasibility/Ease

Scientific reasoning:

Protection of existing healthy habitat and restoration of riparian habitat would advance all riparian and water quality targets, and ultimately increase large wood frequency. Depending on the enhancement goals specific to each project, restoration of instream habitat would address channel bed form targets including pool frequency and depth; pool/riffle ratio and shelter.

Description:

Protection of land through conservation easements or acquisition of fee title is a useful tool for conserving and improving habitat, and for fairly compensating landowners for property that the public deems has a higher value for resource protection than for residences or commercial use. Parcels wholly within the SCA that cannot be developed in compliance with Recommendation 3 should be considered for acquisition and restoration, as well as larger parcels that could be restored to provide critical habitat. Restoration of protected property can ease the pressure on residential parcels to provide all the elements needed to support healthy salmonid populations.

Priority should be given to parcels that meet at least one of the following criteria:

- Parcel has healthy riparian habitat with minimal cover of invasive species
- Parcel is adjacent to well-functioning instream habitat
- Opportunities are present to significantly enhance riparian, over-wintering, and/or rearing habitat

The ECR, Section 4, and the reach-specific recommendations identify areas that are likely to meet these criteria. The North Fork of San Geronimo Creek, Upper San Geronimo, and Arroyo/El Cerrito/Barranca are identified as "tributaries and reaches with the greatest need of preservation" (ECR Section 5.5). The existing redwood stand along the North Fork and the California bay laurel-dominated riparian site along Barranca Creek are characterized as "minimally affected sites" that would meet the intact riparian zone criterion (ECR Section 3.6.3). Available parcels at tributary confluences should be evaluated for their potential to create backwater habitat for winter/spring flow refugia.

Appendix J addresses the logistical issues of land conservation. First, the landowner must be willing to sell or donate an easement or the entire property, and second, an entity, usually a public agency or land trust, must be willing to accept the property and provide stewardship in perpetuity. The value of the land or development rights needs to be assessed and agreed upon by both parties. Finally, funding must be available to purchase development rights or fee title and care for the property. Chapter 6 identifies funding mechanisms that could be used to conserve streamside parcels.

Who would implement Recommendation 5:

Marin County and land trusts through development of a long-term plan and acquisition of conservation easements or fee title.

State and federal agencies and private foundations through financial assistance

Recommendation 6:
Consider development of a process to promote the replacement, removal, and modification of unpermitted structures in the SCA that adversely effect fish habitat.

Priority: **MEDIUM to LOW**

2-3 Effect on salmonids or their habitat
2 Urgency
1 Feasibility/Ease

Salmonid lifestage affected:

Summer rearing, over-wintering, spawning

Scientific reasoning:

Each small structure may not have a measurable impact on stream health, but cumulatively, these structures increase impervious area in the riparian zone, reduce habitat continuity, and limit growth of riparian plants. When these structures shelter animals such as chickens or horses, they cause animal waste to be located close to channels.

Description:

Small sheds, chicken coops, other small structures, and areas of pavement in close proximity to stream channels are common in San Geronimo Valley. Most of these were likely built before the enactment of stream setbacks; some were constructed illegally. A long-term (25 year) goal of removal or modification of structures and pavement within a minimum 35-foot buffer and ultimately within the SCA would facilitate recovery and sustainability of healthy stream functions. However, immediate, whole-sale removal is impractical and would distract efforts from more urgent actions to improve salmonid habitat.

In the meantime, incremental progress towards removing these structures should be made through the following:

Prioritize removal of structures that most affect fish and their habitat.

Work first to modify or remove structures that:

- prevent the establishment of riparian plants within the riparian buffer, especially those such as overhanging decks that preclude vegetation immediately adjacent to streams

- channel storm runoff directly into streams (driveways and other connected impervious areas)
- generate pollutants (chicken coops, dog runs)
- restrict opportunities to increase channel complexity in targeted reaches

Develop a process to evaluate legalization of existing structures.

Provided that the structure or paved areas do not meet criteria listed above or increase effective impervious area, the County should consider a process to legalize structures. Participating landowners would need to agree to at least one significant enhancement action that would result in a net environmental improvement. Examples could include revegetating with native plants, removing invasive species, and reducing overall effective impervious area on the parcel. Actions could take place in other locations within the SCA if no opportunities exist on-site. This program is also a prime candidate for cost-share through grants to assist landowners. Chapter 6 addresses possible funding mechanisms.

Who would implement Recommendation 6:

- **CDA** and DPW would develop process to consider legalization of structures within the SCA
- **Homeowner**s through voluntary replacement or modification of structures
- **Marin County, local organizations**, and **state and federal funding sources** to develop and administer a cost-share program for homeowners

Recommendation 7:
Develop plan to increase channel complexity to improve habitat quantity, value, and resiliency for all life stages.

Salmonid lifestage affected:

Spawning, summer rearing, over-wintering, and migration

Summary of recommended approach:

Priority: **HIGH**	
5	Effect on salmonids or their habitat
3	Urgency
1-3	Feasibility/Ease

- Install large wood structures in the channel where safe and appropriate.
- Leave naturally recruited large wood debris in the channel after consultation with the County, CDFG and/or MMWD to determine its potential to induce erosion or threaten health and safety.
- Construct inset floodplains and/or gently slope vertical banks where feasible.
- Promote native tree and shrub establishment on channel margins and banks, leave undercut banks where structures are not threatened.

Scientific reasoning:

Channel complexity, in the form of large wood and heavily vegetated banks, provides the critical habitat elements needed to create and maintain numerous, shelter-rich, deep pools and retain coarse, clean spawning gravels. Mainstem San Geronimo Creek and its major tributaries are deeply incised, simplified, and lacking sufficient inset floodplains, instream large woody debris, and complex root structures (ECR Section 5).

Photo by Prunuske Chatham, Inc.

Large woody debris (LWD) is consistently identified by research scientists as a primary factor in the determination of high quality habitat for anadromous salmonids (Opperman 2005 citing Beechie and Bolton 1999; Bisson et al. 1987; Murphy et al. 1986; National Research Council 1996), and it has been documented that coho salmon juvenile abundance is positively correlated to the presence of large wood within a stream reach (Bryant and Woodsmith 2009). In the northern California coastal watersheds, with their Mediterranean climate-related low summer streamflows, the habitat value of pools associated with woody debris structure and cover are likely particularly important to the successful rearing of juvenile salmonids (Opperman 2005).

Installation of large wood structures in the channel is one of the easiest and most effective ways to immediately improve instream habitat structure for salmonids in urbanized or mixed land use reaches. According to NOAA Fisheries (Southwest Region, In Press), 6 to 11 large, key pieces of LWD are needed per 100m (328 ft) for good salmonid habitat conditions.

In coastal, hardwood-dominated watersheds, such as San Geronimo, live trees adjacent to the channel are key elements in the formation of LWD-related pools and instream structure (Opperman and Merelander 2007; Opperman 2005). Vertical and steeply sloped banks, as are common throughout San Geronimo Creek and its major tributaries, hinder the establishment of riparian trees on channel banks. Vertical, unvegetated banks maintain high velocities and are prone to erosion. Over time, incised channels would typically widen and establish inset floodplains (ECR Section 2.3.1) as they move to a more stable form. This could take decades or centuries, and channel encroachment by development typically arrests this process through bank protection and stabilization practices.

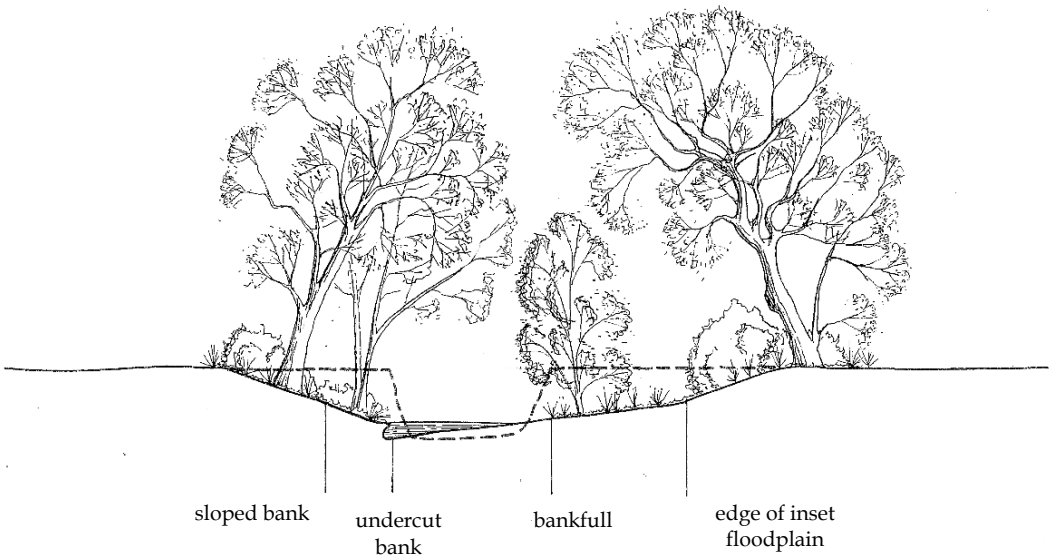
Helpful Definitions

Incised Channel – A stream that has degraded, cutting into the valley floor and is no longer connected to its historic floodplain.

Inset Floodplains – in incised channels such as San Geronimo, the creek is no longer connected to its historic floodplain. Over time the channel will widen and create small benches within the terrace banks that provide the same functions as historic floodplains – slowing and storing floodwaters, providing low velocity habitat, and supporting complex vegetation communities.

Vegetated floodplains also provide critical high flow velocity refugia for salmonid juveniles. Sufficient, high quality winter rearing habitat is considered one of the primary factors limiting the coho population in the San Geronimo/Lagunitas system (ECR Section 5). See the illustration below for a comparison of existing incised channel form (dotted line) and a stable, well-vegetated cross section that maximizes salmonid habitat conditions.

Figure 3. Channel cross-section.



Mature trees and their root systems provide a multitude of high quality habitat elements when they are located immediately adjacent to the channel. The tree canopy provides shade over the creek, insects and leaves to feed fish and aquatic invertebrates, and branches for debris accumulation. The tree roots provide bank stability and, when undercut, premium complex habitat for juvenile salmonids.

Description:

Promote the installation of large wood structures and small wood bundles.

A reach-based plan to guide design and placement of structures should be developed (Recommendation 12), but this does not preclude the installation of large and small wood structures when opportunities arise. General guidelines for large wood structure installation are:

- Design structures to provide critical habitat based on salmonid lifestages present (e.g., summer rearing reaches need deeper pools and cover in pools, spawning reaches need large wood to trap and sort gravels and provide refugia for emergent fry).
- Enhance existing habitat features.
- In reaches constrained by channel size and bank erosion concerns (significant property loss, top-of-bank infrastructure), size the wood used to be stable, yet not overwhelm the system and cause dramatic channel adjustments in width or location.
- Forested banks are more stable and less prone to erosion caused by changing site hydraulics from the large wood—install structures where banks are stable and well vegetated or design to help stabilize.
- Complex, multiple log structures provide greater habitat value, as do those that offer refuge at a variety of flow depths.

Small wood bundles can provide shade and shelter in pools, as well as velocity refugia along banks and on floodplains during baseflow and storm events. Depending upon their size and placement the bundles may need to be replaced annually after high flows.

Leave naturally recruited large wood and small woody debris in streams.

It is illegal to remove large wood from creeks without contacting California Department of Fish and Game (CDFG) or another designated agency for consultation. Occasionally a fallen tree will threaten infrastructure or cause significant bank erosion. Landowners should contact the agencies listed below for professional assistance. Often a downed tree can be trimmed or re-oriented to reduce potential damages to property and still provide critical salmonid habitat elements.

The following are some general guidelines for landowners to track. Please refer to the Lagunitas Creek Watershed Woody Debris Management MOU

(http://www.co.marin.ca.us/efiles/BS/AgMn/agdocs/070515/070515-13g-OS-agree-AGR.pdf) for more explicit details and information:

- If a tree falls into the stream **do not remove it**. Consultation with CDFG staff is required when considering removal and/or movement of large wood in the channel. CDFG may not allow removal of LWD.
- SPAWN also provides assistance to landowners seeking guidance and help with downed trees in the riparian corridor.
- A CDFG streambed alteration agreement is needed to remove or alter large wood in the channel. A Regional Board permit may also be needed if large equipment is being used in the stream.
- Leave branches and trees on the banks, as they provide refugia for juvenile fish during high flow events. They also help trap fine sediment and promote tree, shrub, and herbaceous plant establishment.

Promote the establishment of inset floodplains or gently slope banks.

Sloping banks back and constructing inset floodplains would stabilize banks, create critical habitat, and support successful riparian vegetation establishment. Where there is existing development this may not currently be feasible, as structures and landscaping often extend to the top of bank. County policy should be developed to set the SCA boundaries at their current location so that any restoration activities that change the top-of-bank location would not shift the SCA area of development restrictions.

Biotechnical bank stabilization using gently-sloped banks and brush mattress. Note narrow bench created next to active channel. Photo by Prunuske Chatham, Inc.

Creation of inset floodplains and the reshaping of stream banks require professional design engineering, consultation with a fluvial geomorphologist, and implementation by creek restoration professionals. Such projects are usually funded in part, with grant funds from resource management agencies such as CDFG, NOAA fisheries, State Coastal Conservancy, and State Water Board. Permits from multiple agencies would be required and assistance from agency staff would help to expedite the permitting process.

Recommendations 1-5 outline practices to create and maintain healthy riparian habitat. Where reasonable and the landowner willing, physical modifications to the bank would promote riparian forest establishment and provide high flow habitat. Recommendation 11 calls for a reach-based habitat implementation plan to provide

specifics on design details, potential implementation locations, and to evaluate habitat trade-offs. General guidelines for the use of sloped banks and inset floodplains are:

- Inset floodplains are generally appropriate for plane-bed or riffle-pool channels with stream gradients less than 2.5% (Montgomery and Buffington 1997)—this includes all of the coho spawning and rearing reaches in San Geronimo Creek and the major tributaries.
- Steep, eroding, unvegetated banks should be sloped back and planted.
- The shallower the bank slope, the greater the habitat potential and overall stability—3:1 or 4:1 slopes are optimal and 2:1 is minimal.
- Sufficient channel length is necessary to make an inset floodplain feasible, as the design of the upstream and downstream transitions is critical for stability.

In locations where site conditions restrict construction of an inset floodplain and well-sloped banks (3:1 or 4:1), such as properties with critical infrastructure at the top of bank or that have limited creek length to work with, include a narrow bench installed at the bankfull elevation in the site plans. Narrow benches allow the establishment and maturation of riparian trees and shrubs, and can greatly improve habitat conditions.

Recommendation 5 calls for the County and other organizations to consider the purchase of conservation easements or fee title on undeveloped riparian lots with high restoration potential. Construction of inset floodplains on such properties, where feasible, is a key priority. In addition, it has been suggested by plan reviewers that unused roads within the SCA should be considered for decommissioning and conversion to small floodplains/swales. Mapping and evaluation of such roads for floodplain conversion is recommended for the entire San Geronimo watershed.

Promote native tree and shrub establishment at bankfull elevations and on stream banks.

A complex, mature riparian forest adjacent to the stream and along the banks provides multiple, critical instream habitat elements. Overall guidelines for promoting the establishment and endurance of native riparian trees and shrubs are:

- Control chronic disturbances, such as grazing, with riparian fencing set back from the top-of-bank.
- Stabilize and gently slope eroding banks to allow recruitment,

Large trees provide roots to stabilize the banks and provide habitat for fish.
Photo by Prunuske Chatham, Inc.

and plant early succession stage species such as willow along with hardwood and conifer species.
- Remove exotic and invasive vegetation.
- Leave or install large wood along bank margins to slow velocities, deposit fine sediment to be used as a rooting medium, and protect seedlings as they grow and become strong enough to withstand high flows.
- Allow undercut banks where structures are not threatened.

Who would implement Recommendation 7:

- **DPW** through managing naturally recruited large wood under the Marin Municipal Water District LWD MOU, and through planning and permitting of creek restoration and stabilization projects.
- **MMWD** through review and guidance to the County under the LWD MOU.
- **Non-profit organizations** through landowner contacts and agreements for installing large wood structures, managing naturally recruited large wood and debris, and streambank restoration designs.
- **California Dept. of Fish and Game** and **NOAA Fisheries** through technical assistance and project funding.

Recommendation 8:
Promote the removal of instream barriers to migration.

Priority: **MEDIUM-HIGH**

3-4	Effect on salmonids or their habitat
2-3	Urgency
2	Feasibility/Ease

Salmonid lifestage affected:

Spawning, summer rearing, and migration

Summary of recommended approach:

- Modify or remove structural barriers that hinder salmonid migration
- Protect and conserve summer stream flows
- Continue stream crossing assessments and removal of barriers

Scientific reasoning:

Adult salmonids need to migrate upstream during spawning season. Juvenile fish need to move in multiple directions to find cool water, cover, and food during the summer; as well as migrate downstream into Lagunitas Creek and Tomales Bay as smolts. The ability for juveniles to move up and down a creek to seek and find refugia, shelter, and food is critical to their survival.

Structural obstructions, usually caused by road crossings, dams, and culverts, can partially or completely block salmonid movement at some or all lifestages. The ECR summarizes the

findings of fish passage barrier assessments conducted by SPAWN and Marin County. Fish passage improvements in San Geronimo Creek and its four major tributaries have been identified as high priority projects for the Lagunitas Creek watershed's coho salmon restoration (ECR Section 3.9.1).

In addition to structural barriers, low flow or dry reaches restrict the movement of juveniles seeking better habitat or to move downstream as smolts. Disconnected pools in tributaries strand fish and can often lead to complete mortality of the subwatershed's population when they dry up.

Description:

Modify or remove structural barriers that hinder salmonid migration.
Based on a 2003 fish passage assessment of County-maintained culverts (Taylor and Associates, 2003), the County of Marin developed a Fish Restoration Program to restore fish passage at 15 high priority sites. Six sites have been completed (ECR Section 3.9.1). Additional identified high priority projects in the ECR include (Section 3.9.1.1):

1. Replacement of circular culvert on Arroyo Creek at the Castro Street crossing.
2. Repair of the fish ladder baffle system at Larsen Creek's Sir Francis Drake crossing.
3. Improvement of fish passage through Roy's Pools and at the bridge below for juveniles and smolts.
4. Retrofit of the box culvert on San Geronimo Creek at the Railroad Avenue crossing.
5. Restoration of fish passage at the Dickson weir in North Fork San Geronimo Creek. It is strongly suggested that an extensive habitat assessment of the reach upstream of Dickson Weir be completed prior to moving forward on this proposed project and a cost/benefit analysis performed.

As the highest priority sites listed above are addressed, a review and prioritization of the remaining barriers, based on the habitats they make accessible, should be completed. Work should continue to remove or modify barriers that limit access to high quality spawning or summer rearing habitat.

Protect and conserve summer stream flows.
See Recommendations 2 and 16.

Continue stream crossing assessments.
As conditions in San Geronimo Valley change due to implementation of this Plan, climate impacts, and unforeseen events (e.g., floods, landslides, earthquakes), the hydraulic characteristics of the barriers and the quality of and need for the upstream habitat may also change. The barrier assessment should be periodically updated at regular (approximately five-year) intervals to capture such changes.

Who would implement Recommendation 8:

- **Marin DPW** through culvert replacement or modification associated with County maintained roads.
- **Community organizations** through agreements with private landowners to replace culverts on non-County maintained roads or modify barriers on private property.

Recommendation 9:
Promote gravel delivery and retention.

Priority: **MEDIUM**	
3	Effect on salmonids or their habitat
2	Urgency
2	Feasibility/Ease

Salmonid lifestage affected:

Spawning

Summary of recommended approach:

- Replace undersized road culverts with larger or arched culverts.
- Modify Dickson weir to allow coarse sediment passage.
- Increase gravel retention through channel complexity improvements.

Scientific reasoning:

Significant portions of mainstem San Geronimo Creek are incised down to bedrock (ECR Section 3.7.1 and Figure 3-13). In these areas gravel storage is minimal and spawning is precluded. San Geronimo valley is the primary gravel supplier to upper Lagunitas Creek, as Kent Lake traps all sediment from the upper Lagunitas basin. Based on preliminary work for the Lagunitas Creek sediment TMDL (total maximum daily load) by the Regional Board and MMWD streambed monitoring program data, the delivery and retention of gravel and cobble may play a critical role in maintaining and enhancing streambed conditions necessary for all salmonid life stages (M. Napolitano, Regional Board, pers. com., 2009).

Culverts and other road crossings block small, first order channels, and limit the delivery of beneficial coarse sediment to tributaries and the mainstem. In addition, sediment management programs to trap and remove bedload were implemented in the mid-80s and 90s to reduce fine sediment delivery. At least one of the sediment management projects, Dickson Weir, also traps gravel.

Incised channels, such as San Geronimo Creek and its tributaries, are subject to high velocities during storm events that scour the channel bed and transport gravels out of the system. Many channel reaches within San Geronimo Valley are scoured down to bedrock, due in part to their lack of channel complexity and obstructions (e.g., floodplains and large wood accumulations) that serve to slow flood flows and reduce bed scour. Other reaches with sufficient gravel deposits where salmonids preferentially spawn may experience redd scour during high flows; leading to loss of eggs and fry.

Description:

Maintain gravel delivery to the stream network.
Stream crossings that trap or slow the delivery of coarse material to the stream network should be replaced or modified. The weir on the Dickson ranch should be managed or modified to allow passage of coarse material to upper San Geronimo Creek.

Before choosing to repair an erosion site that is not a threat to human health or safety, the site should be assessed for its potential to deliver coarse sediment to tributaries and the mainstem. Small landslides in agricultural or open space lands, for example, might be better left alone to deliver sediment to the local stream channel.

Increase channel complexity to support gravel retention.
See Recommendation 7 for channel elements that capture and store gravel.

Who would implement Recommendation 9:

- **Marin DPW** through replacement of culverts on County maintained roads.
- **MCFD** and **MMWD** through agreements with Marin County and private landowners.
- **Non-profit organizations** through agreements with private landowners on non-County maintained roads.
- **California Dept. of Fish and Game** and **NOAA Fisheries** through technical assistance and project funding.

Recommendation 10:
Minimize and reduce streambank armoring.

Priority: **MEDIUM - HIGH**

5	Effect on salmonids or their habitat
1-2	Urgency
2	Feasibility/Ease

Salmonid lifestage affected:

Summer rearing and over-wintering

Summary of recommended approach:

- Replace existing hard repairs with biotechnical methods, where appropriate.
- Require new bank stabilization repairs be designed to increase channel width and utilize biotechnical approaches where feasible.

Scientific reasoning:

Bank stabilization practices are designed to halt erosion and lock the channel in its current location. Often this is done to protect valuable property or prevent damage to infrastructure. However, traditional hard streambank armoring such as riprap, gabions, shotcrete, or concrete walls can exacerbate downstream erosion and initiate upstream or cross-stream

bank failures. Armoring also usually precludes the establishment of riparian vegetation—reducing and, in many cases, impairing instream habitat. A hardened bank devoid of vegetation increases water temperatures, provides little to no cover for fish, increases bed and bank velocities, and often inhibits pool formation. Thus, permitting agencies have become less willing to permit these approaches.

In reaches where summer water temperatures are above optimal levels for rearing and there is a lack of deep pools with cover or high flow refugia, the presence of existing hard bank protection is likely limiting habitat rehabilitation and salmonid success.

Description:

Replacement of hard bank armoring can occur through two circumstances:

1. failure of existing bank protection initiates a request for repairs, or
2. a landowners' desire to replace existing functional bank protection with a more "fish-friendly" solution.

Where possible, streambanks should be sloped back to a 2:1 slope, with 3:1 or 4:1 slopes preferred (Recommendation 7), and room for a riparian buffer (Recommendation 2). Replacement should use bioengineering methods. Bioengineering is the practice of using native plant materials in combination with engineering practices to stabilize soil while creating habitat. Bioengineering can be used on very active, severe bank erosion, but it must be carefully designed to fit site conditions. Hard repair techniques such as toe rock are sometimes incorporated into bioengineering solutions if existing infrastructure at the top of bank is clearly threatened—based on analysis of predicted velocity, shear stress, bank material, and bank failure process. Conceptual plan 2 in Appendix H contains examples of bioengineering bank stabilization methods including methods that can be used in shady sites.

Funding support and guidance should be available to help homeowners design and implement bioengineering solutions.

Who would implement Recommendation 10:

- **Individual landowners** with assistance from **Marin County resource management agencies** and **non-profit organizations**
- **Marin DPW**, state and federal agencies through permitting of bank stabilization projects.

Recommendation 11:
Develop an Instream Habitat Enhancement Implementation Program.

Priority: **HIGH**

5	Effect on salmonids or their habitat
3	Urgency
3	Feasibility/Ease

Salmonid lifestage affected:

Guides efforts to implement projects that address migration, spawning, summer rearing, and over-wintering habitat targets

Summary of recommended approach:

- Develop specific reach-based goals and conceptual designs for instream habitat improvements.
- Prioritize channel reaches and projects.
- Coordinate activities and funding programs amongst organizations to maximize effectiveness.

Scientific reasoning:

Chapter 3 of the Plan summarizes a preliminary analysis of the amount of effective habitat needed in San Geronimo Valley to support each coho life-stage population goal. Chapter 3 also describes the instream components that compose each life-stage's habitat, with indicators and targets listed (Tables 2-4). Although these targets are dependent on many different factors and are highly variable, they provide a foundation that can guide instream enhancement efforts.

With the coho on the verge of extinction throughout the Central Coast ESU (Spence et al. 2008; NMFS 2009, Appendix C) it is critically important to increase survivorship of the remaining population. Based on documentation and evaluation of salmonid populations during their tenure in the watershed it appears that both overwintering and summer rearing habitat conditions are limiting factors to coho recovery (Stillwater Sciences 2008; ECR Sections 3.9 and 5; Plan Chapter 3).

Description:

To maximize habitat rehabilitation effectiveness and efficiency an implementation plan is needed. Recommendations 7 through 10 outline the types of projects needed to improve channel structure and habitat quality, and they should be implemented as opportunities arise. However, many of the instream actions would require multiple, adjoining landowner participation, extensive engineering design, and an analysis of opportunities, constraints, and ecosystem tradeoffs.

After the areal extent and quality of the critical lifestage habitat elements has been determined (Data Gap 2), reach-based actions and priorities to shift the system closer to targets can be developed. Thoughtful, well designed, prioritized instream habitat enhancement projects are needed to quickly boost channel complexity, pool depth and

cover, and high flow refugia area. Concentration of efforts using a spectrum of enhancement techniques within prioritized reaches will likely yield more effective results. For example, a bank stabilization project that creates an inset floodplain for high-flow refugia paired with installation of in-channel large wood, pool-forming structures will maximize habitat and velocity protection at all flows; whereas installation of a large wood structure at a hardened, vertical bank will only provide limited habitat value.

The Instream Habitat Implementation Program should include:

- evaluation of habitat component conditions and targets,
- reach goals for habitat components for each lifestage,
- recommendations on the best measures for each reach to achieve the goals,
- specific projects and project types to systematically improve habitat conditions in high priority reaches,
- potential locations where stream conditions support specific enhancement activities, such as installing woody debris for pool cover or constructing inset floodplains,
- known constraints including difficult access and potential impacts to other protected species or riparian habitat,
- opportunities where land use or ownership patterns support reach-scale rehabilitation,
- an analysis of trade-offs between long-term habitat gains and potential short-term losses to existing riparian cover or bank stability,
- an implementation plan that outlines the organization(s) that will undertake the projects necessary to significantly improve habitat through the proposed actions.

Who would implement Recommendation 11:

- **Marin DPW** through plan coordination.
- The **Lagunitas Technical Advisory Committee** through the formation of a technical San Geronimo working group (TWG)—chaired by the County—to guide and review plan development and program implementation. Participants in the TWG would include agencies such as CDFG, NOAA Fisheries, Regional Board, MMWD and local non-profits.
- **Marin DPW, MMWD, MRCD,** and **non-profit organizations** to design and implement projects listed in the reach-based plans.

Recommendation 12:
Promote increased watershed-wide stormwater retention and disconnection.

Salmonid lifestage affected:

Spawning, summer rearing, and over-wintering

Priority: **HIGH**	
5	Effect on salmonids or their habitat
2	Urgency
2	Feasibility/Ease

Summary of recommended approach:

- Map connections between road runoff and streams.
- Disconnect and filter road drainage.
- Promote reduction of unnecessary impervious surfaces and drainage networks.
- Promote reduction of connected impervious area in existing development, especially on steep slopes or if connected to a stormwater drainage system that drains directly to a creek.
- Re-plumb downspouts and other stormwater systems away from creek.
- Require no net increase in effective impervious area and runoff in new or re-development.

Scientific reasoning:

Urbanization has multiple, direct, deleterious effects on freshwater habitats and the species they support (ECR Section 2.3). The impacts of urbanization include increased water yield from the basin, with a shift to higher peak flows coupled with lower base and dry season flows; increased drainage density and channel incision; encroachment on and loss of riparian corridors; and increased sediment loads and pollutant contamination carried in runoff. The effects on salmonids, as discussed throughout this Plan, are loss of high quality habitat, physiologic impairment, and direct mortality (ECR Section 2.3.4).

Many of the impacts of urbanization are linked to impervious areas that collect and concentrate runoff. Through stormwater drainages and pathways, development and land use practices on ridgelines, hillslopes and areas away from the creeks have a direct impact on instream habitat conditions and salmonid survival.

One of the many studies cited in Section 2.3 of the ECR noted that when impervious surfaces are directly connected to streams (through culverts, roads, and storm drains), even small rainfall events deliver water and pollutants that degrade stream habitat and impact aquatic species (Walsh 2004). Both the total amount of impervious surfaces (TIA) in a watershed and the connection of these impervious surfaces through pipes and drains to the creek (known as effective impervious area or EIA) are important to managing pollutant loads.

Mitigation of urbanization impacts to aquatic ecosystems have recently begun to focus on stormwater disconnection. Protection of human health and stream ecosystems is dependent upon implementing strategies that reduce drainage connections to streams, disconnect impervious areas, and use low-impact urban design approaches (Stillwater Sciences 2009 citing Roy et al. 2008; Walsh 2004; Hatt et al. 2004).

The County of Marin recognizes the impacts of stormwater on streams and aquatic ecosystems, even in the less densely populated areas such as San Geronimo Valley. The Marin County Municipal Code addresses stormwater management for unincorporated areas of Marin under Title 23: Natural Resources, Chapter 23.18 Urban Runoff Pollution Prevention (Ord. 3225 § 2 (part), 1996). The following are selected sections from Chapter

23.18 that support stormwater management for salmonid habitat protection and enhancement.

> "Maintaining pre-development stormwater runoff rates and preventing nonpoint source pollution whenever possible, through stormwater management controls and ensuring that these management controls are properly maintained."
>
> "The director of public works may require, as a condition of project approval, permanent controls designed for the removal of sediment and other pollutants. The selection and design of such controls shall be in general accordance with criteria established or recommended by federal, state and local agencies. Where physical and safety conditions allow, the preferred control measure is to retain drainageways above ground and in as natural a state as possible or other biological methods such as vegetated swales."

Description:

Map stormwater systems that connect road runoff and streams.
The locations and connectivity of stormwater pipes, ditches, and stream outlets should be documented for design and planning of stormwater management and filtration projects. Efforts should be focused on the subwatersheds with the highest TIA (Woodacre, Montezuma, and mainstem San Geronimo Creek). Prioritize projects based on amount and quality of runoff delivered to the creeks.

Disconnect and filter road drainage.
Systematic efforts should continue by all road management entities to disconnect and filter drainage. Effective practices include:

- outsloping gravel or dirt roads to eliminate or reduce the need for ditches and culverts,
- maintaining herbaceous vegetation where road ditches are needed,
- installing small retention basins at culvert and storm drain outfalls,
- diverting runoff into flat, well-vegetated areas, and
- developing guidelines for paved driveways, parking areas, fire truck turnarounds and other roadways, including those on steep hillsides, to encourage impervious materials and reduce focusing water flow in ditches.

Opportunities should be assessed for decommissioning dirt and paved roads under the County's jurisdiction as well as road-islands and other impermeable surfaces to create opportunities for stormwater filtration and recharge (e.g. rain gardens, infiltration trenches/basins).

Regular winter effectiveness monitoring is very important to ensure that the measures are working without causing new problems.

Promote reduction of connected impervious surfaces and drainage networks in existing development, especially on steep slopes or if connected to a stormwater drainage system (BIO-4.20).

All watershed residents can help San Geronimo Creek and its fish by disconnecting impervious surfaces and limiting the size of new impervious structures. Existing development on steep slopes often contributes a high proportion of stormwater and pollution to the stream system. Homeowners should be encouraged to:

- replace impervious driveway and sidewalk pavements, decks, and patios with pervious materials,
- replace dirt roads and driveways with pervious materials,
- intercept and dissipate runoff from roofs and driveways,
- remove all downspout pipes that cross top of bank and route water directly into a channel,
- redirect drainage features or pipes away from the stream or drainage ditch and into vegetated swales away from the riparian buffer, and
- store rainwater for slow release into gardens and landscaping in the dry season.

Impervious area *includes roofs, pavement, and any hard surfaces that prevent water from infiltrating into soil.* ***Total impervious area (TIA)*** *measures all such surfaces in a given area.* ***Effective impervious area (EIA)*** *measures hard surfaces that are connected directly to stream channels. An example is a roof that directs water directly onto a paved driveway, then to a road ditch, through a stormdrain, and finally into a creek.*

Conceptual Plan 3 in Appendix H illustrates methods for disconnecting and infiltrating storm flows. Resources for additional information on Low Impact Development (LID) and rainwater harvesting are in Appendix I.

Technical support and compelling incentives to help reduce costs are critical to implementation of this action. Incentive programs should first focus on the Woodacre Creek subwatershed and those SCA areas with the highest TIA—Montezuma, Larsen, Lower San Geronimo Creek, and the Arroyo/Barranca/El Cerrito Complex (ECR Section 3.3). Suggestions for incentives are in Chapter 6.

Require no net increase in effective impervious area and runoff in new or re-development.
New development in the watershed should use Low-Impact Development (LID) measures and other techniques to capture and infiltrate all runoff before it leaves the site. These practices should maintain pre-development stormwater runoff rates and prevent pollution delivery to the waterways, as described in the Marin County Municipal Code (see above).

Who would implement Recommendation 12:

- **Marin DPW, Marin County Fire Department, and Marin County Open Space** through management of County owned and maintained roads.
- **Individual landowners** with assistance from Marin County and resource management agencies**.**

- **Marin Resource Conservation District, SPAWN** and other **organizations** through workshops and grant-funded assistance for private landowners on non-County maintained roads.
- **Marin County CDA and Public Works** through new and re-development permits and plan review.

Recommendation 13:
Develop a community-supported program to assist homeowners with addressing leaking septic systems. Give highest priority to systems within SCA and in reaches with higher nutrient levels.

Priority: **MEDIUM**	
4	Effect on salmonids or their habitat
2	Urgency
2	Feasibility/Ease

Salmonid lifestage affected:

Spawning, summer rearing, over-wintering

Scientific reasoning:

High levels of nitrate and fecal coliform in Woodacre Creek and San Geronimo Creek, particularly during storm events, indicate septic system leakage (ECR Section 3.5). High nitrate levels can increase algal growth which in turn reduces oxygen levels. Fecal coliform does not directly affect fish, but if septic systems are leaking, they are likely contributing organic matter, nutrients, pharmaceuticals, and other toxics to Valley streams.

Targets directly addressed by this action include dissolved oxygen, nutrients, and toxicity. Poor water quality also affects salmonid food availability through changes in the composition and numbers of macroinvertebrates (aquatic insects).

Description:

A program is needed in San Geronimo Valley to bring homeowners, Marin County Environmental Health Services, and the Regional Board together to repair or replace leaking septic systems. The Tomales Bay Watershed Council (TBWC) has been working on septic system assessment and planning in the San Geronimo watershed. The program should include an evaluation process designed to identify needs without penalizing participating homeowners; a strategy or series of strategies for implementing repairs; and a strategy to find and administer funding to assist homeowners. Priority should be given to homes within the SCA and in those subwatersheds where monitoring shows high nutrient or coliform levels.

Because septic system replacement and repairs can be prohibitively expensive, any implementation strategy selected must include making repairs affordable for Valley homeowners. Cost reduction measures could include lower-cost design and installation

alternatives, cost shares through grant programs administered by the County or local non-profit organizations, and collective purchase of materials and services.

Marin County has local examples of innovative approaches to effective management of on-site systems. After repeated ballot measures for a sewage treatment facility failed, Stinson Beach County Water District took over management of septic systems in Stinson Beach. Through the Onsite Wastewater Management Program, the Water District issues permits for new systems and inspects all systems regularly to ensure they are functioning properly. Along the east shore of Tomales Bay, Marin County has implemented the first phase of a grant-funded program to upgrade septic systems and build small community treatment facilities.

Use of properly managed graywater systems should be considered where appropriate as one tool to reduce pressure on septic systems and conserve water. Graywater is the wastewater that drains out of washing machines, sinks, bathtubs and showers. Extreme care must be taken to design and manage graywater systems to avoid contamination of surface and groundwater.

Who would implement Recommendation 13:

Marin County EHS, TBWC, Regional Board, and **homeowners** through development of a community-supported program to evaluate and, where needed, upgrade septic systems or provide alternative sewage treatment facilities

State and federal agencies to support upgrades through grants and low-interest loans

Recommendation 14:
Promote minimal usage and proper disposal of chemicals, nutrients, and toxic materials to avoid impacts to fish and their habitat.

Priority: **MEDIUM-HIGH**

3-4	Effect on salmonids or their habitat
2	Urgency
2-3	Feasibility/Ease

Salmonid lifestage affected:

Spawning, summer rearing, over-wintering,

Summary of recommended approach

- Develop outreach materials and program to manage nutrient and pollutant inputs to the watershed.
- Follow NOAA Fisheries (2008) guidelines to mitigate pesticide delivery.
- Reduce toxic spills.

Scientific reasoning:

The Regional Board has determined that surface water in the Lagunitas watershed, which includes San Geronimo Creek, is impaired due to excessive pathogens and nutrients. Nitrates routinely exceed and orthophosphates occasionally exceed the EPA guidance level in mainstem San Geronimo Creek and its tributaries, with both levels highest in Woodacre Creek (ECR Section 3.5.2). The upper and lower reaches of San Geronimo Creek are the second and third largest contributors of coliform bacteria in the Tomales Bay watershed. The San Francisco Bay Water Quality Control Board has concluded that failing septic systems are largely responsible for the bacteria loads, as well as stormwater runoff with pet waste from horse facilities (Ghodrati and Tuden 2005).

Acute accumulations of the toxic metals chromium, nickel, arsenic, copper, and mercury have been found in sediments in San Geronimo Creek (ECR Section 3.5, Stillwater Sciences 2009). Given the level of development and impervious area in the San Geronimo Valley, it is likely that other urbanization-related pollutants, such as pharmaceuticals, and compounds associated with herbicides, pesticides, plastics, solvents, and petroleum-based fuels, are also present in the waterways. Testing would be required to determine levels and locations. These pollutants are toxic to aquatic organisms, with salmonids being particularly sensitive.

Both adult and juvenile salmonids are increasingly showing sublethal and lethal responses to typical pollutant concentrations, such as diazinon and malathion in surface waters (ECR Sections 2.3.3 and 2.3.4, Laetz et al. 2009, NOAA Fisheries 2008). In a recent biological opinion, NOAA Fisheries prescribes measures to alleviate effects of chlorpyrifos, diazinon, and malathion (organophosphate pesticides) on salmonids and their critical habitat in California and the Pacific Northwest (NOAA Fisheries 2008). Their recommended measures include the following:

1. Prohibiting aerial applications of the three pesticides within 1,000 feet of salmon waters.
2. Prohibiting ground applications of the three pesticides within 500 feet of salmon waters.
3. Requiring a 20-foot non-crop vegetative buffer around salmon waters and ditches that drain into salmon habitat.
4. Prohibiting applications of the three pesticides when wind speeds are greater than or equal to 10 mph.

Description:

Medicines, some cleaning products, herbicides, pesticides, plastics, solvents, and petroleum-based fuels are toxic to fish and other aquatic organisms. Replacing toxic materials with safer alternatives, careful use when toxic materials are necessary, and proper disposal would help keep these materials out of San Geronimo Creek and its tributaries.

Develop outreach materials and program to manage nutrient and pollutant inputs to the watershed. MCSTOPPP has excellent information on cleaning and draining swimming pools and spas, alternatives to pesticides and herbicides, less toxic cleaning products, and a list of places in

Marin County where residents can safely disposed of unwanted medicines (www.mcstoppp.org). The Stinson Beach County Water District has information on chemicals that harm the essential bacteria in septic systems and reduce the systems' effectiveness (www.stinson-beach-cwd.dst.ca.us).

Sources of excess nutrients to streams include animal waste, fertilizers, compost, and yard clippings. Manure from confined animals, primarily horses in San Geronimo Valley, should be stored and managed in accordance with Best Management Practices (BMP) guidelines in Appendix I. Compost and yard clippings should be stored at least 35 ft from stream channels. Proper timing and application rates for both organic and chemical fertilizers reduce nutrient runoff.

Outreach and technical assistance should be offered to owners of horses and other confined animals in the watershed to help them implement BMPs. Efforts should be made to include small-scale horse owners who may not have as ready access to current technical information as larger facilities. Equestrian organizations, Marin County RCD, MCSTOPPP and UC Cooperative Extension are candidate organizations to provide information and support.

Follow NOAA Fisheries (2008) guidelines to mitigate pesticide delivery.
While Marin County flood control and road maintenance crews do not use herbicides or pesticides, the County should continue to adhere to guidelines promoted by its Integrated Pest Management program.

In addition to MCSTOPPP's current efforts, a focused outreach campaign should be undertaken to inform or remind San Geronimo Valley residents about the impacts of chemicals, fertilizers, and toxic materials on salmon and steelhead, alternatives, and safe disposal methods. Ideas to promote toxic reduction include a salmon-friendly sign program for safe products at local stores, a toxic-free fair with products for sale, free disposal, and a valley-wide Pesticide/Herbicide free zone.

Reduce toxic spills.
Accidental spills are another source of contaminants into San Geronimo Creek and its tributaries. Past spills have included treated water from breaks in MMWD water lines, fire retardant, and paint (DPW personal communication). Prevention, rigorous enforcement, and prompt remediation are needed to reduce the frequency and environmental impact of spills. The County Hazardous Materials Area Plan provides guidelines for preventing and handling spills. (http://www.co.marin.ca.us/depts/PW/Main/pdfs/hazmat)

Who would implement Recommendation 14:

- **MCSTOPPP,** and **community organizations** through outreach and education
- **Regional Board** through enforcement of clean water regulations
- **MMWD and MCFD** through spill prevention. All cooperating agencies through implementation of the County Hazardous Materials Area Plan.

- **Homeowners** through use of fish-friendly products and proper disposal of swimming pool water and toxic materials; storage of animal waste, compost and yard waste; and application of fertilizers.

Recommendation 15:
Reduce fine sediment delivery from roads and upland erosion.

Priority: **MEDIUM to HIGH**

4-5	Effect on salmonids or their habitat
1-2	Urgency
3	Feasibility/Ease

Salmonid lifestage affected:

Spawning, summer rearing, over-wintering

Summary of recommended approach:

- Inventory and assess private roads for fine sediment delivery.
- Implement BMPs for road maintenance to manage and reduce fine sediment and stormwater delivery.
- Decommission non- or under-used roads within the watershed.
- Fix poorly designed roads to reduce the potential for chronic sediment delivery or failure.
- Repair upland gullies.

Scientific reasoning:

Fine sediment can collect between larger particles to reduce the flow of water and oxygen in spawning gravels. Excessive sand-sized material can entomb incubating eggs or emerging alevins, and decreases dissolved oxygen levels in the gravels below levels necessary to support hatching. A 10-year streambed monitoring program in neighboring Lagunitas Creek has shown that the percentage of sand has been increasing (Hecht 2008). Based on erosion and sedimentation studies of the Lagunitas watershed, it is suggested that fine sediment from San Geronimo Creek watershed is contributing to degraded aquatic habitat conditions and declines in fish populations. (Stillwater Sciences 2008b).

Numerous erosion control projects have been completed by MMWD, Marin Resource Conservation District, SPAWN, Trout Unlimited, and private landowners in San Geronimo Valley since the 1980s to reduce sediment delivery to the system. Since implementation of these projects embeddedness, a measure of the intrusion of fine sediment into the streambed, declined in San Geronimo Creek between 1998 and 2006 (ECR Section 3.7).

The geology of the watershed, its land-use history, and residential development on steep hillslopes creates a high potential for excess fine sediment supply and delivery, which is likely to adversely impact salmonid growth and survival during every freshwater life stage. Many miles of privately maintained dirt roads and driveways in the watershed are sources of sediment to San Geronimo Creek (ECR).

Four subwatersheds within San Geronimo Valley account for over half of the fine sediment delivered to the stream channels. They are North Fork San Geronimo Creek, Woodacre Creek, Larsen Creek and the Arroyo/Barranca/El Cerrito Creeks subbasin (Stillwater Sciences 2007).

Description:

Efforts to control and reduce fine sediment delivery from roads and other anthropogenic upland erosion sources, such as gullies and new construction, should continue. Projects that hydrologically disconnect roads or other sediment sources, both as a fine sediment reduction and runoff attenuation action, should be a priority.

Inventory and assess private roads for fine sediment delivery.
A thorough assessment of road-related sediment and high priority repair sites should be performed to focus restoration efforts.

Implement Best Management Practices (BMPs) for road maintenance to manage and reduce fine sediment and stormwater delivery.
BMPs for new construction should be rigorously adhered to for all new construction. Road maintenance should continue to focus on intercepting, dispersing, and infiltrating runoff. The Lagunitas TAC Roads MOU developed with the County, MMWD and other entities contains detailed guidance (http://fishnet4c.org/pdf/marin_roads_mou.pdf). Appendix I includes references for BMPs, road maintenance and construction, and erosion control. Additional suggestions include:

- establish a program to train and certify heavy equipment operators, contractors, and landowners who perform road grading projects in proper road maintenance techniques
- expand County road maintenance in urbanized areas to include street sweeping and vacuuming
- increase outreach to owners of dirt roads regarding maintenance through workshops and demonstration projects

Decommission non- or under-used roads within the watershed.
Abandoned or non-maintained roads should be decommissioned and stabilized.

Fix poorly designed roads to reduce the potential for chronic sediment delivery or failure.
High priority road sites should be repaired based on the road inventory. Small assessment districts for private roads should be considered to support maintenance and repair.

Repair upland gullies.
Upland gullies should be repaired with biotechnical techniques to restore the vegetative cover and hydrology.

Who would implement Recommendation 15:

- **Marin DPW, MCFD, MCOS,** and **MMWD** through maintenance of County roads and implementation of the Lagunitas TAC Road MOU
- **MMWD** through completion of an assessment of all unpaved roads in the watershed followed by implementation of road drainage improvement on MMWD-owned roads and roads that support MMWD pipelines and other infrastructure facilities
- **Landowners** through proper maintenance of private roads
- **Marin RCD** and other **non-profit organizations** through workshops and assistance to private landowners on non-County maintained roads
- **FishNet4C** and **California Dept. of Fish and Game** through technical assistance and project funding.

Recommendation 16:
Protect and enhance summer streamflow.

Priority: **HIGH**	
5	Effect on salmonids or their habitat
3	Urgency
2	Feasibility/Ease

Salmonid lifestage affected:

Summer Rearing

Summary of recommended approach:

- Assess streamflow.
- Remove instream pumps from the creeks.
- Protect upland springs and reduce groundwater extractions in alluvial aquifers.
- Develop and implement a streamflow conservation program to replace non-potable, extractive supplies.
- Develop template for and implement groundwater-surface water impact evaluations.

Scientific reasoning:

Maintenance of summer streamflows is critical to maintaining high quality rearing habitat and the survival of salmonids. At some locations in San Geronimo Creek and its tributaries during the summer, water temperatures exceed optimal temperatures and dissolved oxygen (DO) levels are less than supportive for juvenile salmonids (ECR). Continuous flow with adequate depth through perennial reaches is a critical component for allowing juvenile fish to move between habitat units to forage, escape predators, or relocate from unsuitable conditions; and to provide a continuous source of food to pools from riffles. Salmonid juveniles in San Geronimo Creek are smaller than those in Lagunitas Creek, which has regulated flows and lower water temperature (SPAWN, 2008; Stillwater 2009).

Although no data currently exists showing the effects of water extraction on streamflow in San Geronimo Valley, local scientists' and agency personnel's best professional judgment

concludes that water extraction reduces streamflow and that there is over-extraction when there is not adequate instream flow for aquatic species (ECR; G. Seymour, CDFG, pers. com., 2009; L. Ferguson, Regional Board, pers. com., 2009). Studies of groundwater extractions in other watersheds in the region have shown a correlation between reductions in flow depth and pool drying (PCI 2006). Incomplete well data indicates that there are approximately 75 groundwater wells in San Geronimo Valley, with the majority located along mainstem San Geronimo Creek (ECR citing Marin EHS 2008).

Some landowners in the SCA currently pump water from the creeks to irrigate gardens and landscaping in the summer. During drought years the numbers of pumps are likely to increase. These pumps have an immediate local effect on streamflow and a cumulative effect downstream.

Urbanization and hardening of the landscape are known to reduce infiltration and thus aquifer recharge (ECR Section 2.3.1), correspondingly reducing the amount of water supplied to the streams during the low flow seasons. Recommendation 12 outlines a process to disconnect impervious surfaces and stormwater pathways that would lead to increased infiltration and groundwater recharge.

Climate change is predicted to reduce water availability with summers becoming hotter and drier (Plan Chapter 2). Management of water supplies for both humans and fish will become even more critical.

Description:

Assess streamflows.
An evaluation of streamflows and potential for salmonid habitat improvement would help determine which areas have the geology and microclimate to support perennial streams, and provide a basis for prioritizing stream flow restoration.

Remove instream pumps from the creeks.
Responsible agencies should enforce no illegal pumping from the creeks and work with landowners to develop alternative water sources, such as roofwater catchment systems or MMWD municipal water where available.

Protect upland springs and alluvial aquifers.
The use of roofwater catchment systems should be encouraged in lieu of developing new springs. Existing wells along streams should receive high priority for replacing some or all of the water withdrawn with roofwater catchment. Correct installation of drip irrigation systems and drought tolerant landscaping will help reduce non-potable water needs.

Develop a streamflow conservation plan and program.
To address water supply and demand issues, a San Geronimo streamflow conservation plan should be developed. The plan would prioritize instream flow protection projects and support landowners in acquiring cost-share assistance to convert to non-extractive water

supplies and/or implement water conservation measures. Incentives for rainwater catchment through rebates and technical support should be developed.

Develop and implement groundwater-surface water evaluations for all existing wells, new well permits, and for development plans outside of MMWD service area.
The interaction between groundwater and surface waters is notoriously challenging to determine. Data Gap # 10 addresses a study to look at these interactions in San Geronimo Valley and how they impact summer rearing habitat conditions for juvenile salmonids. Once this study is complete a template with criteria for evaluating the impact a new well may have on salmonid habitat should be developed and applied to new well applications. In the meantime, new wells are not recommended within the Stream Conservation Areas inside the MMWD service area.

Who would implement Recommendation 16:

- **Landowners** through voluntary reductions of their use of extractive water sources.
- **Marin DPW and/or partner agencies and organizations** through streamflow assessment and development of a streamflow conservation program.
- **Marin County** and **MMWD** through review and permitting of groundwater wells and spring development, and through incentives and rebates to encourage rainwater harvesting.
- **SPAWN** and other **local organizations** through assisting landowners with reducing consumption and developing non-extractive water supplies.
- **State Water Board (Division of Water Rights), CDFG, and NOAA Fisheries** in regulating legal riparian and appropriative water rights and determining illegal water diversions.

Recommendation 17:
Develop and implement a coordinated monitoring program to track habitat conditions, salmonid populations, and trends associated with enhancement activities.

Priority:

HIGH

Salmonid lifestage affected:

Informs and tracks spawning, summer rearing, and over-wintering habitat and lifestage population targets.

Summary of recommended approach:

- Instream habitat monitoring.
- Water quality monitoring.
- Flow monitoring.
- Population monitoring.

Scientific reasoning:

The Plan outlines habitat elements and targets based on lifestage needs (Chapter 4). Many of the targets are associated with habitat structure such as gravel quantity and quality, frequency of large wood accumulations, inset floodplains, velocity refugia, and pool/riffle ratios. High quality habitat is also dependent on water quality conditions and adequate streamflow. Procedures to collect, analyze, and track individual habitat components, lifestage habitat area targets, and salmonid populations at the range of lifestages are needed to assess effectiveness of habitat enhancement and physical process restoration actions over time.

Local and regional entities, including MMWD, Regional Board, SPAWN, and the Tomales Bay Watershed Council (TBWC), have collected water quality data in mainstem San Geronimo and its main tributaries at varying frequencies and locations since 1995 (Stillwater Sciences 2009a). Results of the monitoring efforts indicate that salmonid health is not consistently supported in the watershed and there are several water quality data gaps that need to be addressed in order to fully understand the impacts of water quality in San Geronimo Creek on salmonid health. Coordination between the entities currently collecting water quality data would allow data gaps to be filled efficiently and in an integrated fashion, as well as supporting continued tracking of water quality trends affecting salmonids.

A stream gage is located in lower San Geronimo Creek near the Lagunitas Bridge, and has been in operation since 1983.
(http://www.balancehydrologics.com/geronimo/creek/index.php)

The accuracy of the low flow monitoring is unknown, yet this is a critical data set for salmonid habitat evaluation. The relationship between summer flow volumes and habitat conditions (i.e. riffle flooding, pool connectivity, extent of connectivity) in San Geronimo Valley and its major tributaries is unknown. Relationships between hydrologic conditions and streamflow are also unknown. These relationships are critical to understand and track in order to prepare for and protect critical summer streamflows for the fishery.

Annual population estimates for each lifestage are invaluable for tracking the fishery and understanding relationships between habitat conditions and survivorship. MMWD and SPAWN currently conduct annual surveys of salmonid redds in the San Geronimo watershed and monitor juvenile coho and steelhead populations in the summer. Their efforts should continue with support as needed from other agencies and educational institutions.

Description:

Instream habitat monitoring
The instream habitat monitoring program should address lifestage habitat requirements and their quality; including large wood frequency and related pool conditions, instream shelter, sediment composition and distribution, and high flow refugia such as inset floodplains and tributary confluence backwaters. The program should incorporate the following tasks:

- assessment of existing areal and habitat component target values (see Data Gap #2),
- development of standardized methods to monitor and analyze habitat components based on targets,
- a process to map and describe projects implemented, and
- a method to assess effectiveness.

Instream habitat evaluation and monitoring should occur in the mainstem and major tributaries. Monitor amount of spawning, summer rearing, and overwintering (velocity refugia) habitat every 2-3 years or after implementation of significant instream enhancement measures.

Water quality monitoring
The water quality monitoring program for the San Geronimo Creek watershed should implement a tiered approach. The first tier should track standard, and seasonally critical parameters, using continuous, permanently installed monitoring equipment at multiple locations throughout the mainstem and tributaries. These parameters include:

- water temperature and
- dissolved oxygen,
- nutrients,
- total suspended solids and/or turbidity.

Other important, yet background condition parameters should be sampled on a set schedule (to be determined). These parameters include, but are not limited to:

- coliform bacteria,
- heavy metals, and
- other known or potential toxins (e.g., organochlorine and organophosphate pesticides, herbicides, PCBs).

The monitoring program should also include follow-up bioassessment surveys to expand the dataset beyond a single site in mainstem San Geronimo Creek collected during the 2001 SWAMP and 2008 MCSTOPP surveys.

Instream flow monitoring
It is strongly recommended that the instream flow monitoring program include:

- Maintaining the existing stream gage at the mouth of San Geronimo Creek.
- Establishing stream gages in the major tributaries that are utilized for rearing and which will have water conservation program projects implemented.
- Monitoring streamflow conditions in the mainstem and tributaries, noting where and when riffles disconnect.

- Analyzing and comparing annual rainfall amounts and monthly distribution, summer streamflow characteristics, and corresponding habitat conditions.

Salmonid population monitoring

Additional annual population monitoring activities should include, but not be limited to:

- Continue and expand smolt trapping to monitor the number and size of smolts leaving the San Geronimo watershed annually to track watershed productivity.
- Continue spawner surveys to document the number of returning adults and document preferred spawning locations.
- Implement early summer juvenile surveys to document fry survival rate; compare to early fall juvenile surveys for summer survival rates.

Who would implement Recommendation 17:

- **Marin DPW** through program coordination and data collection.
- **MMWD, Regional Board, Tomales Bay Watershed Council, SPAWN**, and **other organizations** through data collection activities
- **CDFG**, **NOAA**, and **Regional Board** through technical and grant funding support.

2.4 Data Gaps

Accomplishing the following actions will provide information useful for prioritization and implementation of the habitat enhancement recommendations. Additional research-related data gaps are listed in the ECR (Section 5.6).

Riparian

1. Collect additional reference-reach information on multi-story plant composition and successional processes to guide large-scale restoration efforts.
2. Collect information on existing levels of bank armoring, locations of over-steepened and eroding banks, and areas of sparse or non-existent riparian cover to inform and guide a reach-based restoration plan.

Instream

3. Conduct CDFG habitat surveys in unsurveyed reaches, including tributaries. Map LWD locations and functioning.
4. Determine existing quantity and quality of rearing habitat, over-wintering velocity refugia habitat, and spawning habitat.
5. Determine the occurrence of redd scour as related to hydrology and location dynamics.
6. Evaluate gravel composition, permeability, and level of fine sediment infiltration and its potential to impact on inter-gravel flow dynamics for spawning and larvae survival.

Water Quality

7. Determine the presence of toxic metals, pesticides, pharmaceuticals and other pollutants. Evaluate their potential for bioaccumulation in, or direct physiologic impairment to, aquatic organisms.
8. Collect baseline data and map effective impermeable areas (EIA) throughout watershed.
9. Determine whether eutrophication is occurring due to excessive nutrient additions and adversely affecting water quality parameters important to salmonid health, such as dissolved oxygen and pH.

Water Quantity

10. Evaluate the effects of water diversions and groundwater pumping on summer stream flows and salmonid rearing habitat.
11. Examine link between summertime low-flow discharges and water temperature.
12. Collect data and analyze relationship between precipitation patterns and streamflow.

Biological

13. Continue and expand biotic monitoring, including juvenile fish surveys and smolt monitoring.
14. Conduct BMI monitoring to track habitat conditions.

2.5 Reach-specific Priorities and Recommendations

The San Geronimo stream network was separated into seven planning reaches during the data analysis phase of the project. Mainstem San Geronimo was divided into two reaches, upper and lower, with the dividing point at Roy's Pools. Two head-water tributary reaches—North Fork San Geronimo Creek and Woodacre Creek—converge at the upstream end of upper San Geronimo Creek. The last three reaches are tributaries to lower San Geronimo Creek; Larsen Creek, Montezuma Creek, and the Arroyo/Barranca/El Cerrito creek system.

This section briefly summarizes known habitat conditions and constraints for each of the aforementioned planning reaches and lists the Plan Recommendations (Chapter 2) that are **high priorities** for implementation in each reach. The information included in this section was assembled from Section 4 of the ECR, which provides detailed discussions of the physical characteristics and habitat conditions of each reach, as known. Some reaches were broken into subreaches if distinctions were warranted based on stream gradient or other physical change. Specific reach vegetation management recommendations are shown in a separate table after the reach summaries.

Many of the recommendations apply to all reaches throughout San Geronimo Valley, including the smaller tributaries not called out in this analysis. The guidelines for protecting and enhancing the riparian corridor (#2) and establishing a 35-foot riparian buffer (#4) apply to all perennial and intermittent channels. Protection of streamflow (#16) within the salmonid-bearing creek reaches is integrally linked with watershed-wide stormwater management practices (#12) and watershed-wide fine sediment reduction activities (#15). The coordinated monitoring program (#17) should be implemented within mainstem San Geronimo Creek and the major tributaries, but would track changes in habitat and land management practices throughout the watershed.

Lower San Geronimo Creek

Salmonids utilize the reach between Roy's Pools and the confluence with Lagunitas Creek for spawning and summer rearing. It is a key reach for over-wintering habitat enhancement. The communities of San Geronimo, Forest Knolls, and Lagunitas are located along Lower San Geronimo Creek. Where parcel densities are high, encroachment on the channel is common. With this urbanization comes an increasing amount of non-native, invasive species in the riparian zone.

The channel is incised with few, high inset floodplains upstream of Arroyo Creek. Downstream of Arroyo the channel widens out with mature riparian trees on small, high terrace floodplains. Bedrock control is present at regular intervals throughout this reach and spawning densities are generally lower than in other reaches. Several low gradient tributaries enter this reach and provide opportunities for improving high flow refugia. Pool frequencies, depths, and cover are insufficient for good habitat conditions. Summer water temperatures and dissolved oxygen concentrations can be non-supportive at times. High nutrient, bacteria, and metal concentrations have been documented, indicating issues with septic systems, urban stormwater and possibly agricultural runoff.

Lower San Geronimo Creek Reach **Specific Habitat Enhancement Recommendations**	**Recommendation #s** **(refer to Chapter 2.3)**
Revegetate riparian zone for temperature control and LWD supply – increase cover and continuity, remove invasive non-natives	**2, 4, 5 and 6**
Improve channel complexity for summer rearing and over-wintering. Improve spawning conditions.	**7 through 11**
Manage pollutants delivery	**12, 13 and 14**
Maintain summer low flows for rearing	**16**

Upper San Geronimo Creek

As in Lower San Geronimo Creek, salmonids utilize Upper San Geronimo Creek during all lifestages. Coho and steelhead consistently spawn in the reach, with high density areas located above Roy's Pools and upstream of Willis Evans Creek. Juveniles are found through the summer in deep pools. Roy's Pools is a complete migration barrier to summer juveniles and possible smolts. In addition to being a barrier, it may actually trap them and cause mortality. The subreach upstream of Willis Evans Creek is less constrained by development than other reaches, with inset floodplains and mature trees at bankfull being fairly common. The entire reach has higher LWD density than other sections of the creek. Thus summer rearing and over-wintering habitat is slightly more concentrated and supportive in Upper San Geronimo Creek. Water quality appears to be a high priority issue. Summer water temperatures and dissolved oxygen concentrations can be non-supportive at times. High nutrient, bacteria, and metal concentrations have been documented, indicating issues with septic systems, and urban stormwater (ECR Section 4.2.3).

Because of the large size of many of the parcels along this reach, significant opportunities exist for coordinated, reach-scale enhancement and management of instream and riparian habitat.

Upper San Geronimo Reach **Specific Habitat Enhancement Needs**	**Recommendation #s** **(refer to Chapter 2.3)**
Revegetate riparian zone for temperature control and LWD supply – increase cover and continuity, remove invasive non-natives	**2, 4, 5 and 6**
Improve channel complexity for summer rearing and over-wintering. Promote development of inset floodplains.	**7, 8 and 11**
Manage pollutants delivery	**12, 13 and 14**
Maintain summer low flows for rearing	**17**

North Fork San Geronimo

Downstream of Dickson Weir salmonids spawn and rear. There is no access to the habitat upstream of Dickson Weir, and the viability of the habitat quality has not been formally evaluated. Upstream of Dickson Weir the banks are incised, locally raw, and eroding; high

amounts of fine sediment are found in the bed sediment; and there is no streamflow in the summer. Determine if sufficient high quality habitat for multiple lifestages exists above Dickson Weir prior to modification for passage. The redwood forest above the dam was identified in the ECR as one of the best examples of pre-EuroAmerican conditions in the watershed (ECR Section 3.6.4). Current management of the property has preserved this state, but if ownership changes, a conservation easement may be useful in maintaining the riparian forest.

Downstream of Dickson Weir are deep scour pools. Riparian vegetation is disturbed, patchy, and has a high component of non-native invasives. The channel is severely incised in places. High percentages of fine sediment are found in the channel substrate. Low dissolved oxygen levels have been measured. Although North Fork San Geronimo Creek typically has abundant fry and juveniles, they often have to be relocated because flow between pools becomes disconnected and creates a barrier to juvenile migration at Railroad avenue. (ECR Section 4.2.1)

North Fork San Geronimo Creek Reach **Specific Habitat Enhancement Needs**	**Recommendation #s** **(refer to Chapter 2.3)**
Revegetate riparian zone for temperature control and LWD supply – increase cover and continuity, remove invasive non-natives. Conserve mature redwood forest above Dickson Weir.	**2, 4 and 5**
Improve channel complexity for summer rearing and over-wintering. Improve spawning conditions by reducing fine sediment delivery. Remove barriers to migration.	**7 through 11**
Reduce fine sediment delivery	**12 and 15**
Maintain summer low flows for rearing	**17**

Woodacre Creek

Lower Woodacre Creek is used by salmonids for both spawning and rearing. It has some of the highest redd densities in the entire watershed. It also has the highest urbanization density and TIA (9%). The riparian zone has been cleared for roads and housing, and many areas lack woody cover, as the small lots have yards abutting the creek bank. This reach has

the highest density of culverts and road crossings, many of which have been modified to improve passage.

The channel is straight, simplified, has limited winter flow refugia, and low LWD accumulations. Water quality appears to be a high priority issue. Summer water temperatures and dissolved oxygen concentrations can be non-supportive at times. High nutrient, bacteria, and metal concentrations have been documented, indicating issues with septic systems and urban stormwater. It is also a high sediment producing basin. (ECR Section 4.2.2)

Woodacre Creek Reach **Specific Habitat Enhancement Needs**	**Recommendation #s** **(refer to Chapter 2.3)**
Revegetate riparian zone for temperature control and LWD supply – increase cover and continuity, remove invasive non-natives	**2, 4, and 6**
Improve channel complexity for summer rearing and over-wintering. Remove barriers to migration.	**7 through 11**
Manage pollutant delivery. Reduce fine sediment delivery from watershed.	**12 through 15**
Maintain summer low flows for rearing	**17**

Larsen Creek

Steelhead and coho use lower Larsen Creek for spawning. Rearing is limited as the channel tends to dry up in mid summer, and relocation of juveniles to mainstem San Geronimo is common. Overall basin TIA is low, though the TIA in the SCA is one of the highest (16%) due to a school and paved golf cart roads along the channel banks. The lower reach was redirected and straightened in the late 1800s. Riparian cover is fairly dense, though there are areas along the golf course that have severe intrusion.

The golf course ponds are known to contain non-native fish and frog species that present a significant threat to the native salmonid and frog populations. Working with the golf course to relocate golf cart roads away from channel banks and re-vegetating the banks is recommended, and the proper use and disposal of chemicals (in particular, herbicides and pesticides).

The channel is incised and simplified. Pool and riffle frequency is very low. Bedrock is present in many locations and LWD accumulations are generally absent. Exposed mature tree roots, undercut banks, and coarse bed material provide the high flow refugia. No water quality data is available. Multiple culverts are present, and a large pond near the upper end of the golf course restricts passage to the upper watershed. The confluence of Larsen Creek with mainstem San Geronimo has some of the best high flow refugia in the system, as Larsen Creek is wide with a large tree in the middle of the channel. This is considered a critical over-wintering habitat area (ECR Section 4.3.1). Because of land-ownership patterns in this subwatershed, excellent opportunities exist for reach-scale enhancement of instream and riparian habitat.

Larsen Creek Reach **Specific Habitat Enhancement Needs**	**Recommendation #s** **(refer to Chapter 2.3)**
Revegetate riparian zone in areas of encroachment. Allow channel to widen. Remove invasive non-natives.	**2, 4 and 5**
Improve channel complexity for over-wintering and spawning. Increase high flow refugia at confluence.	**7, 8 and 11**
Manage pollutants delivery	**12**
Maintain spring flows and summer low flows for rearing habitat improvement	**17**

Montezuma Creek

Lower Montezuma Creek is utilized by salmonids for spawning and over-wintering. The Creek is dry in the summer, thus has little rearing potential. Dense housing developments in the community of Forest Knowles are found along Montezuma Creek. This is reflected in the TIA in SCA, which at 20% is the highest in San Geronimo Valley.

The lower reach through the housing development does not appear to be dramatically incised, though no inset floodplains were observed and there are areas of reported flooding. Encroachment up to top of bank is common, as is bank armoring. No reach-wide information is available on instream habitat such as pool frequency, cover elements, or LWD abundance. Limited observations of the channel indicated low channel complexity. Water quality data is limited. Low dissolved oxygen levels occur on occasion, and presence of high nutrient levels noted. A barrier upstream of Candelero Creek prevents migration to upper Montezuma Creek. (ECR Section 4.3.2)

Montezuma Creek Reach **Specific Habitat Enhancement Needs**	**Recommendation #s** **(refer to Chapter 2.3)**
Maintain and revegetate riparian zone for channel complexity and LWD supply – increase cover and continuity, remove invasive non-natives.	**2, 4 and 3**
Improve channel complexity for spawning and over-wintering. Remove barriers to migration. Remove streambank armoring and constrictions.	**7, 8, 11 and 12**
Manage pollutants delivery	**12 through 15**

Arroyo/Barranca/El Cerrito

Arroyo Creek up to its confluence with Barranca and El Cerrito Creek has consistently high coho and steelhead redd densities, and it is used for summer rearing and over-wintering. Multiple culverts and private road crossings limit access to the upper reaches. The basin has one of the lowest overall TIA (4%) and TIA in the SCA (11%); however it has the highest potential for TIA increases due to new development.

The channels are incised and have limited, disconnected inset floodplains. Riparian cover appears to be fairly continuous and adequate to maintain water temperatures. Limited water quality data exists, though low summer dissolved oxygen levels have been documented. There is no documentation of instream habitat condition such as pool and riffle frequencies, cover, and LWD accumulation. It appears that winter velocity refuge is composed primarily of undercut banks and root complexes. (ECR Section 4.3.3)

The ECR identifies the Arroyo/Barranca/El Cerrito complex as one of the watershed reaches in greatest need of preservation (ECR Section 5.5). Barranca Creek contains the best example of relatively-undisturbed riparian habitat with California bay-laurel, white alder, bigleaf maple and many native shrubs and herbaceous plants (ECR Section 3.6.3). As in the redwood forest above the Dickson weir, this area is obviously currently preserved by the existing landuse. However, conservation easements might be warranted for long-term protection.

Arroyo/Barranca/El Cerrito Reach **Specific Habitat Enhancement Needs**	**Recommendation #s** **(refer to Chapter 2.3)**
Maintain riparian zone vegetation for temperature control and LWD supply. Remove invasive non-natives.	**2, 4 and 5**
Improve channel complexity for summer rearing and over-wintering. Improve spawning conditions.	**8, 9 and 11**
Manage pollutants delivery	**12, 14 and 15**
Maintain summer low flows for rearing	**17**

Table 3. Reach vegetation recommendations.

Reach	Native Revegetation & Stewardship	Invasive Control
ALL REACHES	Protect existing native vegetation, including juvenile trees that have regenerated naturally. Species capable of contributing LWD in the future are especially important.	Periwinkle, English ivy, French broom, and Himalayan blackberry are the most common invasive riparian species in the watershed. These should be removed and appropriate natives planted in their place.
Upper San Geronimo Creek, Subreach 1	Protect existing native riparian vegetation, which has declined in the past decade. Revegetate gaps in riparian corridor.	Remove Italian thistle and French broom on gravel bars. Remove periwinkle from banks or interplant with native trees and shrubs to establish riparian canopy and diversity.
		Valley flat: remove Himalayan blackberry, French broom, periwinkle, and spreading hedge parsley.
Upper San Geronimo Creek, Subreach 2	Protect existing native riparian vegetation, which has declined in the past decade. Revegetate gaps in riparian corridor.	Remove Himalayan blackberry, French broom, and periwinkle from understory.

Reach	Native Revegetation & Stewardship	Invasive Control
North Fork San Geronimo	Upper watershed, and first unnamed right-bank tributary: Work with ranchers to manage livestock grazing to reduce erosion; consider grassland restoration efforts.	Remove and contain French broom to areas along roadsides.
	North of Sir Francis Drake Blvd. (SFDB): Restore canopy cover in pasture.	Remove periwinkle and English ivy, esp. from San Geronimo Valley Road (SGVR) to the valley flat.
	Increase continuity of riparian tree cover, including species capable of contributing large woody debris. Redwood and coast live oak above Dickson weir; bay, bigleaf maple, and Oregon ash in lower areas.	
Woodacre Creek	Educate and work with homeowners to increase planting and maintenance of riparian vegetation in residential areas. Native trees include: bigleaf maple, bay, redwood.	Remove French broom and English ivy.
	Lower East Fork: Increase continuity of riparian canopy (esp. lowermost 600 m, to the upper end of Oak Grove Avenue, and other lower-gradient channels).	Lower East Fork: Remove dense cover of cherry plum, Himalayan blackberry, English ivy, and periwinkle. Remove exotic vines from trees and shrubs.
	East Fork between Garden Way and Crescent Drive: Maintain riparian plantings in restored area.	
Larsen Creek	San Geronimo Golf Course: Restore riparian vegetation west of pond/wetland area. Restore riparian canopy along approx. 50 m where creek passes under first golf course bridge, downstream of unnamed tributary junctions.	Lower reaches: Remove English ivy on floodplain and banks.
Montezuma Creek	Educate and work with homeowners to increase planting and maintenance of riparian vegetation in residential areas (esp. along Montezuma Avenue).	Remove periwinkle and Himalayan blackberry along banks.
Arroyo/Barranca/El Cerrito Creeks	Protect existing native riparian vegetation, especially species capable of contributing LWD in future.	Barranca: Remove Himalayan blackberry and forget-me-nots.

Reach	Native Revegetation & Stewardship	Invasive Control
		Arroyo: Educate and work with homeowners to reduce periwinkle from floodplain and cherry plum, English ivy, and Himalayan blackberry from banks along lower reaches.
		El Cerrito: Target small infestations of periwinkle, cherry plum, Himalayan blackberry, and English ivy.

Chapter 3. Summary of Salmonids and their Habitat in San Geronimo Valley

The health of San Geronimo's fish populations and their associated habitat is fairly well-documented compared to other coastal creeks in California. With one of the few remaining wild coho salmon runs in the Central California Coast ESU, the community, resource management agencies, and regional scientists have focused their attention on the Lagunitas Creek watershed; tracking numbers of fish and their movement, assessing factors impacting their survival, and implementing projects designed to improve habitat. Coho are listed as endangered (Federal Register, February 28, 2005) and, as such, are provided special status with federal and state-mandated protections. Steelhead populations appear stable yet at much lower numbers than historically present. Steelhead are listed as threatened in the Central California Coast ESU (Federal Register, January 5, 2006).

The Existing Conditions Report for this Plan (ECR, Stillwater Sciences 2009a) details the findings of the research and monitoring programs in the Lagunitas and San Geronimo watersheds. This chapter briefly summarizes information detailed in the ECR, including salmonid life stages, key habitat elements needed at each life stage to thrive, and what we humans do that either directly impacts the fish or indirectly threatens the overall quality and vitality of the riparian ecosystem in which they live. Also presented are future threats from climate change and natural disturbance regimes.

Helpful Definitions

Anadromous salmonids - salmon and steelhead which begin their life in freshwater, migrate to sea to mature before returning to freshwater to reproduce

Spawning – process of building a nest (**redd**) in gravel, mating, and laying eggs.

Alevin – salmonid larvae still in the gravel with their yolk sacs attached

Fry- young salmon or steelhead rearing in freshwater

Smolt – a juvenile seaward-bound salmonid in the process of transition from fresh to saltwater

3.1 The Fish

Coho and Chinook salmon and steelhead trout are the three species of anadromous salmonids utilizing San Geronimo Creek and its tributaries during their life cycle. Figure 3 indicates the stream reaches within San Geronimo Valley where each species consistently utilizes the available habitat for both spawning and rearing. The life cycles of these three species have many similarities, although the precise schedule of each and the amount of time spent in freshwater and the ocean varies (Figure 4). Details of the life stages and habitat needs are found in Chapter 2 of the ECR (Stillwater Sciences 2009). The discussion below focuses on coho, with steelhead and Chinook salmon variations called out where pertinent.

Adult salmonids enter the Lagunitas Creek watershed and make their way up to the San Geronimo Valley in the late fall and winter (concentrated in October through February) after storm events. Coho typically arrive in late November or December. They spawn in gravels at the downstream ends of pools. Mainstem San Geronimo Creek, lower Woodacre Creek, and Arroyo Creek up to the confluence with Barranca Creek are currently the primary spawning areas. Lower Montezuma and Larsen Creeks are also commonly used.

Figure 4. Extent of salmonids in San Geronimo Valley (ECR Figure 3-17).

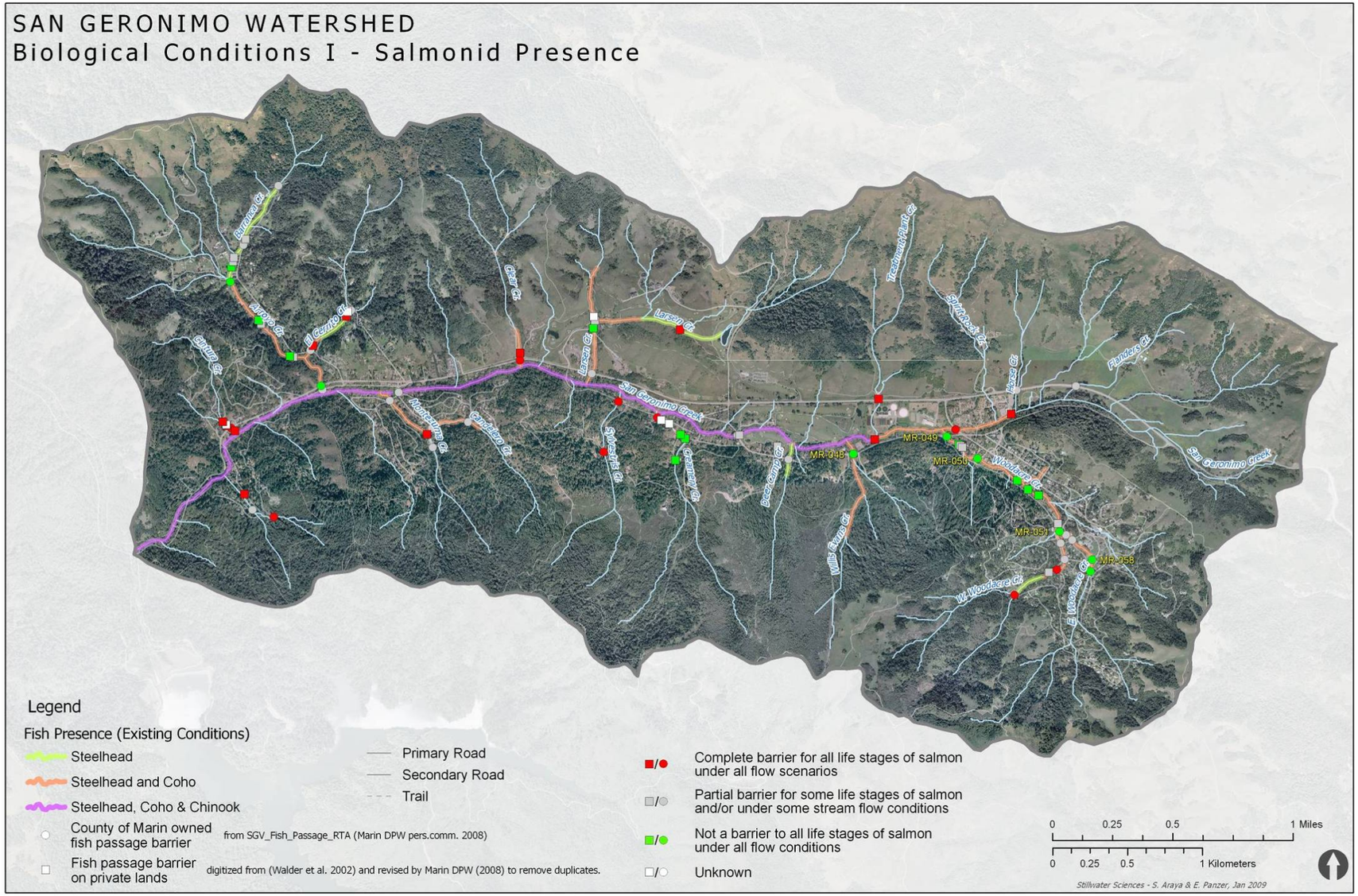


Figure 5. Timing of life stages for the anadromous salmonids present in San Geronimo Valley.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Chinook Salmon												
Upstream migration and spawning												
Egg incubation												
Fry emergence												
Rearing												
Smolt emigration (3 months)												
Steelhead												
Upstream migration and spawning												
Egg incubation												
Fry emergence												
Rearing												
Smolt emigration (1 to 4 years)												
Coho Salmon												
Upstream migration and spawning												
Egg incubation												
Fry emergence												
Rearing												
Smolt emigration (typically 1+)												

The salmonid larvae (alevins) remain within the redd after hatching. During this time their survival is dependent upon high quality gravels with low amounts of fine sediment and clean, well oxygenated water. When the juvenile salmonids first emerge from the gravel, they are referred to as fry. These young, very small fish are particularly vulnerable to high velocities associated with storm flows. They use the spaces between gravel particles and vegetation along the shallow stream margins for safety from high velocities and predators. As they gain strength and mobility, juveniles will begin to seek out deeper, swifter water; yet they continue to need complex, low-velocity habitats throughout their rearing period.

Juvenile coho stay in the Lagunitas Creek watershed for approximately one year after emerging from the gravel. Steelhead may remain for one to 4 years in their natal stream, while Chinook only remain for a few months (see Figure 4). Some remain near where they hatched in the San Geronimo Valley, while others migrate downstream to Lagunitas Creek and, in particular, the Tocaloma reach. Pools in mainstem San Geronimo Creek and lower Woodacre and Arroyo Creeks currently provide the summer rearing habitat, as other tributaries in the Valley typically dry up.

After spending a summer and the following winter in the watershed, the coho juveniles – now known as smolts – emigrate to the ocean where they complete their maturation to adults. Research has shown that over-wintering and smolt marine survival, and their likelihood for spawning return, are correlated to their size (Holtby 1998; Quinn and Peterson 1996). Larger and fatter smolts have a better survival rate. As stated by Quinn and Peterson (1996), "The size advantage of juvenile coho at the end of the summer may have ramifications for their entire lives. It initially affected their likelihood of over-winter survival and size as smolts. Marine survival is positively correlated with smolt

size within year classes of coho salmon (Mathews and Ishida 1989; Holtby et al. 1990)." Coho juveniles reared in San Geronimo Valley are approximately 10% smaller than those reared in neighboring Devil's Gulch and Lagunitas Creek (Ettlinger et. al. 2008 and SPAWN 2008).

In the fall of their third year, after having spent a year and a half in the ocean, adult coho return to their natal stream to spawn. After spawning, they die. Steelhead, on the other hand, do not die immediately after spawning; approximately 10% survive to spawn another year (ECR Section 2.2.2).

3.2 Populations and Survival Indicators

To document annual salmonid population numbers and track trends over time, Marin Municipal Water District (MMWD) and the Salmon Protection and Watershed Network (SPAWN) have been collecting data on number of adults returning each year and the number of juveniles in the system. The focus of this effort is coho, though steelhead information and some Chinook data are collected.

The number of returning adults is estimated by the number of redds (nests) observed in mainstem San Geronimo Creek and its tributaries. Figure 5 shows the annual variation in number of redds observed in the 11-year period (1997 to 2007). The average number of redds is 117, with a range of 55 to 258. It is assumed that for each redd there are two adult fish; thus the annual adult coho returns to San Geronimo Valley have ranged from approximately 110 to 516 over the period of record.

Figure 6. Number of coho redds observed in the San Geronimo watershed during the spawning periods 1997/8 through 2007/8 (data from ECR, Table 3-16).

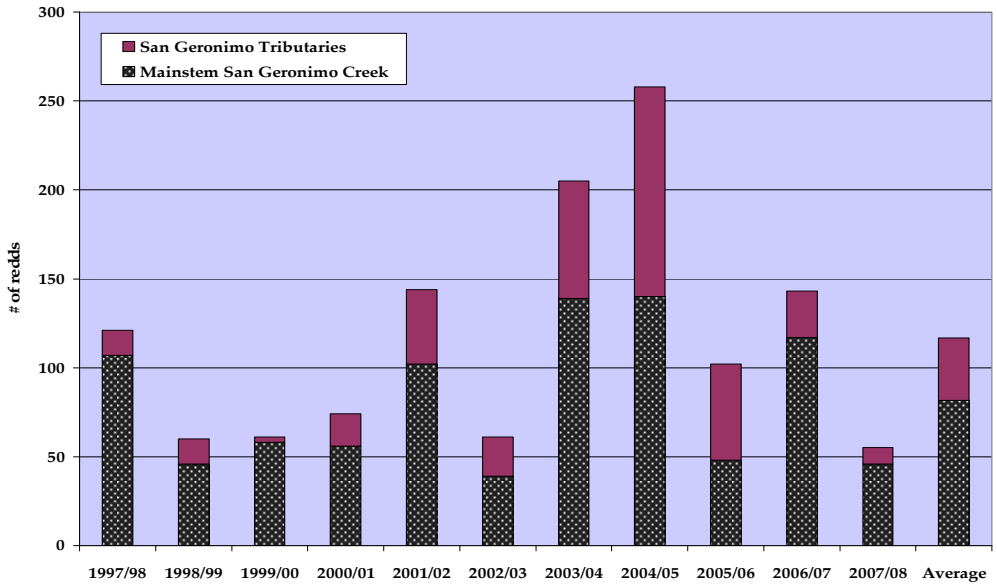
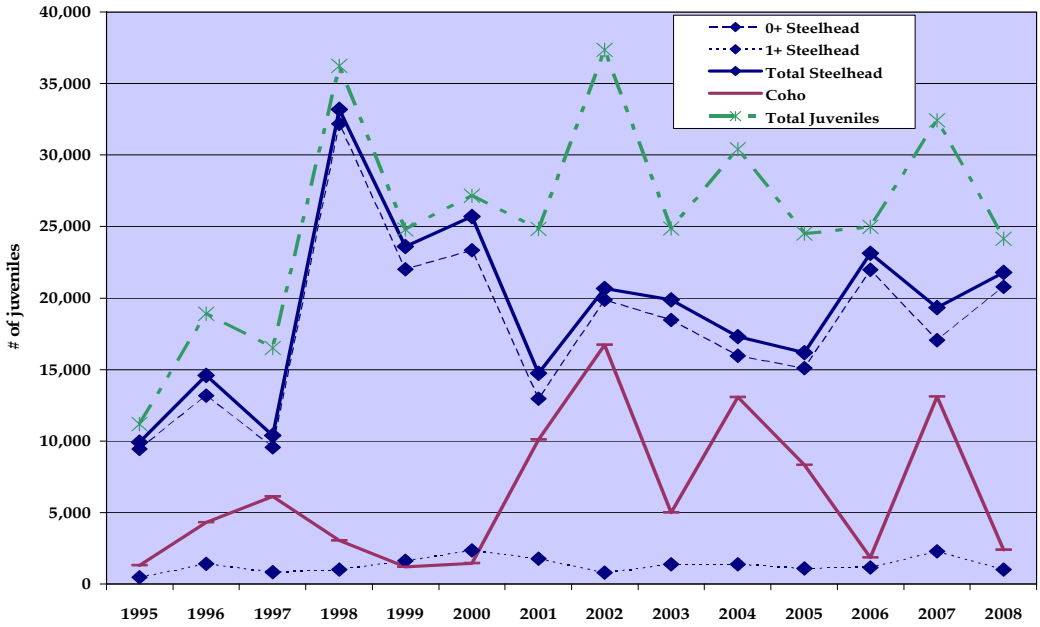


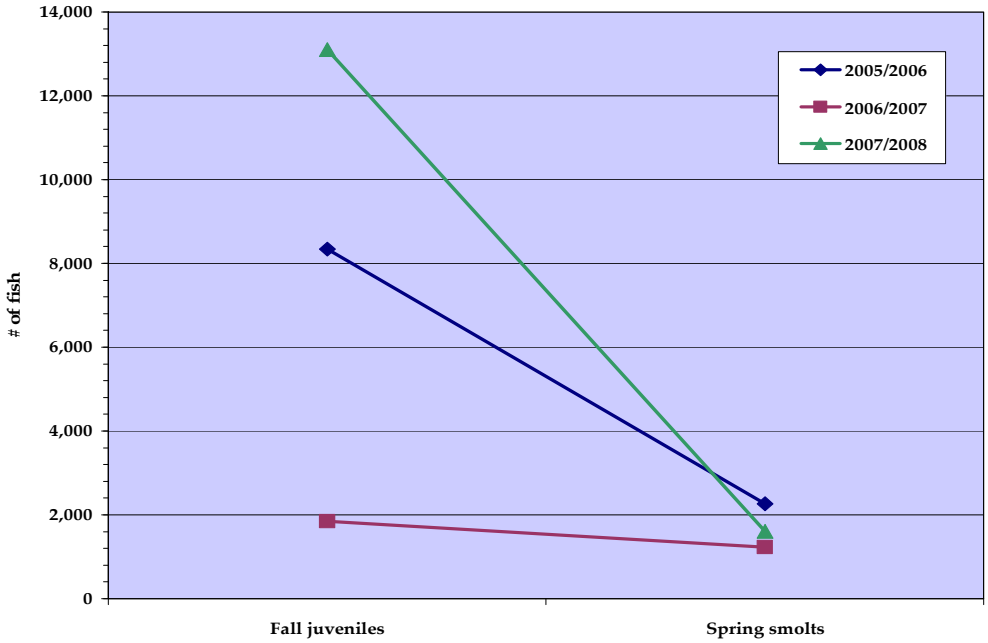
Figure 7 shows the estimated number of juveniles (both coho and steelhead) reared through the summer in San Geronimo Valley each year from 1995 through 2008 (ECR; Ettlinger et al. 2008). Juvenile counts are collected by snorkel surveys in pools. Additional information on juvenile locations and densities are collected by SPAWN when staff relocate juveniles trapped in drying pools to locations in the mainstem. Summer juvenile populations are variable and do not appear to be closely correlated to number of adults or redds, indicating habitat factors play a large role in population at each life stage.

Figure 7. Population estimates of steelhead and coho in San Geronimo Valley in late summer, 1995-2008 (data from ECR, Table 3-17).



Juvenile coho winter survival in San Geronimo Valley has ranged from 12-67% in the last 3 years (Figure 7), with the highest mortality occurring in the years with the highest fall populations (ECR Section 3.9.4). The data suggests that winter habitat in the watershed can currently only support approximately 2,000 coho. The entire Lagunitas watershed appears to support approximately 6,500 juveniles during the winter (ECR Table 3-18). A similar winter survival trend can be seen in the steelhead population numbers shown in Figure 6; a wide variability in the 0+ juvenile population numbers is reduced after the first winter to an average of 1,300 1+ year juveniles the following summer. The dramatic decreases in population numbers between late fall and spring are the result of both mortality and downstream migration into Lagunitas Creek. Stillwater Sciences (2008) concluded that winter habitat severely limits recovery of the coho population in San Geronimo Valley, as well as the Lagunitas watershed as a whole.

Figure 8. Comparison of coho juvenile abundance in the fall and the following spring, indicating apparent winter survival and habitat carrying capacity of the San Geronimo Valley (data from ECR, Table 3-18).



The salmonid population in San Geronimo Valley in any given year during any given life stage is highly variable. The analysis of the numbers is complex, especially when factoring in the fact that San Geronimo is an upper tributary to Lagunitas Creek and salmonids utilize the whole basin in any given year, responding to subtle cues and large events. What is known is that the population in San Geronimo Valley and the Central Coast ESU is in crisis (NOAA Fisheries in press, Spence et al, 2008). This is most clearly indicated by the fluctuations in number of adults returning annually; some years there is a robust number of adults, while other years there are barely enough to seed the next generation. See Chapter 4 for more details on population dynamics.

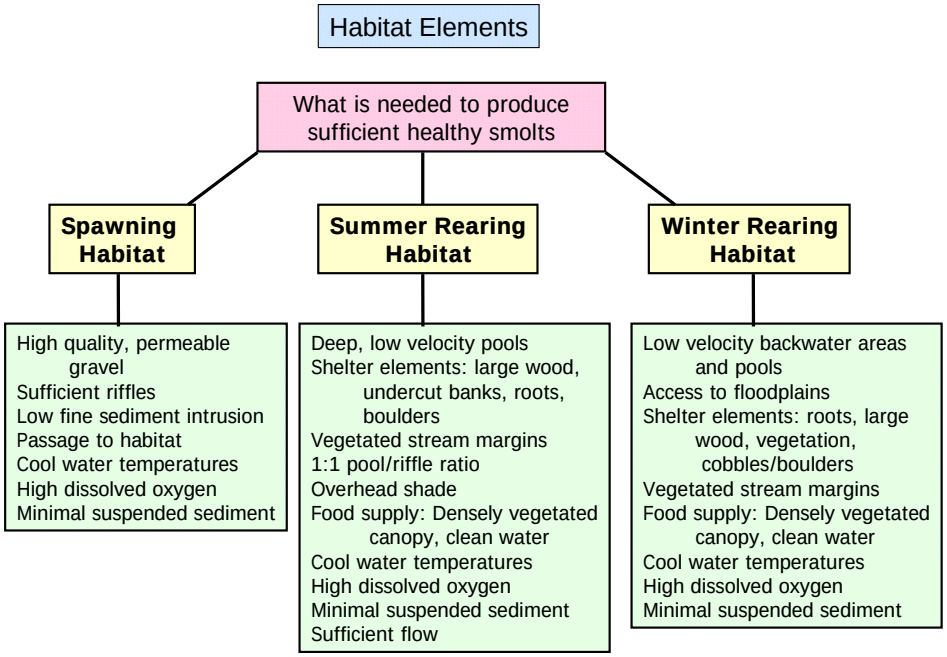
3.3 The Habitat

That the coho and steelhead populations have crashed in the last 30-40 years throughout California and the Pacific Northwest is undisputed. Understanding the particulars of their ideal habitat and how to re-create it requires an understanding of channel dynamics, hydrologic processes, ecology, and salmonid physiology and behavior. The Existing Conditions Report for this Plan (Stillwater Sciences 2009a) provides a wealth of detailed information in Sections 2, 3, and 4 of what ideal conditions might look like for coho and steelhead and what we know to be present in San Geronimo Valley. This section provides a brief summary of that information.

Simplistically, salmonids need water. The water should be clean, cold, oxygenated, and shaded. They need shelter, including deep, complex pools to hide. They need easily accessible areas of low velocity during winter base flows and floods. They need coarse riffles to spawn and forage in with an abundant food supply.

The diagram below illustrates the instream habitat components that are required during the seasonal life stages of salmonids. Chapter 4 explores these components and provides guidance on actual targets associated with "good" habitat conditions. Spawning habitat components support the physical requirements of adults returning from the ocean to complete their life cycle. They also support the eggs and the alevins growing in the gravels until they emerge as fry in the spring. Winter rearing habitat is necessary to support both the newly emergent fry in the spring, the 1-year juveniles, and the smolts on their journey to the ocean. Summer rearing habitat supports coho and steelhead juveniles through their first summer after hatching. It also supports steelhead adults who have stayed in the watershed after spawning and 1+ year juveniles.

Figure 9. Habitat components that support salmonid life stages.



Specifics on the science related to the habitat elements listed above and conditions within San Geronimo Valley can be found in the Recommendations (Chapter 2) and in Chapter 4.

3.4 Human Impacts

Humans have been altering San Geronimo Valley for centuries. The native Miwok and their predecessors likely used fire to manage for preferred vegetation types. by the mid-1800s European's brought land-clearing practices for agriculture, cattle grazing, road and home building, logging, and fire suppression. The first settlers in San Geronimo Valley built homes along the creeks, installed a network of roads, and built a train that ran from eastern Marin out to Tomales Bay through the Valley. Redwood and Douglas-fir timber was harvested and shipped to San Rafael and San Francisco.

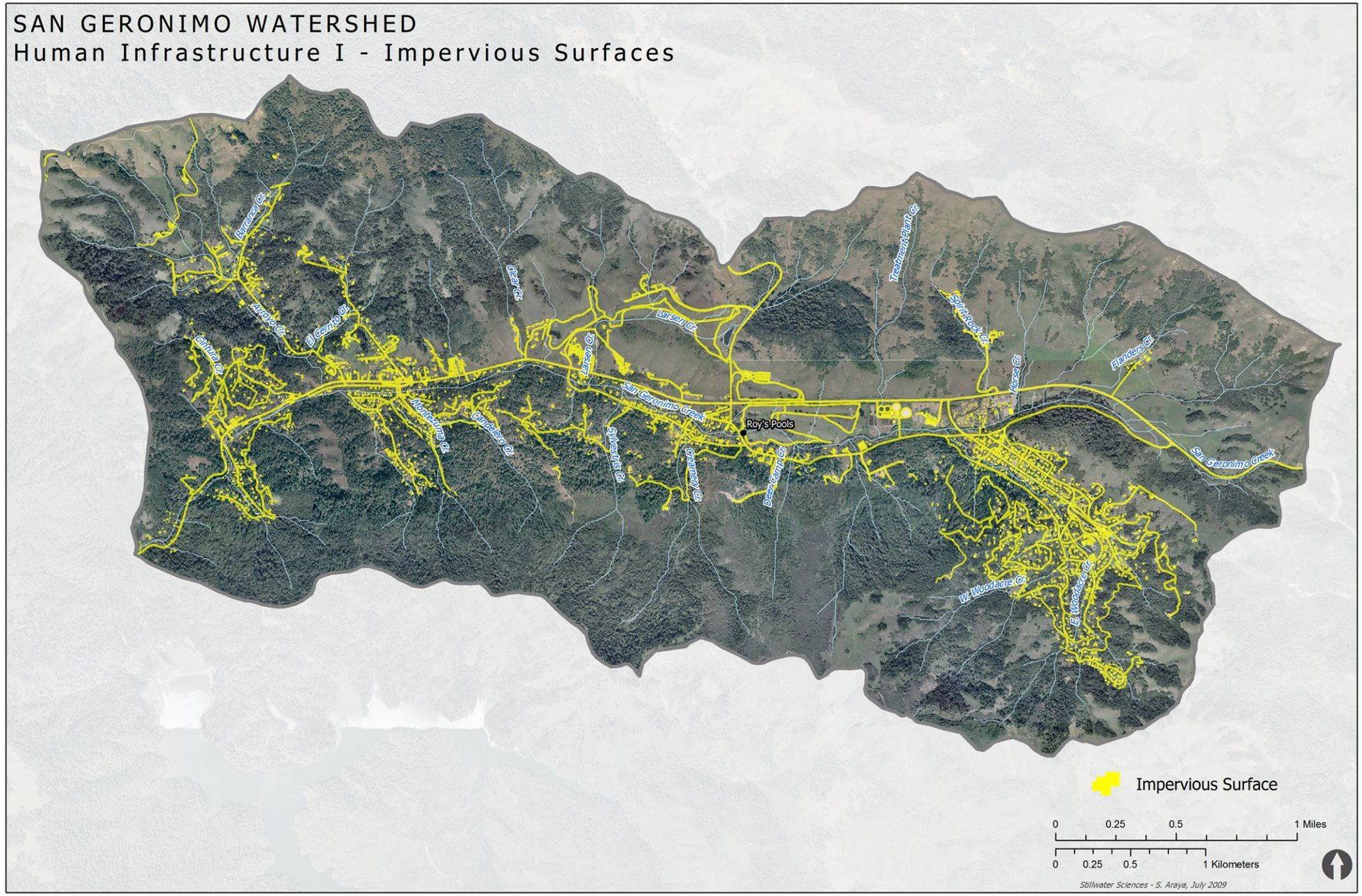
The early land clearing, especially the large-scale logging efforts and high-density cattle grazing, likely had an enormous impact on the streams. The severely incised, simplified channels that we see today are a result of those actions. When ground is cleared and compacted, the amount of runoff increases, new drainages are formed to move the water off expediently, and those drainages transport sediment derived from the barren ground and eroding channels to the streams.

In San Geronimo Valley, as is typical in Marin County, development has clustered in the valley bottoms along the creeks (Figure 7). This urbanization pattern puts immediate and chronic stressors on the creeks, on their associated riparian zones, and on salmonids. These stressors include the increased amount of water and sediment mentioned above; pollutants and nutrients transported in stormwater; water-borne bacteria, nutrients, and pharmaceuticals from near-channel septic tanks; cleared riparian vegetation; channel management practices, including removal of large woody debris; and situational disturbance of the fish.

One of the methods of tracking the level of impacts urbanization has on streams and the natural resources is the measurement of total impervious area (TIA). Impervious surfaces can be buildings, roads, patios, and any other hardened surface that prevents rainwater infiltration and increases runoff. Impervious surfaces concentrate water and pollutants. These surfaces are often connected through gutters, drains, ditches, and storm drains – transporting water and pollutants directly to the streams. The effects of connected impervious surfaces are greatest in the riparian corridor and on the aquatic environment (ECR Section 2.3).

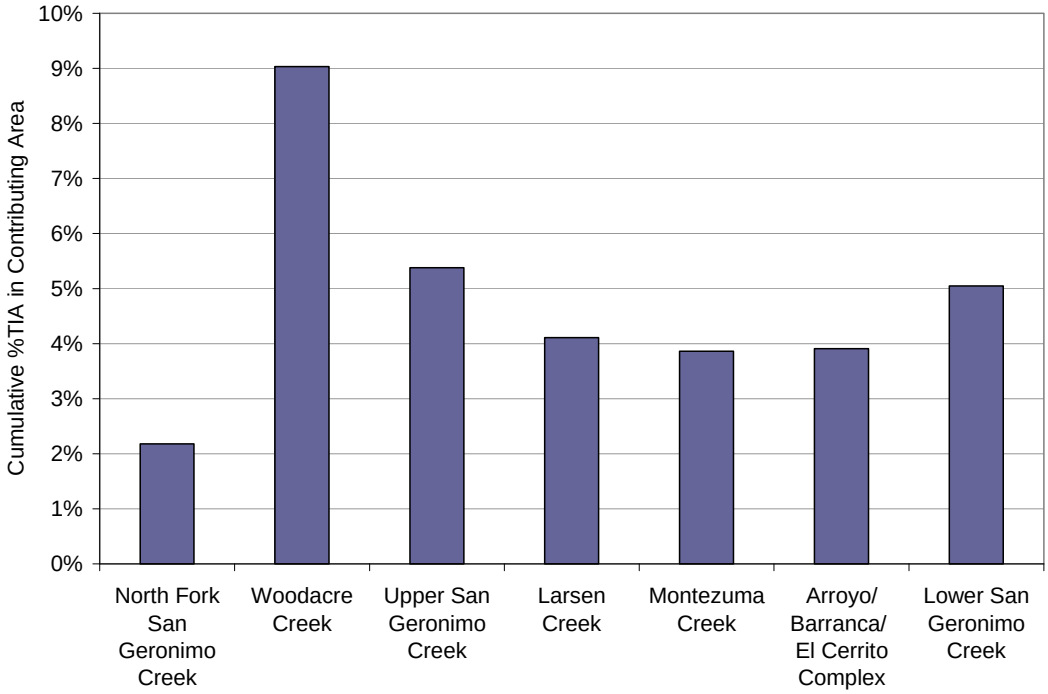
One of the methods of tracking the level of impacts urbanization has on streams and the natural resources is the measurement of total impervious area (TIA). Impervious surfaces can be buildings, roads, patios, and any other hardened surface that prevents rainwater infiltration and increases runoff. Impervious surfaces concentrate water and pollutants. These surfaces are often connected through gutters, drains, ditches, and storm drains – transporting water and pollutants directly to the streams. The effects of connected impervious surfaces are greatest in the riparian corridor and on the aquatic environment (ECR Section 2.3).

Figure 10. Existing development pattern as shown by impervious surfaces in San Geronimo Valley (ECR Figure 3-2).



TIA has been calculated for the San Geronimo watershed and for each of its major subwatersheds (Figure 8). Even at low levels of urbanization, impacts to stream ecosystems can be recognized (Booth et al. 2002; National Academy of Sciences 2008). Based on the existing literature, some impacts are almost certainly occurring as a consequence of the existing levels of development in this watershed (ECR). Although TIA is easier to measure, it is likely not as important as the effective impervious area (EIA). EIA describes the amount of impervious area that is continuously and hydrologically connected to the stream system.

Figure 11. Cumulative percent TIA in reaches of San Geronimo Valley as an indicator of level of urbanization (ECR Figure 3-4).



Although the overall TIA levels are presently low compared to other urbanized areas, impervious surfaces in the Stream Conservation Area (SCA) are significantly higher. In San Geronimo Valley the SCA is a 100 ft wide strip on either side of the creek's top of bank that has special protective status (see Chapter 5 for a detailed description of SCAs). Any clearing and development in the SCA can have direct and immediate effects on the riparian zone and instream habitat. Measurements of TIA within the SCA along mainstem San Geronimo Creek and its main tributaries show that all but one study reach has greater than 10% TIA in the SCA. In Woodacre and Montezuma Creek study reaches, TIA in the SCA is approximately 20% (ECR Section 3.3.2).

The land uses and urbanization patterns described above also impact groundwater levels and summer stream flows. Dry season streamflows are maintained by shallow

groundwater, which is largely dependent upon annual winter rainfall amounts and its infiltration into the shallow aquifers. Historic development patterns and practices have concentrated impervious surfaces on top of the shallow groundwater basins. Urbanization and land practices that harden the ground surface and promote the efficient removal of runoff to drainages, rather than its infiltration or temporary storage on site, reduce the annual groundwater recharge. Commonly, this results in lower summer streamflows.

All of these impacts from human habitation and use over the centuries have had a cumulative effect on stream condition and habitat quality. The next sections outline additional projected changes to the landscape that will add to the stressors on the system. Salmonids populations are reflective of the cumulative impacts within the San Geronimo Valley as well as those within the larger ecosystem.

3.5 Threat - Climate Change

Salmonids face many potential impacts from projected changes in temperature and precipitation. Average temperature in California has risen 1.5° F over the past 50 years and is projected to rise another 2-4° F by the end of the century (Karl et al. 2009). Summer extreme heat events may temporarily push streams above thermal maximums while warmer summer evenings are likely to increase water temperature overall during the warmest months (Luers et al 2006). In addition to direct thermal stress, higher water temperature may indirectly affect salmonid habitat through promoting algal growth and lowering dissolved oxygen. These changes, in turn, reduce the quantity of preferred insect food sources even as warmer water raises fish metabolism and food demand. Both high water temperatures and low dissolved oxygen have direct physiologic impacts on juvenile salmonids. Temperature changes may also result in increased competition from warm water species (Bisson 2008).

In California, precipitation is likely to decline slightly overall but with more intense storms during a shorter rainy period with a longer, hotter dry season, resulting in both more droughts and more floods (Karl 2009). Battin et al. (2007) found the three most important climate-induced hydrologic changes for salmonids are peak flow during egg incubation, stream temperature during pre-spawning and minimum flow during spawning. Scour from high flows during incubation is a significant negative impact for winter-run species (Bisson 2008). The longer dry season is likely to reduce summer and early fall minimum flows thereby exacerbating higher temperature conditions and resulting in insufficient water quantity for juvenile summer rearing and fall spawning.

Climate change is also affecting ocean conditions for salmonids. Winter-run salmonids often have outmigration timed to coincide with maximum plankton blooms, for example. Changes in wind pattern and strength are leading to changes in upwelling that result in less plankton (Mote et al. 2003). Climate change impacts to salmonid survival in the ocean are greatest during the first few months after return (Francis and Mantua 2003), at which time the effects of rearing habitat quality are most evident. Full

rehabilitation of stream systems can limit climate change-related declines in salmonid populations, although it cannot entirely mitigate their effects (Battin et al 2007).

3.6 Threat - Disturbance Regimes

Landscapes are in constant dynamic motion, geologically speaking. Landscape-scale disturbances are natural forces that reset successional processes, bring nutrients and structural elements into a system, and promote genetic resiliency and adaptation. Floods, fire, earthquakes, drought, invasive pests are all natural disturbance regimes. They disrupt the ecological status quo, damaging existing habitat in the short term yet shaping the community composition, structure, and function over the long term (Agee 2002).

Salmonids evolved under disturbance regimes. The landscape of San Geronimo Valley, by the nature of its geology and climate, is prone to big events such as floods, earthquakes, and fire. Historically, fish could find refuge in other nearby watersheds or populations were large enough to reseed a watershed if a disturbance decimated a year's production. However, with the current populations so close to extinction and little redundant habitat available, one large disturbance or multiple smaller ones could have fatal consequences to the fishery.

The following sections outline the value of the major disturbance regimes and how our alteration of the environment has made disturbances more challenging for salmonids.

Floods

Typically, when a river or creek floods, it overtops its banks, spilling out into the floodplain. When it does, the water slows down, flowing through vegetation and dropping out its fine sediment. Water may stand in the floodplain for a few hours to a few weeks. This process is an important one for distribution of nutrients and sediment from upstream to downstream areas. Flooding scours the channel, refreshes gravel in the stream, and deposits rich soils in the riparian area as the flow spreads and slows across the floodplain. These nutrients nourish the riparian community. Slow-moving water on the floodplain and within the riparian vegetation provides critical high flow refugia for young salmonids.

In an incised channel, such as San Geronimo and its tributaries, the loss of floodplains means there is less area to absorb and slow the flood waters. As flows increase, velocities accelerate. Fish cannot survive high velocities unless there are undercut banks, logs, or other obstructions where they can find refuge.

Fire

Since the mid-1900s, fire suppression has dramatically reduced the number of fires. Fire suppression in the 20th century has led to highly increased fuel loads, giving rise to uncharacteristically intense fires when they do occur (Agee and Skinner, 2005; Marin CDA 2007). Aerial photographs of Point Reyes show that since the implementation of fire suppression, Douglas-fir forest has begun to move into the grassland area at high elevations (Brown et al 1999), and similar changes may be taking place in San Geronimo Valley.

The San Geronimo watershed experienced large, destructive fires in 1878, 1904, 1923, and 1945 (ECR Section 3.2). No major fire has occurred since then, and the forests are primed. The last large fire in the region was the 1995 Mount Vision Fire on Point Reyes. Any fire that gets out of control could burn large swathes of forest, leaving slopes bare and vulnerable to erosion.

Large fires typically deforest hillsides, leaving them vulnerable to erosion and landslides. Sediment delivered to streams after fires can choke spawning gravels, fill pools, and can physiologically impair juvenile salmonids.

Invasive Species

Exotic species are introduced to native systems both intentionally (e.g., stocking sport-fishing species, planting nursery plants) and accidentally (e.g., traveling in bilge water, seeds in hay). Not all are considered invasive. An invasive species shows characteristics of strong population growth that tend to displace native species, reducing habitat complexity and species diversity. The riparian corridors in San Geronimo are invaded by Himalayan blackberry, vinca, French broom, giant reed, and English ivy (ECR Section 3.6.1). Vinca and English ivy provide little in the way of habitat value to native species, reducing the food base of the riparian community. Himalayan blackberry does provide fruit and cover to native birds and small mammals. However, Himalayan blackberry, French broom, and giant reed are extremely aggressive in displacing native species, forming large patches, and reducing biodiversity and ecosystem function.

An invasive species having profound effects on aquatic systems in northern and central California is the bullfrog, Rana catesbieana. Bullfrogs eat and compete with native aquatic species. Native fish are also being stressed by competition with introduced warm-water fish species, such as blue gill and large mouth bass. Both bullfrogs and warm-water fish have been introduced to the San Geronimo Creek watershed, with at least one source of origin from the San Geronimo Valley Golf Course ponds (SPAWN 2001). In addition, released aquatic pets as well as introduced signal crayfish and swamp crayfish, which have currently spread to all tributaries, prey on juvenile salmonids.

Pests and Forest Pathogens

Pests and forest pathogens can also cause large, systemic habitat disturbance. Often invasive species cause the most damage, but native pests and pathogens can have large outbreaks when system dynamics change, from climate change, for example. Sudden Oak Death (SOD), a recently introduced forest pathogen, is already having large effects on Marin County forests. SOD kills some oak trees and other species such as tan oaks, and weakens many more. The pathogen is hosted on bay trees, among others. (See Appendix I for more information on SOD.) It is spread during wet weather by rainfall run-off from host plants and by animals carrying it on feet, fur, or feathers. Humans effectively spread the disease both within parcels and large distances (Cushman and Meentemeyer 2008).

Chapter 4. Targets for Recovery and Habitat Rehabilitation

Chapter 3 introduces the habitat needs for salmonids at each life stage and briefly describes how these habitats are degraded in San Geronimo Valley. This chapter introduces information that can be used to understand coho population recovery requirements, and evaluate baseline habitat area and critical elements needed to support each life stage. We outline the current understanding of what composes good habitat elements—with quantified targets where possible—to help guide rehabilitation efforts and monitoring programs. However, this is just the beginning: recovery of the coho and steelhead populations to more stable and resilient levels will take more than adding habitat elements back in the streams; it will take rehabilitation of the hydrologic and ecologic processes that support sustainable habitat.

It was beyond the scope of this Plan to collect new data or reanalyze existing data to provide a detailed assessment of baseline conditions for the proposed habitat targets. Future assessments and monitoring programs, as outlined in Chapters 5 and 6, can use and expand upon the framework presented here.

4.1 Salmonid Life-stage Population Goals

In Figure 11 and the following discussion, we present a conceptual approach for estimating life-stage population and habitat area requirements for coho in San Geronimo Valley. The approach uses the NOAA draft coho recovery plan's (NOAA Fisheries, in press) adult spawner targets, "intrinsic potential" habitat analysis, and numerical "properly functioning conditions" to provide starting points for the calculations. Additional information sources include recent San Geronimo and Lagunitas datasets and the scientific literature.

This approach and analysis is not a true population model. It is a preliminary, conceptual attempt to link NOAA's coho salmon population recovery goals with habitat targets for San Geronimo Creek and its major tributaries. The intention is to inform restoration efforts and habitat monitoring activities while providing a conceptual framework for evaluating an adaptive management program. The population and target numbers represent 12-year averages, not absolutes. The values for all the inputs are highly variable, and the numbers presented are general references used for this Plan to guide habitat targets. Both the population numbers and habitat area calculations are targets that are dependent upon all the other variables; change one variable or input, such as winter survival or ocean survival rate, and all the other targets will change.

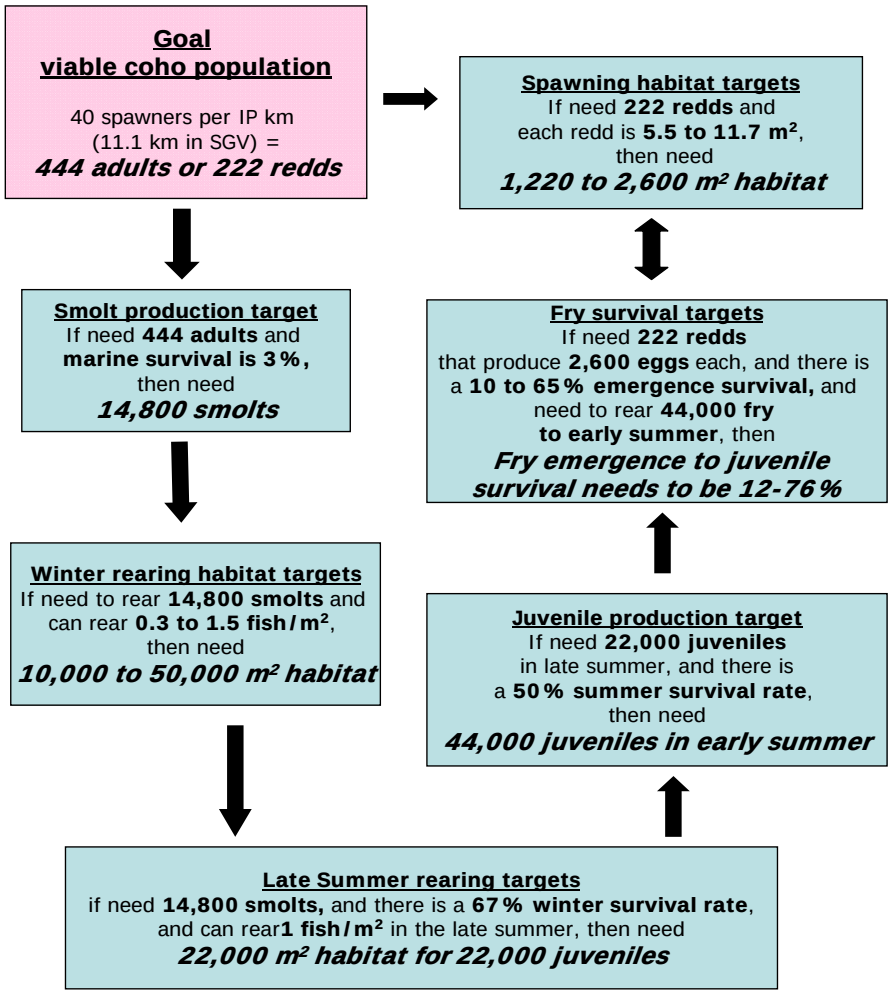


Figure 12. Conceptual approach summarizing the estimation of habitat area needs and life-stage density goals to support a minimum viable coho population in the San Geronimo Creek watershed.

Our analysis assumes, for the sake of simplification, that San Geronimo Valley functions independently from the rest of the Lagunitas Creek watershed. One problem to this approach is that while we are treating San Geronimo Creek as a distinct population, in actuality the population is migratory, and highly connected to the remainder of the Lagunitas watershed. It is known that many juveniles migrate out of San Geronimo throughout the year to rear in downstream reaches of Lagunitas Creek, and specifically

in the Tocaloma Reach. Because of incised channel conditions and San Geronimo Valley's role as an upper tributary of the Lagunitas basin that, to some degree, exports juveniles to rear and smolt in the lower reaches of the watershed, the smolt production goal for coho discussed here may not be achieved exclusively within the San Geronimo watershed. However, through both habitat improvement efforts in San Geronimo Valley and the progeny of the Valley's adults rearing and smolting elsewhere in the Lagunitas Basin, the smolt target may be obtained. It is anticipated that habitat restoration in the Tocaloma Reach and the Giacomini Ranch tidal wetlands at the mouth of Lagunitas Creek will provide abundant summer and winter rearing habitat for juvenile coho, boosting the overall salmonid production of the Lagunitas watershed.

NOAA Recovery Plan

NOAA is developing a draft coho recovery plan for the Central California Coast ESU (NOAA Fisheries, in press). The recovery plan sets population goals for the region. San Geronimo Valley is grouped in a subset of watersheds with geographically linked populations and similar environmental conditions labeled the coastal "diversity strata", which encompasses all of the Lagunitas Creek watershed, Walker Creek watershed, the Russian River watershed, and smaller coastal streams between Gualala Point and San Francisco Bay. The coastal diversity strata is one of five in the Central California Coast ESU.

Recovery of the species depends on the combined abundance within each of the five diversity strata, rather than on the abundance in individual watershed populations. Thus, each subwatershed's population goals are linked with and support the other watersheds to produce a regionally viable population with low extinction potential.

NOAA has determined that "historic viability" for the coastal diversity strata was 23,700 spawners (12 year average) for all three watersheds combined, with 4,500 annual spawners in Lagunitas Creek (Kit Crump, NOAA Fisheries, pers. comm., 2009). NMFS has determined that the minimum viability goal, expressed as half of historic viability, for the coastal diversity strata is 11,000 spawners, with a minimum viability estimate of 2,600 spawners for the Lagunitas Creek Watershed. Our approach and analysis assumes that NOAA's recovery goals are scientifically defensible. In this approach we do not attempt to determine if specific habitat limitations within San Geronimo Creek, such as the intrinsic potential of winter habitat, would have historically limited the abundance of coho salmon to less than the NOAA recovery plan goals.

NOAA's recovery planning process also evaluates the stream length in each watershed that has "intrinsic potential" to support salmonids; otherwise known as IP km. The intrinsic potential of a stream is based on channel slope, accessibility, and historic occurrence of coho (see Bjorkstedt et al 2005 for additional information). There are a total of 69.3 IP km for Lagunitas Creek watershed (based on no fish passage at Seeger Dam), of which an estimated 11.1 IP km is in San Geronimo Creek (Kit Crump, NOAA Fisheries, pers. comm., 2009).

Spawner abundance goal and habitat area target

Based on current accessible coho salmon habitat in the Lagunitas Creek watershed, a spawning density of 40 spawners/IP km is required to achieve NOAA's recovery goal for the watershed. With 11 IP km, San Geronimo Creek has an approximate NOAA coho salmon draft recovery plan goal of 444 annual spawners or 222 redds as a 12 year average. For comparison, based on a 14 year record, redd counts currently average 108, with as few as 6 and as many as 258 redds observed (ECR). Based on the years of high spawner abundance, it appears that under current conditions an average density of 40 spawners/IP km has been achieved in at least two of the last 14 years (MMWD 2007; ECR).

Burner (1951) reported that the average area of a coho redd was 2.84 m^2 (30.6 ft^2), similar to the figure reported by Crone and Bond (1976) for the average area of gravel disturbed by a spawning coho, which was 2.6 m^2 (28.9 ft^2). Burner (1951) found that the area required by a spawning pair of coho was 11.7 m^2 (126 ft^2), and Ettlinger (2003) report an average redd size for coho salmon in the Lagunitas watershed of 5.5 m^2 (59.2 ft^2). Based on an assumed required suitable spawning gravel area of between 5.5 and 11.7 m^2, approximately 1,220–2,600 m^2 of suitable spawning gravel is required to support the population goal within the San Geronimo watershed.

Although the amount of suitable spawning habitat in San Geronimo Creek and its main tributaries under current conditions has not been explicitly mapped, there are currently 10.4 km of mainstem and tributary habitat in San Geronimo Creek where spawning is observed, of which observed redd densities are relatively high in 3.1 km, and medium or low in the remainder (ECR). Spawning gravel quality and extent are limited by exposed bedrock in mainstem San Geronimo Creek or high percentages of fine sediment. It is not clear whether the low number of redds is due to poor spawning habitat conditions or a paucity of adults. Improvements in spawning gravel quality and extent may contribute to increased salmonid survival and production.

Smolt production goal and winter habitat area targets

The NOAA coho salmon draft recovery plan smolt production goals are based on the number of smolts required to sustain the spawner abundance goals. The NOAA approach assumes marine survival of 1% and is based on the best available information for the state of California. However, Lagunitas watershed-specific data indicates that marine survival of smolts tends to be closer to 3% (Leslie Ferguson, Regional Board, pers. comm., 2009), although it has been as high as 8% in some years (Stillwater Sciences 2008a). Based on a marine survival of 3%, 14,800 smolts would need to be produced to achieve an adult return goal of 444 adults. For comparison, under current conditions (only three years of observations) smolt production has been observed to range from approximately 1,200 to over to 2,300 smolts, while the whole Lagunitas basin produced an estimated maximum of 6,700 smolts during the same period (ECR Section 3.9.4).

To achieve a spring smolt abundance of over 14,800 individuals, an adequate amount of habitat is required during winter and spring to provide rearing and refugia opportunities for at least this many fish. Winter survival rates have been observed to range from 12–67% in three years of estimates (ECR). Spring smolt abundance does not appear to be positively correlated to fall juvenile abundance (Plan, Section 2.1, Figure 6). This indicates that winter habitat may not be adequate under current conditions to support the population goal. Stillwater Sciences (2008a) determined that, for coho salmon, winter habitat availability is one of primary constraints to smolt production in Lagunitas watershed, and presumably in San Geronimo as well. For example, in fall 2007 the estimated coho juvenile abundance in San Geronimo Valley was 13,000; very close to the smolt target. However, only 12% of the 13,000 juveniles survived the winter to smolt in spring 2008.

The amount of suitable winter habitat required to support the smolt production goal depends on the rearing density that the habitat can support. Bell (2001) examined winter rearing of juvenile coho salmon in Prairie Creek, a relatively undisturbed California coastal stream, and found winter rearing densities during baseflow conditions in complex main channel pools averaged 0.3 fish/m^2, and that in complex backwater pools densities were typically greater than 1.5 fish/m^2 (with densities greater than 5 fish/m^2 in some habitat units). Research in a disturbed tributary to the North Umpqua River in Oregon found similar densities in high quality habitat units (Stillwater Sciences, unpublished data).

An example of tributary junction that provides complex, high-flow refugia habitat. Photo by Prunuske Chatham, Inc.

Based on the range of densities described above, between 10,000 m^2 and 50,000 m^2 of suitable winter habitat is needed to support smolt production goals in San Geronimo Valley, as determined by the quality of the habitat (i.e., low velocity, high cover pools; high flow refugia on vegetated inset floodplains or tributary backwaters). For comparison, in a relatively pristine reach of Prairie Creek, California, around 2,500 m^2 of suitable winter habitat was measured in a 5.5 km reach, albeit main channel pools were likely undercounted (Bell 2001). Therefore, achieving enough winter habitat within San Geronimo Creek to support a smolt production goal of 14,800 may be very challenging. Achieving this goal may require enhancement beyond the intrinsic winter habitat potential of San Geronimo Creek or restoration of other potential winter

habitat rearing locations within the Lagunitas Creek watershed. No estimates exist for current winter/spring habitat conditions, current rearing densities or the potential to increase winter/spring habitat. However, in general, winter habitat within Lagunitas Creek appears to be in low supply (Stillwater Sciences 2008a).

Juvenile production goals and spring/summer rearing habitat targets

In the coho salmon draft recovery plan, NOAA Fisheries is considering 1 fish/m^2 as an indicator of "good habitat". If a smolt production goal of approximately 14,800 fish and an optimistic winter survival of 67% is assumed, then approximately 22,000 m^2 of suitable summer habitat is needed to support 22,000 juveniles (at summer rearing densities of 1 fish/m^2). Summer juvenile abundance under current conditions averages over 6,000 in late summer, and has been observed to range from just over 1,200 to over 16,000 (ECR), suggesting summer juvenile abundance goals are achievable.

Juvenile coho in Salmon Creek, Sonoma County.
Photo by Joe Pecharich

Higher fish densities, up to 2 fish/m^2 or greater, are not uncommon in very high quality habitat locations (i.e., high degrees of instream cover, deep pools, good food availability, and flows to maintain low water temperatures) (Burns 1971). Average rearing densities in pool habitat in nearby Devil's Gulch have been observed as high as 1.5 fish/m^2 in some years. For comparison, juvenile coho salmon densities in San Geronimo Creek have been observed by MMWD (Ettlinger et al. 2003) to range from a low of 0.05 fish/m^2

to a high of 0.7 fish/m^2. The juvenile population goal could be achieved within less habitat area if enhancements are successful at improving rearing habitat quality.

If 22,000 juveniles are needed in late summer to seed the winter habitat, and a 50% summer survival rate is assumed, then at least 44,000 individuals would need to be present in June. To achieve this initial summer juvenile rearing density, adequate survival from egg-to emergence and from fry to juvenile is required.

For example, based on an average fecundity of 2,600 eggs per female (Stillwater Sciences 2008a), and conservatively assuming survival-to-emergence rates between 10% (Stillwater Sciences 2008a observed minimum rates for emergence) and 65% (moderate value observed in other coastal streams, e.g. Shapovalov and Taft 1954), we would expect the 12 year average of fry produced in San Geronimo Valley to be between 54,080 and 351,520. If conservative estimates of fry to summer juvenile survival averages between 12% and 76%, this is plenty of fry production to seed summer habitat goals discussed above.

Based on similar assumptions of fecundity and survival-to-emergence, survival from fry to juvenile under current conditions has been observed to be less than 1% during years of low summer abundance and high spring flows, suggesting that a lack of suitable habitat for fry during high spring flows is a potential factor limiting production in the San Geronimo watershed (Stillwater Sciences 2008a). It is presumed that increasing winter rearing habitat, as described above, would also result in increased low-velocity stream margin habitat preferred by recently emerged fry, which should increase fry survival.

The analysis presented above is for coho salmon. Chinook salmon and steelhead population recovery is also a goal. Steelhead have similar habitat requirements to coho and the two species are often found together. Steelhead inhabit a wider range of summer rearing habitats, higher locations in the watershed, and are more tolerant of water temperature fluctuations and higher velocities. Thus, habitat area in addition to that described above, is necessary to support both coho and steelhead.

Other than juvenile abundance, steelhead population numbers have not been monitored to date. Based on the juvenile estimates, the annual population of 0+ and 1+ steelhead in San Geronimo Valley in the late summer ranges from 9,900 to 33,000, with an average of 19,000 (ECR Section 3.9.3). An additional dataset collected from 2006-2008 by SPAWN on salmonids outmigrating from the San Geronimo Valley resulted in a population estimate of between 700-1,700 steelhead smolts reared there each year (SPAWN, 2008).

4.2 Habitat Elements and Components Required to Support Population Targets

This section presents tables outlining the critical habitat elements for each life stage, with specific components and their target values. The targets are based on values cited in the scientific literature. Some targets can be used as design guidelines for instream habitat

restoration, while others are driven by multiple, complex factors and are thus best suited as watershed health monitoring guidelines (Appendix B). The tables are broken into two segments. The first segment lists one or two elements that best capture the overall habitat type and target for the associated salmonid life stage, as described in the previous section above (based on coho salmon population goals). The second provides details on the components that compose each critical habitat element.

The information presented in Tables 3 through 5 are metrics commonly used by scientists to quantify watershed and stream health; assessing what needs improvement and what appears to fall within normal ranges for a well-functioning system. The compiled targets are from a number of sources. Appendix B (Stillwater Sciences) recommends and discusses metrics for evaluating and tracking watershed health, including indicators used in NOAA's "Properly Functioning Conditions" criteria in their draft coho recovery plan (NOAA Fisheries, in press). The project's Technical Advisory Committee (TAC) extensively discussed and reviewed the targets and critical habitat elements tables presented in this chapter. Deviations from and/or additions to the metrics presented in Appendix B are a result of these deliberations.

The habitat components and targets listed in Tables 3 through 5 apply to both coho and steelhead, and the spawning habitat elements apply to Chinook salmon as well. The habitat area needs for each life-stage are from Figure 9 and associated discussion in the sections above, and only take coho into account.

Over-wintering Habitat

In most years, over-wintering habitat (Table 3) has been hypothesized to be the primary factor limiting salmonid success in San Geronimo Valley and the Lagunitas basin (Stillwater Sciences 2008 and ECR Section 5). However, as shown in the life-stage population analysis presented above, late spring and summer rearing habitat also appears to be limiting coho survival and production.

In the late fall and winter, as flow increases in the stream channel, water velocity increases and juvenile salmonids must find calm water in which to take refuge. Typically, high-flow refugia are found on broad floodplains with backwater areas and at low-gradient tributary junctions where protected eddies form. In highly incised and confined channels that have limited floodplain areas, such as San Geronimo Creek, quality high-flow refugia is scarce. Just as important are calm, protected areas in the active channel during winter base-flows. Base-flow habitat is provided by shelter and energy dispersal elements along the banks and in the streambed. These include deep pools, undercut banks with complex root structures, large and small wood accumulations, boulder complexes, and backwater features on the downstream side of gravel bars and at tributary confluences.

Very few inset floodplains exist in the Valley, and those that do are small and discontinuous (ECR Section 3.7). Inset floodplains are most commonly found in the

lower gradient sections where local channel slope is around 1%. Shelter components are limited throughout much of the mainstem and tributaries, well below optimal levels (ECR Section 3.8). Large wood pieces and accumulations are relatively infrequent (ECR Section 3.7 and 3.8) and well below proposed frequencies.

Other essential components necessary to support optimal habitat conditions for salmonids in the winter are outlined in Table 3 and include supportive water quality conditions, channel bed structure, and sufficient food supply.

Summer Rearing Habitat

Summer rearing habitat (Table 4) relies upon many of the same components as the base-flow winter habitat—deep pools, shelter from predators, high water-quality conditions, abundant food, and sufficient flow to allow passage and maintain water depths. Dense canopy cover is also important in the summer to provide thermal regulation, as warm water temperatures have immediate and detrimental effects on juvenile salmonids. During the summer and early fall period, the fish are also more susceptible to poor water-quality conditions, as flows are reduced and any pollutants in the system are concentrated and can affect growth and physiologic development. Optimally, the summer is a time for juvenile salmonids to feed—increasing their length and weight so they are better equipped to withstand winter conditions and the transition to adulthood in the ocean.

Evaluation of juvenile fish density data from San Geronimo Valley with comparisons to lifestage population goals (see discussion above) indicates that summer rearing habitat is inadequate to rear the minimum viable juvenile population and may be a keystone limiting factor. Water quality does not consistently support salmonids, the frequency of pools is rated as poor, and pool shelter values are low (ECR Section 3).

Spawning Habitat

Gravel quality and quantity are critical to support successful spawning for the adult target numbers (Table 4). Salmonids require well-sorted gravels with minimal amounts of fine sediment (low embeddedness) and high permeability. Salmon prefer to spawn in the "tails", or downstream end, of pools where sediment conditions are generally optimal. Unimpeded passage to spawning sites maximizes potential success and limits competition for limited gravels. Road crossings, weirs, culverts, and dams are common salmonid migration obstructions. Insufficient base flows or delayed winter storms can also impede adult migration and spawning. Water temperatures and dissolved oxygen concentrations affect hatching rates and success, as well as fry survival to emergence. High flows can scour redds if bed sediment is mobilized or deposit fines, potentially smothering eggs.

Existing data are insufficient to fully characterize spawning gravel composition and permeability. Extent of riffle habitat has ranged from 11 to 28% in the last 14 years with

embeddedness consistently greater than 30% (ECR Section 3.8). Several riffles sampled in 2004 appear to have low percentages of fine sediment (e.g. less than 10% of sediment is smaller than 1mm in diameter), likely indicating good spawning habitat (O'Connor 2006).

Table 4. Targets for critical habitat elements of salmonid over-wintering habitat to support emergent fry survival and juvenile survival to smolting.

Over-wintering Habitat* To support at least 14,800 juvenile coho smolts for minimum viable population (assuming 3% ocean survival)				
Habitat Type	**Components**	**Estimated Coho Habitat Area Needs**	**Existing Conditions**	
High Flow Velocity Refugia	Instream shelter – roots, large wood, small wood, aquatic vegetation	Approx. 50,000 m² of suitable habitat with <30 cm/s [1.5 ft/sec] (for all flood stage depths)	Unknown	
	Cobbles/boulders			
	Inset, vegetated floodplains			
	Low-gradient tributary confluence backwater habitat			
	Habitat connectivity			
Base Flow Velocity Refugia	Main channel pool habitat w/instream shelter and food	Approx. 50,000 m² of suitable habitat with <30 cm/s [1.5 ft/sec] (based on 0.3 fish/m²)	Unknown	
	Complex backwater habitat and side channels w/instream shelter and food	Approx. 10,000 m² of suitable habitat (based on 1.5 fish/m²)		

Critical Habitat Elements	Indicators	Targets	Do current conditions meet Targets? (as reported in ECR)	Focus Area for Actions
Water Quality	Turbidity	Peak: <100-500 mg/L TSS Chronic: trend toward sub-lethal concentrations by duration[2]	Data inconclusive	Water Quality and Riparian Corridor
	Temperature	<14^{0}C [3]	Yes	
	Dissolved oxygen	7.0-9.0 mg/L or ≥85% of saturation [4]	Yes (mainstem) No (Montezuma and Woodacre Creeks)	
Channel Bed Form	Pool frequency (# of pools/channel width)	0.25-0.5 [5]	No 0.13 to 0.24 (mainstem)	Instream Habitat Structure and Riparian Corridor
	Pool/riffle ratio	1:1	Unknown	
	Residual pool depths	Increasing trend >2ft[6]		
	Shelter	Increasing trend		
	Large wood frequency	Increasing trend in loading and forced pool-riffle units (reach based) or 6-11 pieces/100m[7]	Unknown	
	Floodplain connectivity	> 80% in low gradient streams (<2.5%)[8]	Unknown	

[2] Appendix B, Stillwater Sciences (2009) for peak value and per Newcombe and Jensen (1997) for chronic
[3] Stillwater Sciences, ECR (2009a) Section 2.2.4
[4] Regional Board Basin Plan
[5] Johnston and Slaney (1996)
[6] Appendix B, Stillwater Sciences (2009) citing Bjornn and Reiser (1991) and Ralph et al. (1994)
[7] From Lisle and Church (2002) and NOAA Fisheries Draft Coho Recovery Plan (Southwest Region, in press) – indicator of "Properly Functioning Conditions"
[8] NOAA Fisheries Draft Coho Recovery Plan (NOAA Fisheries, in press) – indicator of "Properly Functioning Conditions"

Food Supply	Macroinvertebrates	BMI metric corresponds to "minimally disturbed"[9]	Yes	Water Quality
	Riffle embeddedness	<25% with decreasing trend (pending basin TMDL determinations)[10]	Unknown	Instream Habitat Structure
	Vegetated canopy	85-95% canopy cover[8]	No	Riparian Corridor

*Habitat requirements for the emergent coho fry in the spring are supported by those necessary for over-wintering juvenile coho

Table 5. Targets for critical elements of salmonid summer rearing habitat to support optimal juvenile growth and survival.

Summer Rearing Habitat To support at least 22,000 juvenile coho for minimum viable population (assuming 67% winter survival)			
Habitat Type	**Components**	**Estimated Coho Habitat Area Needs**	**Existing Conditions**
Rearing Habitat	Frequent, deep pools with high percentage of cover (i.e. large and small wood, undercut banks, overhanging vegetation)	Approx. 22,000 m^2 of suitable habitat (based on 1 fish/m^2)	Unknown
	Cool, well-oxygenated water with minimal nutrients or toxins		
	Abundant, accessible food		
	Unrestricted passage between pools and out of poor quality habitat areas		

[9] Appendix B, Stillwater Sciences (2009)
[10] M. Napolitano and L. Ferguson, Regional Board, personal communication (2009)

Critical Habitat Element	Indicators	Targets	Do current conditions meet Targets? (as reported in ECR)	Focus Area for Actions
Channel Bed Form	Pool frequency (# of pools/channel width)	0.25-0.5 [11]	No 0.13 to 0.24 (mainstem)	Instream Habitat Structure
	Pool/riffle ratio	1:1	Unknown	
	Residual pool depths	Increasing trend >2ft	Unknown	
	Shelter	Increasing trend		
	Large wood frequency	Increasing trend in loading and forced pool-riffle units (reach based) or 6-11 pieces/100m[12]	Unknown	
Water Quality	Turbidity	Chronic: trend toward sub-lethal concentrations by duration[13]	Data Inconclusive	Water Quality and Riparian Corridor and Water Quantity
	Temperature	MWAT <15^{0}C	No (not all locations)	
	Dissolved oxygen	7.0-9.0 mg/L or ≥85% of saturation [14]	No (not all years or all locations)	
	Nutrients	Nitrates: 0.155 mg/L Orthophosphates: 0.03 mg/L[15]	No	
	Toxicity	No acute, sub-lethal, or chronic toxicity concentrations[16]	No	
	Riparian canopy	85-95%[14]	No	
Food Availability	Macroinvertebrates	"minimally disturbed" IBI value[14]	Yes	Water Quality
	Riffle embeddedness	<25% with decreasing trend (pending basin TMDL determinations)[17]	Unknown	Instream Habitat Structure

[11] Johnston and Slaney (1996)
[12] From Lisle and Church (2002) and NOAA Fisheries Draft Coho Recovery Plan (NOAA Fisheries, in press) – indicator of "Properly Functioning Conditions"
[13] Newcombe and Jensen (1996)
[14] California Regional Water Quality Control Board San Francisco Region (2007)
[15] Stillwater Sciences (2009a), ECR Section 3.5.5
[16] Appendix B, Stillwater Sciences (2009b)

Critical Habitat Element	Indicators	Targets	Do current conditions meet Targets? (as reported in ECR)	Focus Area for Actions
	Riparian canopy	85-95%[14]	No	Riparian Corridor
Passage	Man-made barriers to migration	90-100% of suitable habitat unimpeded[14]	No	Instream Habitat Structure
	Flooded riffle	Increasing trend	Unknown	Water Quantity

Table 6. Targets for critical elements of salmonid spawning habitat to support returning adults, successful egg hatching, and emergence.

Spawning Habitat To support at least 444 adult coho or 222 redds (12 year average) for minimum viable population				
Habitat Type	**Components**	**Estimated Coho Habitat Area Needs**	**Existing Conditions**	
Spawning Riffle Habitat	Sufficient, high quality gravels with low percentages of fine sediment intrusion	At least 1,220 - 2,600 m^2 of suitable habitat (based on 5.5 to 11.7 m^2 per spawning pair)	Unknown	
	Cool, well-oxygenated water			
	Unrestricted passage to high quality spawning areas			

[17] M. Napolitano and L. Ferguson, Regional Board, personal communication (2009)

Critical Habitat Element	Indicators	Targets	Do current conditions meet Targets? (as reported in ECR)	Focus Area for Actions
Bed Sediment Quality[18]	Sediment size	D_{50} = gravel w/increasing trend	Unknown	Instream Habitat Structure
	Gravel permeability	TBD – increasing trend	Unknown	
	Gravel embeddedness	<25% with decreasing trend (pending basin TMDL determinations)	Unknown	
	% fine sediment	TBD – decreasing trend	Unknown	
Water Quality	Temperature	<14^{0}C [19]	Yes	Water Quality and Riparian Corridor
	Dissolved oxygen	7.0-9.0 mg/L or ≥85% of saturation [20]	Yes (mainstem) No (Montezuma and Woodacre Creeks)	
Passage	Man-made barriers to migration	90-100% of suitable habitat unimpeded	No	Instream Habitat Structure

4.3 Rehabilitation of Physical Conditions and Processes to Support Critical Habitat Elements

Development and land management practices have altered the San Geronimo Valley landscape and its waterways. As discussed in Chapter 2, these alterations have had dramatic effects on hydrologic processes, sediment transport dynamics, vegetation composition and distribution, and channel form. Ongoing impacts related to existing development will continue to place stress on the ecosystem. The salmonid population of the Lagunitas Creek basin and the entire Central California Coast ESU is on the brink of extinction (Spence et al. 2008). Forecasts for climate change (Chapter 2) suggest that summer stream flows will experience the greatest impacts, as water supply for humans and wildlife experience increasing pressures. More extreme droughts and higher summer air temperatures are likely. Floods may become more intense and frequent,

[18] Bed sediment quality targets require modeling background levels for the basin. These parameters will be defined as part of the Lagunitas sediment TMDL. M. Napolitano and L. Ferguson, Regional Board, personal communication (2009)
[19] Stillwater Sciences, ECR (2009a) Section 2.2.4
[20] California Regional Water Quality Control Board San Francisco Region (2007)

reinforcing the need for high-quality refugia habitat. Thus, it becomes even more critical to recreate a resilient stream corridor and ecosystem.

The impacts of our actions over the last 200 years cannot be fully erased. We can, however, take steps to reverse them and reestablish the physical and biological processes that encourage high-quality, resilient habitat conditions. In the previous section, instream habitat elements were broken down into very specific components with target values for each. However, many of the instream targets cannot be reached without restoring watershed-wide hydrologic processes and riparian zone function and composition.

The Riparian Zone

The riparian zone is a transitional area between upland regions and the stream. Widths and specific characteristics of riparian zones vary depending on climatic region, geology, slope, and stream type. A dense riparian forest strip adjacent to the stream that transitions to shrubs and herbaceous vegetation is a vital feature in most, but not all, riparian zones. Intact riparian zones provide filtration of sediment and other pollutants, streambank stabilization, shade for temperature regulation, shelter, and food sources for a range of fauna. Riparian zones also hold water in winter to recharge in-stream flows in summer months.

*The **riparian zone** is an area adjacent to the streams that supports or has the potential to support plant and animal species adapted to living near water. The riparian zone provides important ecological services including filtration and storage of water, temperature control, wood production, and wildlife refugia habitat. It can encompass homes and other infrastructure.*

*A **riparian corridor** is the linear extent of intact riparian habitat, often providing linkage between other distinct habitat patches.*

*A **riparian buffer** is an undisturbed area immediately adjacent to a stream. Its purpose is to protect the stream from human land uses, and human infrastructure from erosion and flooding.*

Another important function of the riparian zone in salmon-bearing streams such as San Geronimo is delivery of both large and small downed wood. Large woody debris (LWD) is essential in these stream systems to create pools, trap coarse sediment, generate channel complexity, and provide shelter from high velocities and predators. Without significant amounts of LWD, channel beds become simplified and unstable, prone to incision. Small wood also provides intricate shelter components during summer low-flow conditions, and its incorporation into large-wood structures improves their functioning during high flow events.

As our climate changes, functional riparian zones may play an even more important role (Seavy et al., 2009). A defining feature of many riparian plants is their ability to withstand hydrologic and geomorphic disturbances. This ability may make riparian species more resilient than upland species to the stresses of increased flooding and drought, which are predicted to accompany climate change in many regions. Other

benefits provided by riparian habitat that are likely to more valuable with changing climate include: shading/thermal refugia, linkages between disparate habitat patches, and moderation of hydrologic extremes.

The riparian targets below address the size, composition, and integrity of the riparian zone. We have included both science-based goals and reasonably achievable targets, given the level of existing development along San Geronimo Creek and its tributaries.

The targets for the width of the riparian zone are based upon the amount of intact habitat needed to support natural regeneration of the dominant plants. (See Appendix E.) The target undisturbed riparian buffer widths will provide shade, filtration of sediment and sediment-related pollutants, some woody debris recruitment, and bank stability. Vegetative cover targets are included for woody and non-woody streams in recognition that some stream reaches in San Geronimo Valley may not have naturally supported tree- or shrub-dominated communities.

The continuity of a riparian corridor influences the degree to which it can benefit water quality, quantity, and wildlife movement. Fragmented corridors are less effective in all of these ways. Continuity of riparian habitat is also likely to increase resilience to climate change impacts.

Targets for native and invasive species reflect the fact that intact riparian habitat consists of animal and plant species that have evolved together for millennia and are interdependent. Intact native riparian vegetation in San Geronimo Valley provides the qualities that native fish and wildlife require, as described above. In many disturbed and developed areas, however, invasive exotic plant species have spread and reduced the extent and diversity of native plants. Invasive species often form dense, uniform stands over large areas, diminishing habitat diversity and value for native wildlife.

Bank armoring as a method of bank stabilization has negative impacts on fish, wildlife, and plant habitat. Protecting existing native vegetation, or revegetating where needed, can provide similar bank stabilization in addition to the many other benefits described above. Armored banks offer little in terms of habitat value or water quality protection. They provide no shade, little shelter, no nutrient inputs, and little filtration of pollutants.

Table 7. Targets for the restoration of a sustainable and resilient riparian zone.

Indicator	Science-based Goal	Target
Undisturbed riparian buffer width and vegetation cover	100 feet or more depending on location	35 ft laterally from bankfull
	85-95% tree and shrub canopy cover in woody riparian corridors, 90-100% herbaceous cover in non-woody riparian corridors	85-95% tree and shrub canopy cover in woody riparian corridors, 90-100% herbaceous cover in non-woody riparian corridors
Woody riparian zone width and vegetation cover (where existing or typical native vegetation is tree or shrub dominated)	100 feet or more depending on location	>200 ft (undeveloped open space) 80-150 ft (agricultural & developed)[1]
	85-95% tree and shrub canopy cover in woody riparian corridors	75% tree and shrub canopy cover in woody riparian corridors[3]
Non-woody riparian zone width and vegetation cover (where typical native vegetation is grassland)	100 feet or more depending on location	35 ft (agricultural & developed)[2]
	90-100% herbaceous cover in non-woody riparian corridors	90-100% herbaceous cover in non-woody riparian corridors
Continuity of riparian zone and undisturbed buffer	90%	Increasing trend
Invasive species cover in riparian zone and undisturbed buffer	0%	Decreasing trend. Not to exceed 25%
Native species cover in riparian zone and undisturbed buffer	100%	Increasing trend
Bank armoring in riparian zone and undisturbed buffer	0%	Decreasing trend

[1] Riparian zone width is based on 3 crown widths of the dominant native tree species or 60% of dominant species tree height, whichever is greater. Example calc: Average 27 ft/crown x 3 crowns = 80 ft width for native conifer and hardwood species OR typical height of 250 ft x 0.6=150 ft for redwood/Douglas-fir and 80 ft x 0.6=48 ft for California bay laurel. These targets address both biodiversity and LWD recruitment functions in the riparian corridor (Benda et al. 2002, Benda et al. 2003, Burns and Honkala 1990, Gilman and Watson 1994, FEMAT 1993).

[2] Areas where potential native vegetation is grassland have not yet been determined for the San Geronimo Creek watershed. Existing distribution of annual, perennial, and serpentine grasslands (ECR Figure 3-11) could be used as a proxy until such mapping has occurred.

Hydrology

Individual salmonid populations have adapted to the unique patterns of climate and streamflow in their natal watersheds, as have the local channel form and riparian vegetation. The Mediterranean climate of the San Francisco Bay area brings extremes in precipitation, with very wet winters and long, dry summers. Although these natural

climatic extremes likely impacted habitat conditions historically, streamflows were sufficient to support and rear two times the coho densities outlined in the population recovery goals (Chapter 3).

Most of us learned the elements of the hydrologic cycle in early science classes – precipitation, infiltration, percolation, runoff, aquifer storage, groundwater tables, and streamflow to the ocean. Within a watershed all these elements are connected; if any of the components of the hydrologic cycle shift their behavior (e.g., infiltration and percolation to the groundwater table is reduced), the other components also shift. The end result is typically changes to streamflow amounts or patterns.

The San Geronimo Valley hydrologic cycle has been altered from its historic regime. Some of the specifics of this were discussed in Chapter 2. Urbanization resulted in hard surfaces covering a portion of the watershed. Paved and structure-covered surfaces, or total impervious area (TIA), accounts for approximately 5% of the overall watershed area. Compacted surfaces from clearing, development, and agricultural practices likely functionally produce a much higher percentage of land in the watershed that is impervious.

Precipitation hitting compacted or paved surfaces does not infiltrate the ground; it runs off as overland flow. Thus, groundwater recharge rates are likely reduced from pre-urbanization conditions. Groundwater extractions further reduce the volume of water stored and the water table. Surface runoff is now routed through connected impervious areas to the stream instead of across pervious slopes and swales where it would eventually be stored or infiltrate. These alterations cause flashier (higher and faster) storm flows, lower winter baseflows, and a reduction in volume and longitudinal extent of summer flows. Table 7 suggests targets that characterize and track the hydrology within San Geronimo Valley.

Table 8. Targets for tracking hydrologic function in San Geronimo Valley.

Indicator	Science-based Goal	Target
Total Impervious Area	< ~10% cumulative per subwatershed	No net increase from existing levels
Effective Impervious Area (impervious areas with continuous connections to waterways)	Not established in literature	No net increase Decreasing trend over time
Flooded riffles in summer	Not established	Stable or increasing trend in locations and period of time
Flood peak flashiness	Not established	Decreasing trend

Chapter 5. Policies and Regulations that Protect Salmonids and their Habitat

Salmon, steelhead, and their habitat are currently protected under a suite of policies and regulations by state and federal agencies.

5.1 2007 Marin Countywide Plan

In 2007, Marin County adopted a major revision of the Countywide Plan (CWP). The 2007 update, while continuing many of the major goals of the 1994 Countywide Plan (as amended in 1994, 1995, 1997, and 1999) related to control of growth and preservation of the environment, focused on sustainability, which is defined as aligning the built environment and socioeconomic activities with the natural systems that support life. It also added a fourth environmental corridor; the four major planning areas in Marin County are now the Coastal, Inland Rural, City-Centered, and Baylands corridors. San Geronimo Valley continues to be planned as part of the Inland Rural Corridor designated for agricultural and rural use with the intention of maintaining community character. CWP policies that affect salmonids and their habitat are shown in Table 8.

The 2007 CWP update reaffirms use of the 1997 San Geronimo Valley Community Plan as the main planning tool for the area. The purpose of the San Geronimo Valley Community Plan is to define land use and conservation guidelines for planning decisions. The Plan presents goals, objectives, policies, and programs designed to preserve the unique natural attributes of the Valley and its communities as well as the historical character of the built environment. The guidelines are used by the Community Development Agency staff, the County Planning Commission and the Board of Supervisors to review specific development proposals within the Valley. The Plan provides direction to property owners, community groups and interested individuals in formulating and reviewing new developments.

The San Geronimo Valley Community Plan includes policies that protect natural resources, preserve community character and separation, encourage agriculture and protect agricultural land, and preserve recreational, cultural, and educational opportunities for residents. Partially as a result of the SGV Community Plan, large portions of the valley are now protected outright as public parks or with conservation easements held by the Marin Open Space District or the Marin Agricultural Land Trust. For more information and to view the plan, go to:
http://www.co.marin.ca.us/depts/CD/main/pdf/planning/San_Geronimo_Community_Plan_1997.pdf

While the major planning designation has not changed for San Geronimo Valley under the 2007 CWP, specific policies have changed the amount and type of allowable development and thus the potential for cumulative impacts to salmonid habitat. Perhaps

the CWP policy with the largest effect is CD 1.1, directing land use to appropriate areas, with urban areas having concentrated development, and sensitive natural areas having much less. Policy CD 1.1, together with Policy CD 1.2 discouraging urban service expansion in non-urban areas and Policy CD 1.3 to reduce building impacts, concentrate the projected number of new housing units countywide in the City-Centered Corridor at transit nodes and effectively reduce planned development in San Geronimo Valley. Implementation measures for these three policies include updates to the Development Code to:

- Confine urban development largely to the City-Centered Corridor and designate areas within and surrounding the City-Centered Corridor for resource protection such as greenbelts, ridge tops, and undeveloped historic baylands.
- Expand protections of sensitive resources in the Baylands Corridor and identify large, undeveloped parcels for priority open space acquisition.
- Calculate potential residential density and commercial floor area ratio at the low end of the applicable range on sites with sensitive resources or lacking public water or sewer systems.

Implementation measures also include working with landowners, agencies, and non-governmental agencies in the Inland Rural and Coastal Corridors to protect resources and preserve community character. The housing overlay created under policy CD 1.2 for the purpose of establishing balanced communities also helps to enact CD 1.1.

Figure 12 shows the undeveloped parcels in San Geronimo Valley and their number of allowable units. Prior to development policies established in the 1994 and 2007 CWPs, buildout potential in the San Geronimo watershed was based on original zoning ordinance criteria. Figure 5 illustrates the reductions in potential housing units under the 2007 CWP. While helping to maintain the character of the small communities in the Valley, it also has positive implications for natural resources, salmonids, and their habitat.

Projected changes in TIA from allowable buildout in the 2007 CWP are low, as shown in Figure 6. The percent increases in TIA over existing levels range from 1% to 16%, with Montezuma Creek having the greatest potential percent increase in TIA.

Figure 13. Map of parcels within San Geronimo Valley with additional potential development units and number of units.
The Stream Conservation Areas are shown for reference. Map and analysis by Stillwater Sciences.

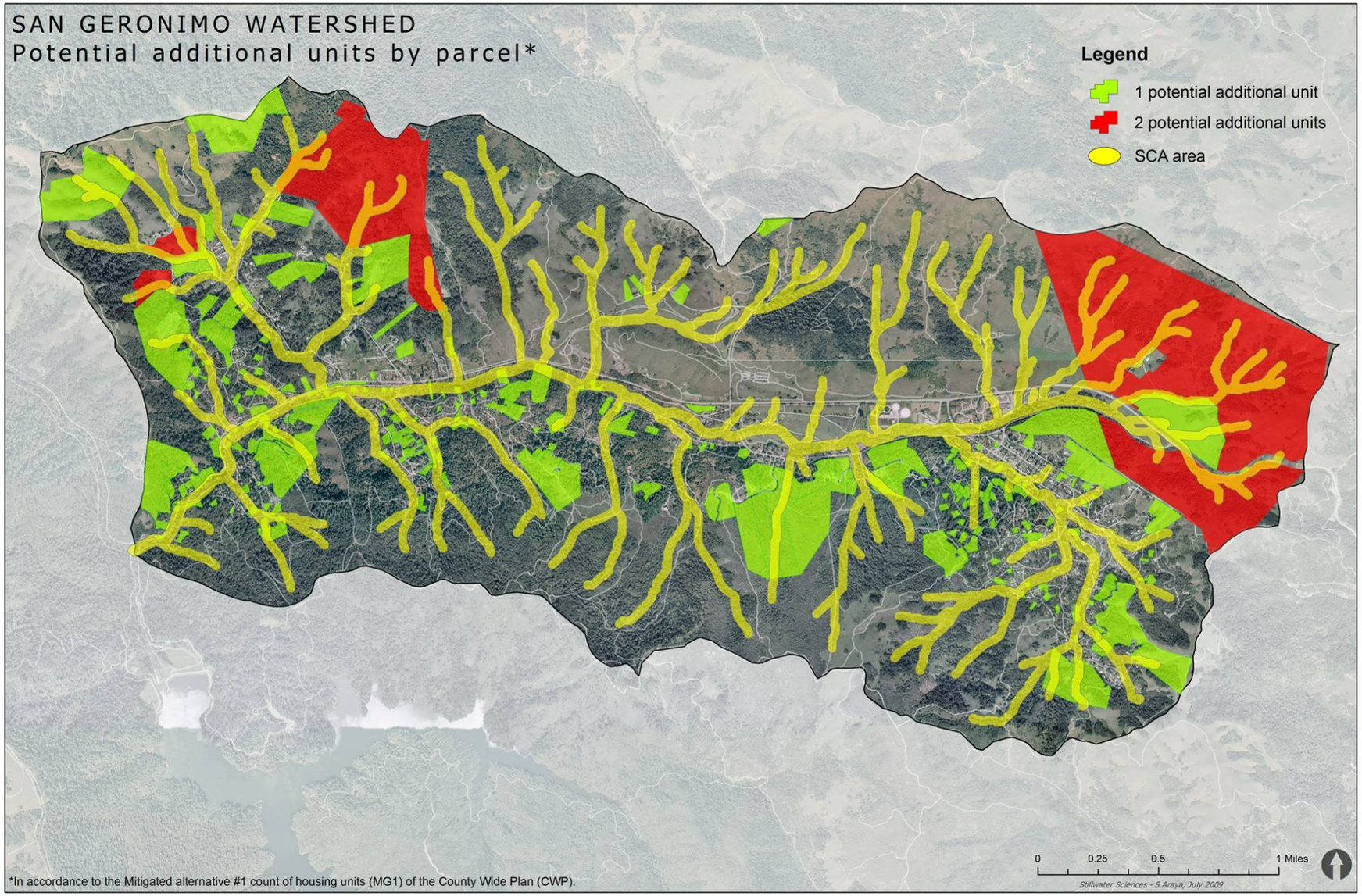


Figure 14. Comparison of development in San Geronimo Valley using existing conditions, original zoning criteria, and the application of the combined 1994 and 2007 CWP policies.

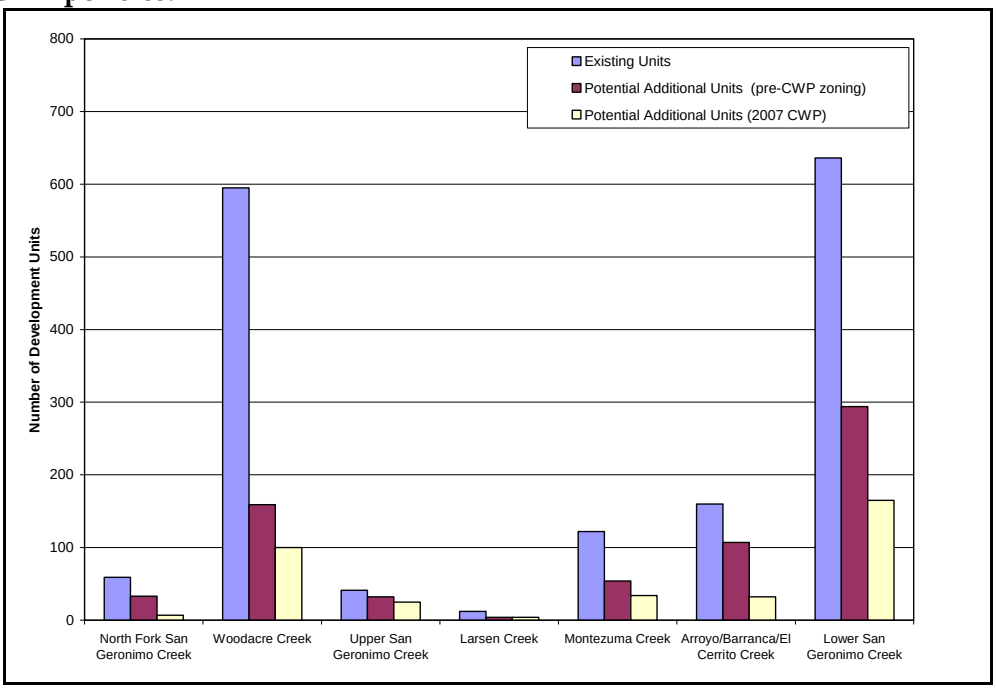
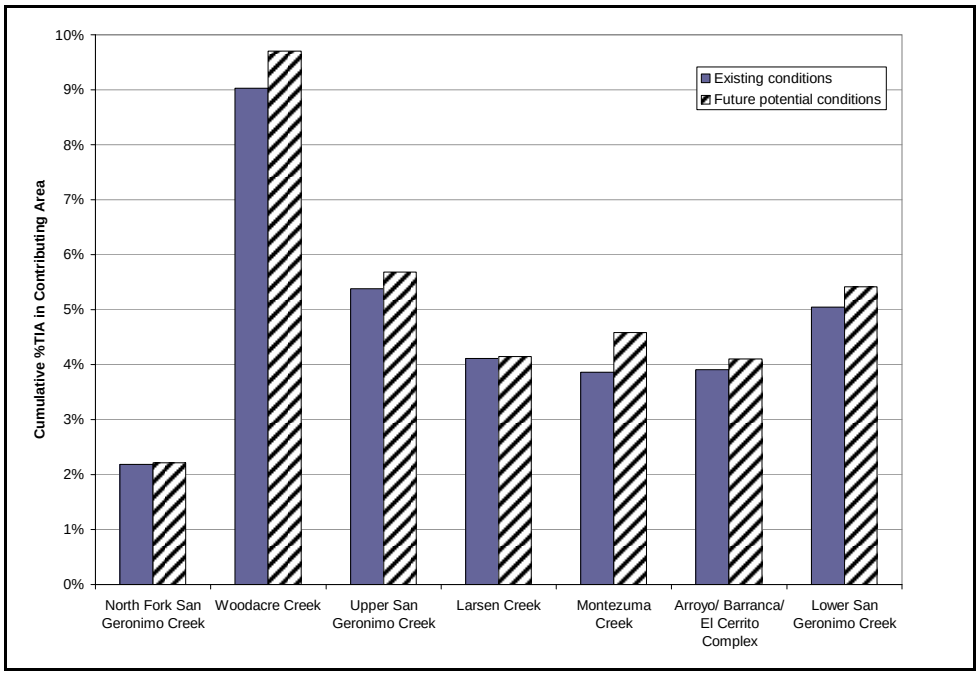


Figure 15. Comparison of existing cumulative TIA and projected cumulative TIA based on 2007 CWP allowable buildout units for each subwatershed.
Description of analysis provided in Appendix F.



The policies that define the Stream Conservation Areas (SCA) and the requirements for development within them are some of the most important in the 2007 CWP for protection of salmonid habitat. Marin County established SCAs to "protect the active channel, water quality and flood control functions, and associated fish and wildlife habitat values... provide a stream buffer, which is important to protect significant resources... and provide a transitional protection zone (from Marin 2007 CWP Policy BIO-4)." SCA policies in the CWP require a development setback of at least 100 feet from the top of the bank in the inland rural corridor with certain exceptions, including driveways if no other location is feasible, utility crossings, and the repair or retrofit of existing permitted or legal non-conforming structures or improvements within the existing footprint (CWP Policies Bio-4.1, 4.2). Exceptions may be allowed if the parcel "falls entirely within the SCA, or development outside SCA is either infeasible or would have greater impacts" provided that development does not adversely alter hydraulic capacity; cause a net loss in habitat acreage, value, or function; or degrade water quality (CWP Policy Bio 4.1).

Preliminary analysis indicates that 203 unimproved single-family residential parcels include portions of the SCA in San Geronimo Valley. Of the total 203 parcels, approximately 108 are not large enough to fit 3,000 sq. feet[21] of development completely outside of the SCA. Fifty-eight of the parcels are wholly within the SCA. The analysis does not consider additional restrictions (e.g., inadequate percolation for septic systems, lack of access) that are likely to reduce the total number of buildable parcels. Appendix D identifies assessor's parcel numbers for property in the San Geronimo watershed SCA.

Table 9 identifies Marin County policies and ordinances for protecting riparian habitat and function. Policies represent the County's adopted position and guide actions by decision-making bodies. The policies listed in the table are found in the Natural Systems & Agriculture Element under Biological Resources (BIO) and Water Resources (WR). Ordinances are adopted and enforceable.

Table 9. 2007 Marin Countywide Plan policies – Natural Systems & Agriculture element.

Policy #	Policy Summary
GOAL BIO-1: Enhanced Native Habitat and Biodiversity	
BIO-1.1	Protect wetlands, habitat for special status species, sensitive natural communities and important wildlife nursery areas and movement corridors

[21] The 3000 sq. ft. estimate is based on 2000 sq.ft home, 500 sq.ft. septic system, and 500 sq.ft. driveway.

Policy #	Policy Summary
BIO-1.2	Acquire habitat areas containing sensitive resources
BIO-1.3	Protect woodlands, forests and tree resources
BIO-1.5	Promote use of native plant species
BIO-1.6	Control spread of invasive exotic plants
BIO-1.7	Remove invasive exotic plants
BIO-1.8	Restrict use of herbicides, insecticides and similar materials
GOAL BIO-2: Protection of Sensitive Biological Resources	
BIO-2.1	Include resource preservation in environmental review
BIO-2.2	Limit development impacts in areas that contain essential habitat for special-status species
BIO-2.4	Protect wildlife nursery areas and movement corridors
BIO-2.6	Identify opportunities for safe wildlife movement
GOAL BIO-4: Riparian Conservation	
BIO-4.1	Restrict Land Use in the Stream Conservation Areas (SCA)
BIO-4.2	Comply with SCA regulations
BIO-4.3	Manage SCAs effectively
BIO-4.4	Promote natural stream channel function
BIO-4.5	Restore and stabilize stream channels
BIO-4.6	Control exotic vegetation
BIO-4.7	Protect riparian vegetation
BIO-4.8	Reclaim damaged portions of SCAs
BIO-4.9	Restore culverted streams
BIO-4.10	Promote interagency cooperation
BIO-4.11	Promote riparian protection
BIO-4.12	Support and provide riparian education efforts
BIO-4.13	Provide appropriate access in SCAs on publicly owned land
BIO-4.14	Reduce road impacts in SCAs
BIO-4.15	Reduce wet weather impacts from development work
BIO-4.16	Regulate channel and flow alteration
BIO-4.18	Promote the use of permeable surfaces when hardscapes are unavoidable
BIO-4.19	Maintain channel stability
BIO-4.20	Minimize runoff
GOAL WR-1: Healthy Watersheds	
WR-1.2	Restore and enhance watersheds

Policy #	Policy Summary
WR-1.3	Improve infiltration
WR-1.4	Protect upland vegetation
GOAL WR-2: Clean Water	
WR-2.1	Reduce toxic runoff
WR-2.2	Reduce pathogen, sediment and nutrient levels
WR-2.3	Avoid erosion and sedimentation
WR-2.4	Design County facilities to minimize pollutant input
WR-2.5	Take part in water quality education
GOAL WR-3: Adequate water for wildlife and humans	
WR-3.1	Conserve water and develop new sustainable sources
WR-3.2	Mitigate water demand in new development

5.2 Marin County Ordinances

Table 10 contains a summary of existing ordinances that apply to the protection of fish habitat. The full text of these ordinances is available online at:

http://www.municode.com/resources/gateway.asp?pid=16476&sid=5

Table 10. Marin County ordinances.

Marin County Ordinance	Overview
DAM PERMIT (amendment) Chapter 11.04	Dams may not be built, enlarged, repaired, altered or removed without a permit and plan for erosion control measure.
WATERCOURSE DIVERSION OR OBSTRUCTION (Creek Permit) Chapter 11.08	Regulates the obstruction of natural creeks or channels including depositing material and building retaining walls. Requires a creek permit with a plan for the structure and may require assessment by a civil engineer. The permit must be issued if the construction will not impede the passage of water in the creek. Retaining walls built without a permit are a public nuisance and may be abated.
GRADING Chapter 19.06	All grading shall be in accordance with Chapter 70 of the Uniform Building Code, except as amended by winter grading provisions included in Chapter 24.04.620

Marin County Ordinance	Overview
SUBDIVISION Chapter 20	Requires subdivision tentative and final maps to show proof of water availability.
ZONING Chapter 21	Establishes floodway and floodplains zoning.
NATIVE TREE PRESERVATION AND PROTECTION Title 22, Article III, Chapter 22.27	Prohibits removal of native trees with diameter breast height (DBH) at least 6 to 10 inches (depending on species) without a tree removal permit unless the tree is a nuisance or hazard. Trees may be removed with a permit if necessary for the reasonable use and enjoyment of the land. Removals must be mitigated by re-plantings or cash payments.
DEVELOPMENT OF VACANT LOTS ALONG ANADROMOUS STREAMS AND TRIBUTARIES Chapter 22.42.045	In those instances where a vacant legal lot of record in the Countywide Plan's City-Centered, Baylands, or Inland Rural Corridor is proposed for development, any proposed development within the Countywide Plan's Stream Conservation Area that adjoins a mapped anadromous fish stream and tributary shall be subject to Design Review as provided by this chapter if the lot is zoned A, A-2, RA, H1, O-A, RR, RE, R1, R2, C-1, A-P, or VCR, including all combined zoning districts. (Ord. 3491 Exh. A (part), 2008: Ord. 3380 Exh. B (part), 2003)
MINING AND QUARRYING 23.06 (amendment)	Applications for mining permits must include erosion control plans in accordance with Chapter 24.04 Section VIII GRADING, and reclamation plans showing how affected streams will be restored and revegetation accomplished.
EXCAVATING, GRADING & FILLING Chapter 23.08	Requires a grading permit for projects of a certain size, except in the case of emergency, when work is done under another permit, or done by a county agency. In addition to the plans, application, and fee, a cash deposit may be required that can be used by the DPW to restore the site if the permit is not followed. The DPW permits only if no siltation of watercourses will occur. Additional bonds may be required if the permit expires.
FLOODPLAIN MANAGEMENT Chapter 23.09	Prohibits new structures in areas of special flood hazard. Prohibits encroachments, including fill, new construction, substantial improvements, and other development in floodways unless no increase in flood levels.

Marin County Ordinance	Overview
URBAN RUNOFF AND POLLUTION PREVENTION ORDINANCE Chapter 23.18	Prohibits discharges of material other than storm water into county storm drains unless in compliance with the NPDES permit. Requires use of adopted BMPs. Prohibits depositing any loose material in watercourse. Authorizes DPW to require permanent runoff controls on construction sites. Prohibits removal of healthy creek bank vegetation.
INTEGRATED PEST MANAGEMENT Chapter 23.19	Requires use of IPM techniques to reduce pesticide use in the county. Creates IPM commission, requires public notification of use by county agencies, etc.
IMPROVEMENTS Chapter 24.04	Specifications for building roads, driveways, parking and loading, sidewalks, paths, drainage facilities, subsidence, grading, trees and landscaping, transit facilities, railroad crossings, utilities and miscellaneous
DRAINAGE Chapter 24.04.520	Standards for culvert sizing and placement.
DRAINAGE SETBACKS Chapter 24.04.560	Drainage setbacks: All structures shall be set back from creeks, channels or other major waterways at least twenty feet from the top of bank or twenty feet plus twice the channel depth measured from the toe of the near embankment, whichever is greater.
GRADING Chapter 24.04.620	All sites shall have an Erosion and Sediment Control Plan in place by 10/15. Winter grading must follow a phasing plan and may require a cash bond. A Surface Runoff Pollution Control Plan may be required with specific construction and post construction BMPs, and posting of a bond to ensure compliance.
MISCELLANEOUS (bridges) Chapter 24.02.875	Vehicular bridges over streams in SCA zones shall minimize disturbance of the stream. Fill and culvert crossings shall only be allowed where they are consistent with these policies and /or are the only reasonable or economically feasible type of access.

5.3 State and Federal Regulations

State and federal regulations also exist to protect salmon, steelhead, and other species and their habitats, and to safeguard other public resources such as clean water and archaeological sites. Table 11 identifies the primary state and federal permits or regulatory approvals needed for actions that affect streams.

Table 11. State and federal permits required for actions that affect stream habitat.

Agency	Authority	Action	Permit
California Dept. of Fish and Game	Public Resources Code 1600-1607	Actions altering streams or rivers	Streambed Alteration Agreement
	California Endangered Species Act (CESA)	Actions that affect species listed by the State of California	Incidental Take Permit for state-listed species; may be processed as part of Streambed Alteration Agreement
Department of Water Resources	California Water Code (plus water rights as below)	Installing dams, reservoirs, and stock ponds	Approval from Division of Safety of Dams
	State Constitution, Article X	Appropriating water from creeks	Water Rights Permit
San Francisco Bay Regional Water Quality Control Board	Federal Clean Water Act Section 401 or State Porter Cologne Act	Any actions affecting waters of the U.S. or the State	§401 Water Quality Certification (if getting federal §404 permit) or Waste Discharge Requirements
U.S. Army Corps of Engineers	Federal Clean Water Act, Section 404	Placement of dredged or fill material to waters of the U.S.	Processed simultaneously with §401 permit if needed
	Rivers & Harbors Act, Section 10	Work in navigable waters of the U.S.	Processed simultaneously with 404 permit process in most instances.
NOAA's National Marine Fisheries Service	Endangered Species Act, Sections 7 & 10	Otherwise legal actions that may affect listed marine and anadromous species	Incidental Take Permit for federally-listed marine and anadromous species; if applying for 404 consultation takes part through permit review
U.S. Fish and Wildlife Service	Endangered Species Act, Sections 7 & 10	Actions that may affect listed species not regulated by NOAA	Incidental take permit for federally-listed species not regulated by NOAA; Consultation on federal actions and CEQA; regulations for

Agency	Authority	Action	Permit
			preservation of resources
State Historic Preservation Officer (SHPO)/State Historic Resources Commission	National Historic Preservation Act, Section 106; CA Public Resource Code and other laws	Federal actions that might affect historic or archaeological resources; any listed or identified resource	Consultation on federal actions and CEQA; regulations for preservation of resources
Federated Indians of Graton Rancheria	SB18	Any actions that might move, remove, or take cultural resources and or human remains	No permit; however, consultation required
This is not a definitive list of permits. Applicants should contact the County Planning or Public Works Department for any additional requirements. Any State and local agency may be required to comply with the California Environmental Quality Act (CEQA).			

Chapter 6. Recommended Implementation Strategies

6.1 Recommendations for Implementation

Recommendations in the Plan could be implemented through three pathways:

- Voluntary activities by landowners and residents with outreach and technical assistance provided to support them. Outreach should be coordinated among the agencies, non-profit organizations, and other entities that work with San Geronimo residents to best fit specific information to the target audiences.

- Activities by public agencies that own land and/or manage infrastructure or resources in the Valley.

- County Community Development agency could incorporate recommendations into the building design review and permitting process. Table 12 summarizes the recommended actions. Further detail is found in Chapter 2.

Table 12. Summary of Recommended Implementation Items.

	Recommendation	Priority	Voluntary activities by residents	Public Agency Recommended Activities *Any future actions will require agency approval*	Outreach and technical assistance by County, other public agencies, and community groups	Funding support from state and federal agencies, and foundations
1	Establish and support a community outreach process to guide implementation of the Plan		Participate in process	Participate in process	Coordination of public participation process	Funding will be needed for coordination, facilitation, and outreach.
2	Protect and enhance the riparian corridor to create healthy, self-sustaining habitat.	High	Keep existing riparian trees and plant more, incorporate native plants into bank stabilization and erosion control projects. See Appendices H, I.	Use guidelines for managing and enhancing riparian habitat on public lands. Incorporate guidelines into review and land-use permitting of development and re-development projects.	Provide workshops, landowner site visits, educational materials, and other resources on planting, Sudden Oak Death, invasive removal, etc.	Funding for workshops, demonstration projects, low-cost plants and materials for homeowners
3	Develop a riparian vegetation management strategy with fire officials to allow fire-safe practices while preserving riparian habitat.	Medium	Follow revised fire-safe guidelines as issued by Marin County Fire Department (MCFD)	Continue coordination between MCFD, DPW, and other agencies to develop strategy and conduct outreach	Update Fire Safe Marin brochures and website	
4	Apply policies, regulations, and guidelines to protect salmonid habitat and the ecological functions that	High	Incorporate SEP guidelines into planning and design of development and redevelopment	Utilize Plan guidelines for design of Capital Improvement Projects and as guidance for review and permitting of development	Provide informational materials for landowners seeking permits	

	Recommendation	**Priority**	**Voluntary activities by residents**	**Public Agency Recommended Activities** *Any future actions will require agency approval*	**Outreach and technical assistance by County, other public agencies, and community groups**	**Funding support from state and federal agencies, and foundations**
	sustain it to all new development and redevelopment currently allowable in the SCA		projects	and re-development projects. Provide training for planners		
5	Consider conservation of key undeveloped streamside parcels through easements or purchase of fee title	Medium		Marin County and non-profit partners develop acquisition plan		Funding needed for planning and acquisition
6	Consider development of a process to promote the replacement, removal, and modification of unpermitted structures in the SCA that adversely effect fish habitat.	Low	Voluntary modification or removal of unpermitted structures.	Consider development of process to promote voluntary replacement, removal, or modification.	Develop outreach materials to promote voluntary replacement, removal, or modification.	Cost-share could be included as a component of a larger restoration program.
7	Develop plan to increase channel complexity to improve habitat quantity, value, and resiliency for all life stages.	High	Leave fallen trees and woody debris. Establish inset floodplains or gently-sloped banks when repairing eroding banks. Plant native trees close to channel.	Incorporate guidance into public projects. and the planning and permitting of bank stabilization projects.	Technical support to evaluate sites and select repairs, assistance with permitting, assistance with coordinating adjoining landowners.	Significant support needed for establishment of inset floodplains.

Exhibit 2. San Geronimo Valley Salmon Enhancement Plan

	Recommendation	**Priority**	**Voluntary activities by residents**	**Public Agency Recommended Activities** *Any future actions will require agency approval*	**Outreach and technical assistance by County, other public agencies, and community groups**	**Funding support from state and federal agencies, and foundations**
8	Promote removal of instream barriers to migration	High	Encourage landowners to remove barriers upstream of completed County projects.	County to continue support of fish passage program	SPAWN and other organizations to assist landowners with removing barriers on private lands.	Significant support needed to match available County funds.
9	Promote gravel delivery and retention.	Medium	Maintenance of private roads.	Encourage public agencies to assess County road crossings and include retrofits as part of watershed wide stormwater and drainage management plan.	SPAWN and other organizations to assist landowners on private roads.	Technical support and funding needed for implementation and landowner education.
10	Minimize and reduce streambank armoring	Medium-high	When existing bank stabilization must be repaired, replace with fish-friendly methods.		Technical support to evaluate sites and select repairs, assistance with permitting, assistance with coordinating adjoining landowners.	Technical support, and cost-share assistance needed for homeowners.
11	Develop an Instream Habitat Enhancement Implementation Program	High		DPW coordinates plan development with residents, local, State and Federal agencies.		Significant support needed to support development of an implementation plan.

	Recommendation	**Priority**	**Voluntary activities by residents**	**Public Agency Recommended Activities** *Any future actions will require agency approval*	**Outreach and technical assistance by County, other public agencies, and community groups**	**Funding support from state and federal agencies, and foundations**
12	Promote increased watershed-wide stormwater retention and disconnection.	High	Use pervious materials for driveways and paths, intercept and dissipate roof runoff, redirect drainage into vegetated swales, store rainwater for slow release.	County DPW conduct watershed wide drainage and stormwater management plan. Incorporate guidance into permitting of new development and redevelopment projects.	Develop workshops and outreach materials for residents.	
13	Develop a community-supported program to assist homeowners with addressing leaking septic systems. Give highest priority to systems within SCA and in reaches with higher nutrient levels.	Medium-High	Participate in planning process, repair leaking systems.	Marin County EHS, Regional Board, work with homeowners to develop community-supported program to evaluate and, where needed, upgrade septic systems or provide alternative treatment.		Significant support needed to plan and implement upgrades.
14	Promote minimal usage and proper disposal of chemicals, nutrients, and toxic materials.	Medium	Use fish-friendly products; store compost, animal and yard waste away from streams; properly dispose of toxic materials	Continue enforcement of existing state and federal clean water regulations. Continue to implement guidelines in County Haz Mat Area Plan (http://www.co.marin.ca.us/depts/PW/Main/pdfs/hazmat_plan.pdf)	DPW to sponsor annual hazardous waste recycling events and focused outreach. Residents can take household products to HHW facility in San Rafael for free disposal and recycling.	Support for outreach, education, demonstrations.
15	Reduce fine sediment	Med-High	Participate in	Incorporate plan guidance	Sponsor roads	Support for

	Recommendation	Priority	Voluntary activities by residents	Public Agency Recommended Activities *Any future actions will require agency approval*	Outreach and technical assistance by County, other public agencies, and community groups	Funding support from state and federal agencies, and foundations
	delivery from roads and upland erosion		workshops and collaborate with neighbors to implement best practices.	into public maintenance and capital programs to treat roads and trails.	workshops for landowners.	outreach, education and demonstrations.
16	Protect and enhance summer streamflow.	High	Replace instream pumps and alluvial wells with roofwater catchment. Reduce demand through water conservation.	MMWD, County and/or partner agencies and organizations to develop streamflow conservation plan. MMWD through promoting water conservation.	Additional workshops, demonstration projects, and cost-share assistance for landowners.	Support for outreach, education, demonstrations, and cost-share programs.
17	Develop and implement a coordinated monitoring program.	High	Identify monitoring activities that could be conducted by landowners (e.g. rainfall measurement)	DPW develop plan with other local, state, and federal agencies. DPW, other agencies, and community groups cooperate in conducting monitoring.	Regular reporting or monitoring results to community.	Funding will be needed for designing and implementing monitoring program.

6.2 Recommended Implementation Measures and Cost Estimates

The order and timing of project implementation is subject to change due to State and Federal agency priorities for salmon recovery and grant opportunities. N**o funding is presently available to implement these recommended measures**. Any future work plans would be developed in consensus with the community and would require authorization and funding support from the Board of Supervisors for implementation. An annual report would be provided to San Geronimo Valley residents and the Board of Supervisors for any funded activities.

- **Rec 1 Web Site Maintenance (public outreach)-**Annual cost to update *marinwatersheds* web site. (*est. annual cost $5,000*)

- **REC 1-Establish Grant Funding for Landowner Stewardship-**Potential exists to partner with existing MMWD grant program. MMWD program is currently suspended for budgetary reasons. *(est. annual cost $50,000*)

- **REC 1-New Senior Planner**-Add one new Senior Planner to manage implementation of the San Geronimo Valley SEP work program Proposed tasks for the Senior Planner include: public education and outreach, preparing grant applications and managing grant agreements, contract management, landowner assistance, environmental review (*est. annual cost: $130,00*)

- **REC 1-Outreach Plan including landowner workshops-**Conduct landowner workshops and outreach around salmon habitat enhancement activities. *(est. annual cost $25,000).*

- **REC 2 & 10-Landowner Assistance Program**-Program would provide technical assistance; funding would cover up to 50 site evaluations/year. Program would be provided through Urban Creeks Council or similar organization. (*est. annual cost: $50,000)*

- **REC 3-Update Fire Safe Marin guidance for creek side residents**-Fire Safe Marin brochures and its web site would be revised to include measures that protect riparian health and provide fire protection *(est. annual cost $10,000)*

- **REC 5-Develop an Acquisition Plan with Non-profit Partners** to identify priority locations for conservation and acquire conservation easements or, where appropriate, fee title from willing landowners. (*est. cost TBD).*

- **REC 6-Voluntary Structure Modification/Removal Assessment**-Evaluate feasibility and develop process to promote the **voluntary** replacement, removal or modification of structures within the Stream Conservation Area. Program would be administered by CDA (*est. annual cost $90,000*)

- **REC 7-Instream Habitat Restoration Plan-**If there is community support for reach scale restoration (*sections of creek between bridges or County road crossings*), develop reach level plan to enhance inset floodplains, re-vegetate creek bank slopes, control erosion and prepare recommendations for the safe placement or retention of large woody debris. The plan would include vegetation and geomorphic monitoring elements (*est. total cost $150,000)*

- **REC 8-Fish Passage Planner**-The Department of Public Works has one (1) full time Senior Planner to secure grants and implement projects to remove fish passage barriers on County maintained roads Countywide. Project priorities are identified in the County's Capital Implementation Program (*est. annual cost for planner $130,000*).

- **REC 9-Promote gravel delivery and retention**-County road crossings would be evaluated to assess which culverts limit the delivery of coarse sediment and gravels. This assessment is partially addressed through the County's fish passage studies prepared by Ross Taylor and Associates and can be refined as an element of the stormwater plan for REC 12(*est. cost tbd*)

- **REC 12-Limit Impervious Surfaces During New and Re-Development-**Public Works staff evaluates all development projects subject to a building permit to recommend measures to infiltrate stormwater whenever feasible.

- **REC 12-Storm Drain Mapping**-The mapping of the Woodacre sub-watershed is complete and was partially funded with State of California grant funds. The next priority is to map the storm drain system within the Montezuma sub-watershed (*est. cost: $10,000*)

- **REC 12-Stormwater Infiltration Plan for County road system-**This two year planning study would include mapping of all road drainage facilities within San Geronimo Valley and would evaluate opportunities to increase stormwater infiltration. All work would be conducted within existing County road rights of way (*est. project cost $600,000*).

- **REC 14-Household Hazardous Waste Recycling Event and Outreach-**Conduct an annual household recycling event plus focused outreach to residents regarding alternatives and safe disposal (*est. annual cost $6500*)

- **REC 15-Reduce Fine Sediment Delivery from Roads-**The Open Space District and MMWD both have existing programs to repair and maintain their roads. These programs are often augmented by grant funds.

- **REC 17-Monitor Salmonid Populations-Coordinate in stream habitat monitoring with ongoing** MMWD salmon monitoring program for adults and juveniles on mainstem San Geronimo Creek (*est. annual cost: $200,000*).

- **REC 17-Water Quality monitoring plan-**Develop plan to continue monitoring of continuous flow and water temperature (*est. cost tbd*)
- **REC 17-Vegetation Monitoring-**Riparian target monitoring recommended every 3-5 years (*est. cost $15,000*)
- **REC 17-Instream habitat monitoring**- Develop plan to evaluate actions to enhance inset floodplains, large woody debris, includes vegetation and geomorphic monitoring component (*est. project cost $50,000*)
- **REC 17-Habitat restoration database**-Database to track project implementation and success (*est. cost $15,000*)

The incomplete estimate to implement the proposed measures is $1,536,500. This total excludes actual habitat restoration costs and is primarily for planning, monitoring, education and outreach.

6.3 Incentives and Resources for Homeowners

For many homeowners, incentives, technical help, and financial assistance can make the difference between thinking about actions and actually doing them. Section 6.4 recommends funding strategies, and Section 6.5 proposes coordinated permitting strategies, both of which can also help homeowners. This section offers other ideas for Marin County to encourage enhancement projects on private property.

Riparian Re-vegetation with native species

- Develop handouts with clear photos of the recommended actions and directions for implementation. Distribute widely in San Geronimo Valley. Post on www.marinwatersheds.org.
- Provide special boxes for invasive species' green waste at no charge.
- Provide landowners who agree to replant riparian buffer with free natives to replant
- Partner with the SPAWN nursery for education/native plant sale days at the SGV Community Center two or three times a year.
- Partner with local nurseries to have native species readily available and clearly labeled as "SGV Fish Friendly."
- Partner with North Bay Conservation Corps to offer "revegetation days" that serve a few homes at a time. Crews could remove invasives, replant with natives, and install irrigation systems. Landowners pay for materials.

Using Nontoxic House Cleaning and Landscaping Products

- Focus on two or three types of products each year. Develop and distribute information on safe alternatives to homes and at local stores.

- Partner with product suppliers to provide free or low-cost nontoxic materials at the plant sale days.
- Work with local stores to make sure they have products available and labeled as fish-friendly.

Native Plant Landscaping

- Sponsor a contest and tour to promote model creekside landscapes. Secure grant funding to offer a substantive prize (e.g., $3,000, a shopping spree at a local hardware store, a rainwater storage tank).
- Offer a cost-share for landowners to work with a landscape architect to design a landscape plan that uses native plants and restores riparian habitat.

Replacing Bank Armoring, Sloping Back Streambanks, Creating Inset Floodplains, Installing Large Woody Debris Structures

- Help homeowners coordinate with their neighbors
- Develop educational materials explaining significance of natural channel restoration to fish habitat. Distribute in San Geronimo Valley, through MCCDA, and on marinwatersheds.org.
- Provide free or low-cost assessment from an engineer/designer to generate options and cost estimates
- Provide landowners assistance with CEQA and permitting process. Consider a programmatic permit for reach scale projects at low or no cost to landowner.

Low Impact Development (LID) for Increasing Stormwater Infiltration

- Promote demonstrations at public or highly visible places.
- Provide a free on-site consultation on increasing stormwater infiltration.

6.4 Funding options

Although a few Plan recommendations are already underway or can be incorporated into existing programs (e.g. REC 2 to modify fire-safe guidelines), most will require additional funding. Some actions, such as Recommendation 7 (*Increase instream habitat complexity*) and 13 (*Address leaking septic systems*) will require substantive financial support over many years and probably a coordinated funding strategy with several funders. Others, such as many of the outreach recommendations, are more likely to be completed quickly under a single funding source.

Primary sources of funding for Plan implementation are grants, low-interest loan programs, and special assessments. Table 13 identifies grant and loan programs from state and federal agencies, and foundations. The list is far from exhaustive and is intended as a starting point. Until California's most recent budget crisis, state agencies were a strong source of funding for natural resource planning and restoration. At this time, many state funding programs are on hold and are not accepting new applications. However, several have access to federal

funding sources and many are working hard to leverage remaining resources to continue modest levels of support while the economy recovers.

Table 13. State, federal, and foundation grant sources.

Funding Entity	Program	Candidate Recommen-dations
State Agencies		
State Water Resources Control Board with San Francisco Bay Regional Water Quality Control Board (RWQCB)	319(h) Nonpoint Source. Funding is through the Environmental Protection Agency (EPA) and is intended for improving water quality through projects that address TMDL implementation or problems to streams, bays, rivers, and lakes that have been listed as impaired.	2, 7, 10, 12, 13, 15
	Small Community Wastewater Grant Program. Recent funding has been through Propositions 40 and 50. The program provides assistance for planning, design, and construction of publicly-owned wastewater treatment and collection.	13
	Clean Water Revolving Loan Fund. Provides low-interest loans for stormwater and wastewater treatment, and implementation of projects to reduce nonpoint source pollution.	12, 13
California Department of Fish and Game (CDFG)	Fisheries Restoration Grant Program. This is a long-standing competitive grant program funded by both state and federal sources. Funding can be used for planning, barrier removal, habitat restoration, monitoring, public involvement, maintenance, and education for projects consistent with current CDFG priorities.	1, 2, 7, 8,10, 11, 12,15, 16, 17
Department of Water Resources (DWR)	Groundwater program. Includes a range of grants for groundwater monitoring and management. This program is currently on hold pending bond funding.	16
	Integrated Regional Water Management Program. Current funding is on hold through Proposition 84. The intention is to integrate sustainable and reliable water supply, better water quality, stormwater management, environmental stewardship, and a strong economy.	All
	DWR also manages many other grant and loan programs.	
California Department of Forestry (CDF)	Fire Prevention Program. Firesafe landscaping for homeowners and communities.	2, 3
	California Forest Improvement Program (CFIP). Provides cost-share assistance to private landowners, RCDs, and non-profit groups for planning, planting, fish and wildlife habitat improvement, and land conservation practices.	2, 15
Federal Agencies		

Funding Entity	Program	Candidate Recommen-dations
Environmental Protection Agency (EPA)	The Environmental Protection Agency website features an extensive catalog, sorted by keyword (e.g., invasive species, monitoring, land acquisition, watershed management), of federal funding sources for watershed protection (http://cfpub.epa.gov/fedfund/keyword_list.cfm).	
National Oceanic and Atmospheric Administration (NOAA) Fisheries	Open Rivers Initiative provides funding and technical expertise for community-driven, small dam and river barrier removals.	8
	NOAA Restoration Center Regional Partnerships provide funding for multi-year regional habitat restoration partnerships including watershed-scale projects that yield significant ecological and socioeconomic benefits.	All
	National Association of Counties and NOAA are partners in the Coastal Counties Restoration Initiative (CCRI). CCRI encourages innovative, county led or supported projects that restore important marine and coastal habitats and living resources. These projects also develop the capacity of county governments, citizens groups and other organizations to conduct community-based restoration that will enhance local watershed-based resource management and promote stewardship.	1 and outreach activities
Natural Resource Conservation Service (NRCS)	NRCS manages a suite of programs to provide technical and cost-share assistance to implement conservation practices, primarily for owners of land in agricultural production. http://www.nrcs.usda.gov/Programs/	2, 15, 16
	The Healthy Forest Reserve Program is a voluntary program established for the purpose of restoring and enhancing forest ecosystems to: 1) promote the recovery of threatened and endangered species, 2) improve biodiversity; and 3) enhance carbon sequestration. It can provide cost-share for conservation practices, a conservation easement in exchange for market value, and Safe Harbor from future regulatory restrictions under the Endangered Species Act.	5
Foundations		
National Fish and Wildlife Foundation (NFWF)	NFWF has a number of programs that could apply. (http://www.nfwf.org/AM/Template.cfm?Section=GrantPrograms). Several are listed below.	
	Native Plant Conservation Initiative supports projects that protect, enhance, and/or restore native plant communities on public and private lands.	2
	Marine and Coastal Conservation Initiative includes a priority to build "the capacity of local communities and watershed associations to participate in local stewardship projects that contribute to and build public support for	1

Funding Entity	Program	Candidate Recommen-dations
	broader restoration goals".	
	Acres for America is a NFWF partnership with Wal-Mart established to conserve important habitat through the acquisition of interest in real property (Recommendation 5).	5
Gordon and Betty Moore Foundation	The Moore Foundation has contributed to a number of conservation projects and programs in the Bay Area and could be a key partner if the San Geronimo fits into their strategic plan. http://www.moore.org/land-protection.aspx.	5
Marin Community Foundation (MCF)	A current focus of the Restoring Ecosystems Program is to promote coordinated, effective, science-based restoration and monitoring. http://www.marincf.org/	1, 2, 12, 14, 17

Additional strategies for funding enhancement measures include:

Local assessments. Property tax and/or special assessments may be appropriate for funding community wastewater management programs (Recommendation 16) and easement or fee acquisitions (Recommendation 4) because these activities have potential to directly improve property values. Developing an assessment program would require careful planning by the County to identify assessment district boundaries, complete cost projections, and analyze specific funding mechanisms.

Low-interest loans repaid through property tax assessments. Sonoma County recently implemented a program through AB 811 that allows private and commercial property owners to borrow money for water and energy conservation measures. Loans are repaid through property tax assessments. This mechanism could be considered for rainwater catchment and other water conservation measures.

Transfer tax rebate program. Berkeley created a program to rebate up to one-third of the transfer tax amount on homes for earthquake upgrades. The program allows new homeowners to perform seismic upgrades for little or no out-of-pocket expense. This mechanism could be explored to gradually improve stormwater management, replace hard streambank armoring with fish-friendly alternatives, and remove small structures from the riparian buffer as ownership changes.

General recommendations for developing a comprehensive and coordinated funding strategy for implementing the Plan include:

1. **Develop a funding schedule.** Many funding sources, particularly state and federal grants, require at least a year and often longer between the initial request and the completed contract. Since many grants require matching funds, the development of a

schedule will also allow County staff and partners to identify how different funding sources can be leveraged to meet match requirements. A schedule also facilitates matching the timing of different activities or elements of activities with the right source. Most grants must be used within a 1-3 year time period and are best spent on one-time projects, while sales tax or assessment-related sources are better matched to ongoing activities.

2. **Identify key partners.** Some partners have already been engaged through the planning process and Technical Advisory Group meetings. In addition to these partners, there may be other agencies and organizations that the County would benefit from working with on SEP implementation. There are many reasons for identifying key SEP program implementation partners early in the process of seeking funding, including:
    - Program partners would provide critical information regarding funding opportunities as well as supporting DPW's and other agencies efforts to secure funds.
    - Some funders have restrictions that prohibit public agencies from directly receiving grants. In these situations, having a variety of partners with different organizational status (i.e., non-profits, special districts, private foundations) would allow the County to identify eligible partners to receive funds and develop appropriate partnership agreements delineating how the funds will be used to implement Plan actions.
3. **Develop a SEP funding partnership committee.** Once a draft implementation schedule is developed and key partners are identified, the County could convene a funding partnership committee. As discussed above, this committee could help the County identify potential funding sources and the most effective manner for securing funds.

6.5 Coordinated Environmental Compliance Strategies

Regulatory compliance requires handling two baskets of work: completing California Environmental Quality Act (CEQA) review and securing necessary permits from local, state, and federal agencies.

CEQA Review

CEQA review is required whenever a local or state agency makes a *discretionary* decision that would result in implementation of a SEP-recommended action that has potential to result in either a direct or a reasonably foreseeable indirect physical change in the environment (CEQA Guidelines §15378). Examples of decisions that would trigger CEQA include a public works activity directly undertaken by the County (e.g., replacement of a culvert under a County road to remove a barrier to fish passage); approval of financial assistance for project implementation (e.g., a CDFG or RWQCB creek restoration grant program); and issuance of a discretionary permit by a public agency (e.g., a CDFG §1602 Streambed Alteration Agreement). Small projects that would not have a significant effect on the environment and do not require mitigation are often categorically exempt (CEQA Guidelines §15300).

For activities that are not exempt from CEQA, environmental review may be performed on a project-by-project or a programmatic basis. Both approaches require detailed evaluation of existing conditions, analysis of potential adverse effects, development of impact avoidance or mitigation measures, and agency and public review. The programmatic approach has been used by a number of agencies in California, including the Marin Resource Conservation District (MRCD), which prepared a Mitigated Negative Declaration (MND) for 16 types of restoration activities, along with avoidance and mitigation measures to ensure potential impacts would be less than significant. The MRCD and regulatory agency staff (e.g., CDFG, RWQCB) evaluate proposed site-specific actions annually for inclusion in the programmatic environmental review. If a proposed activity does not meet the conditions of the MND, separate CEQA review is conducted.

A checklist of SEP-recommended actions and mitigations could be developed for use by County staff to evaluate site-specific projects (CEQA Guidelines §15168(c)(4)). Actions that do not meet the conditions on the checklist would need to undergo environmental review as separate projects; however, CEQA compliance for actions that do meet the conditions on the checklist would be complete. It is recommended that County staff keep the documentation of their assessment on file and notify the Board of Supervisors when CEQA review has been completed.

Using the programmatic approach has several advantages over project-by-project review. It would allow the County to negotiate agreements with state and federal regulatory agencies during CEQA review about acceptable parameters for SEP-recommended actions, including avoidance and mitigation measures, which would streamline the permitting process. Although permits would still be required, the MRCD has found that when regulatory agency staff are already familiar with the proposed actions, project approval is more efficient. Working with state and federal agencies would also allow the County to evaluate potential funding and partnership opportunities. Finally, the programmatic approach would allow the County and landowners to proceed with project development knowing that the actions described in the programmatic CEQA document have been through agency and public review.

Permits

Chapter 5 identifies regulatory agencies with authority in the San Geronimo Valley. Whether or not permits are required depends on a number of project-specific factors, including location, natural resources present, and the proposed design. In addition to securing permits for actions implemented by the County, staff should evaluate to what extent the County could assist landowners with obtaining permits.

Some agencies utilize a programmatic approach to permitting. However, generally each project must be individually evaluated for potential impacts. Based on this experience, and assuming a programmatic CEQA document is developed, specific steps the County could take to streamline permitting of SEP actions include:

1. **Permit applications:** Initiate discussions with regulatory agencies regarding application materials and procedures. Many Bay Area regulatory agencies utilize a Joint Aquatic Resources Permit Application (JARPA) that bundles a number of separate projects that share similar goals. SEP habitat restoration actions would be excellent candidates for use of an annual programmatic JARPA.
2. **Permit fees:** Negotiate the potential for establishing fees at a programmatic level. Both CDFG and the RWQCB require substantial fees, even for restoration activities. In general, federal agencies (e.g., U.S. Army Corps of Engineers, National Marine Fisheries Service, U.S. Fish & Wildlife Service) do not require permit fees.
3. **Avoidance and mitigation planning:** Develop standard avoidance and mitigation measures for SEP-recommended actions that may require permits (e.g., replacement of hardened banks with biotechnical stabilization) for inclusion in both the CEQA documentation and permit applications. These measures should be negotiated with the applicable agencies and reviewed for consistency with existing and/or anticipated County policies and ordinances.
4. **Existing permits:** Identify existing documentation (e.g., Biological Opinions, Corps Nationwide Permits, California Endangered Species Act Consistency Determinations) under which some SEP actions can be permitted.
5. **Landowner outreach and education:** The County outreach could include direction on how to obtain natural resource information and other permit materials. Landowner site visits would be an excellent opportunity to discuss any permits that might be needed.

6.6 Monitoring for Adaptive Management

Monitoring for adaptive management in the San Geronimo Creek watershed is conceptually introduced in the Watershed Health Evaluation (Stillwater Sciences 2009b), prepared as part of Plan development (see Appendix B). As discussed in the Watershed Health Evaluation, achieving measurable beneficial change in the San Geronimo Creek watershed via enhancement activities requires that monitoring for biological, physical, and chemical indicators be incorporated into enhancement planning. Treating enhancement recommendations as measurable actions should be the basis for adaptive management in San Geronimo Creek and its watershed, where monitoring will provide a scientific basis for changing management actions (e.g., restriction on development in the SCA, instream installation of LWD, riparian buffer replanting), should suboptimal performance be observed (Holling 1978, Ralph and Poole 2003).

While a detailed monitoring plan is beyond the scope of this Plan, consideration of adaptive management principles has been undertaken in both the recommendation of multiple watershed health metrics for the Watershed Health Evaluation (see Table 5, Appendix B) and the subsequent development of numeric targets for salmonid recovery and habitat rehabilitation in the Plan (see Chapter 4). The recovery and habitat targets are akin to success criteria and metrics, and in many cases they would serve as the primary assessment tool for measuring effects of planned restoration activities using the adaptive management paradigm. Predetermination of the form and content of success criteria is critically

important to the assessment of enhancement success (SER 2004, Ruiz-Jaen and Aide 2005) and the targets and health metrics have been crafted with this in mind. For example, the targets and health metrics have been considered on the basis of whether they are sufficiently precise to show change, and whether data collection is feasible for a sufficient time to demonstrate change (or its absence); thus addressing two of three criteria for suitable indicators using the adaptive management approach (Stillwater Sciences 2009b). The third criterion, a focus on location(s) and spatial scale(s) where management actions are anticipated to show greatest influence, must still be considered as part of a detailed monitoring plan for the San Geronimo Creek watershed.

Identification of specific monitoring types and the alignment of the suite of health metrics and recovery targets with these monitoring types should serve as a next step in the development of such a monitoring plan. There are a variety of reasons why an enhancement or restoration project may not meet the originally conceived goals and/or objectives, thus a well-designed monitoring program should include three types of monitoring: implementation, effectiveness, and validation monitoring (MacDonald et al. 1991, Kershner 1997, Mulder et al. 1999). As shown in Table 14, each monitoring type focuses on a different aspect of the restoration or management action and necessarily involves a specific time frame for monitoring activities. Locations and spatial scales for each type of monitoring would depend on the particular objective or hypothesis being addressed.

Table 14. Monitoring types for restoration or enhancement projects.

Type of Monitoring	Question Addressed	Time Frame
Implementation	Was the project installed as planned?	1–6 months
Effectiveness	Was the project effective at meeting restoration or enhancement objectives?	1 year to decades
Validation	Are the basic assumptions behind the project conceptual model valid?	5 to 10 years to decades

Implementation monitoring is undertaken to determine whether the implemented restoration followed the design or the planned management action was carried out as intended (e,e, naturally recruited large wood is in fact left in the stream channel). As such, implementation monitoring components are critical to the validity of the effectiveness monitoring objectives. For construction actions, implementation monitoring is achieved through an as-built survey immediately following implementation, however some aspects can be carried out during the project as a check on design appropriateness (Kershner 1997). If field conditions make the original design unworkable, midcourse corrections can be implemented so that specifications are met. Where implementation monitoring objectives cannot be met (or corrected) for some reason, it may be necessary to alter or remove effectiveness monitoring objectives.

Individual enhancement recommendations, such as re-planting of a riparian buffer (element of Recommendations 1-4), removal or modification of unpermitted structures in the SCA (Action 6), establishment of inset floodplains or gently sloped banks (element of Action 7), removal of instream barriers to migration (Action 8), and replacement of armored banks with biotechnical methods (Action 10), are examples of SEP recommended actions that would require implementation monitoring. Table 15 gives examples of common implementation monitoring components for these types of projects, although it is not a complete list. A detailed monitoring plan for the San Geronimo Creek watershed should also consider whether implementation monitoring can be applied to the larger-scale watershed actions, such as overall management of the riparian corridor and SCA to achieve self-sustaining natural habitat (Action 1).

Table 15. Example of implementation monitoring components for restoration projects anticipated in the San Geronimo Creek watershed.

Component	
C1. Constructed channel topography /bathymetry match those in design drawings	**C3.** Planted vegetation are the species specified in the specifications report.
C2. Constructed inset floodplain topography matches those in design drawings and specifications.	**C4.** Planted vegetation are the sizes specified in the specifications report.

Effectiveness monitoring is more complex than implementation monitoring. As in other watersheds undergoing rehabilitation, effectiveness monitoring for enhancement efforts in the San Geronimo Creek watershed would necessarily involve evaluating the outcome of multiple objectives relating physical, biological, and biogeochemical factors at work in the ecosystem. As related to individual enhancement projects (see example set above), effectiveness monitoring would be applied following the development of project-specific objectives. In some cases, the recommended actions themselves represent the objective (i.e., Action 5: Conserve key undeveloped streamside parcels; Action 2: Allow fire-safe practices while preserving functional riparian habitat), but depending on the complexity of the implemented action, multiple specific objectives may need to be developed for a given project or action. Objectives should be cast as testable statements or hypotheses and clearly linked to recovery targets and/or health metrics, so that effectiveness of the project can be clearly assessed.

Validation monitoring is carried out to verify the underlying assumptions of the project or ecosystem conceptual model. As a consequence, this type of monitoring primarily has a research focus (Kershner 1997). In the context of the San Geronimo Creek SEP, validation monitoring would focus on the responses of the riparian corridor, water quality, and water quantity to the recommended management actions, as well as test the overarching conceptual model of salmonid response to changes in available habitat. While an explicit salmonid population model has not been developed for the San Geronimo Creek watershed,

NMFS coho and steelhead recovery targets for number of returning adults have been used to estimate how much instream habitat is needed during each life stage to support viable, resilient populations (see Chapter 4). The assumptions behind these calculations could be tested using validation monitoring as well as the assumption that the key limiting factor for the long-term success of salmonid populations is over-wintering habitat (Stillwater Sciences 2009a). As validation monitoring would be driven by a set of hypotheses derived from both the effectiveness monitoring objectives and the project conceptual models, articulation of the conceptual model should be included in the monitoring plan, which describes presumed linkages between ecosystem inputs, physical processes and forms, habitat structure, and biotic response. Validation monitoring requires the development of testable hypotheses and the inclusion of metrics and time scales appropriate to the research question and may also benefit from a weight-of-evidence evaluation to reduce uncertainty inherent in the project conceptual models.

Finally, in order to support scientific learning wherein the project is treated as an experiment and used as the basis for changing management actions, development of a monitoring plan should consider the application of a Before-After-Control-Impact (BACI) study design that controls for natural effects occurring outside of the project area. This type of study design may be necessary to ensure adequate statistical power of future analyses and to address the problem of measuring response to restoration activities within the inherent variability of natural populations. In a system such as the San Geronimo Creek watershed, where widespread development may hinder the possibility of identifying a site, or ideally a group of sites, to adequately represent the reference condition, application of BACI study design allows for testing of success criteria using a control site in place of a reference site (Green 1979, Stewart-Oaten and Bence 2001). The appropriateness of other study designs should be considered as well, including those that allow for temporal replication (Underwood 1996).

6.7 Plan Oversight

An advisory committee should continue to provide oversight and guidance to the County on implementation of the Plan. The County should consider expanding the current committee to include additional representation from the community. Advisory committee tasks could include review of monitoring data, assessment of Plan recommendations, and guidance on whether recommendations need to be modified in response to monitoring data. An active advisory committee is also critical for facilitating coordination with other agencies and the broader community.

In addition to the advisory committee, a technical advisory group should be formed to provide oversight and review of a coordinated monitoring program, and to support Marin County in securing funds for designing and implementing the program. This group could operate as a subcommittee to the existing Lagunitas Technical Advisory Committee to encourage coordination with broader monitoring efforts.

Chapter 7. References

Agee, J. and C. Skinner. 2005. Basic principles of forest fuel reduction treatments. *Forest Ecology and Management* 211:83-96.

Agee, J. 2002. The fallacy of passive management: managing for firesafe forest reserves. *Conservation* 3:1.

Battin, J. , M.W. Wiley, M.H. Ruckelshaus, R.N. Palmer, E. Korb, K.K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. *Proceedings of the National Academy of Science* 10:1073.

Bell, E. 2001. Survival, growth and movement of juvenile coho salmon (*Oncorhynchus kisutch*) over-wintering in alcoves, backwaters, and main channel pools in Prairie Creek, California. Master's Thesis. Humboldt State University, Arcata, CA.

Benda, L. E., D. Miller, J. C. Sias, D. Martin, R. Bilby, C. Vehldhuisen, and T. Dunne 2003. Wood recruitment processes and wood budgeting. *Transactions of the American Fisheries Society* 37:49-73.

Benda, L. E., P. Bigelow, and T.M. Worsley. 2002. Recruitment of wood to streams in old-growth and second-growth redwood forests, Northern California, U.S.A. *Canadian Journal of Forest Research* 32:1460-1477.

Bisson, P.A. 2008. Salmon and Trout in the Pacific Northwest and Climate Change, June 16, 2008. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. http://www.fs.fed.us/ccrc/topics/salmon-trout.shtml

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K. V. Koski and J.R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present and future. College of Forest Resources, University of Washington, Seattle, Washington.

Bjorkstedt, E.P., B. Spence, J.C. Garza, D.G. Hankin, D. Fuller, W. Jones, J. Smith and R. Macedo. 2005. An analysis of historical population structure of evolutionarily significant units of Chinook salmon, coho salmon, and steelhead in the north-central California coast recovery domain. Department of Commerce, NOAA National Marine Fisheries Service. Technical memorandum.

Booth, D.B., D. Hartley, and R. Jackson. 2002. Forest cover, impervious-surface area, and the mitigation of stormwater impacts. *Journal of the American Water Resources Association.* 38(3):835-845.

Brown, P., M. Brown, M. Kaye and D. Buckley. 1999. Fire history in Douglas-fir and coast redwood forests at Point Reyes National Seashore. *California Northwest Science* 73(3):205.

Bryant, M.D. and R. D. Woodsmith. 2009. The response of salmon populations to geomorphic measurements at three scales. *North American Journal of Fisheries Management* 29:549-559.

Burner, C. J. 1951. Characteristics of spawning nests of Columbia River salmon. *U. S. Fish and Wildlife Service Fishery Bulletin* 52:97-110.

Burns, J. H. 1971. The carrying capacity for juvenile salmonids in some northern California streams. *California Fish and Game* 57:44-57

Burns, R.M. and B.H. Honkala. 1990. Silvics of North America, Vol. 1, Conifers. Washington, DC: USDA Forest Service Agriculture Handbook 654.

California Department of Fish & Game. 2003

California Regional Water Quality Control Board San Francisco Bay Region. 2007. San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan). Accessed online at: http://www.swrcb.ca.gov/rwqcb2/basin_planning/shtml.

Center for Watershed Protection. 1998. Rapid watershed planning manual. Ellicott City, Maryland.

Crump, Kit. 2009. NOAA Fisheries. Personal communication.

Cushman, J.H., and R.K. Meentemeyer. 2008. Multi-scale patterns of human activity and the incidence of an exotic forest pathogen. *Journal of Ecology* 96: 776-776.

Ettlinger, E. 2008. Lagunitas Creek Habitat Typing Survey 2006 Analysis. Marin Municipal Water District. Corte Madera, CA.

Ettlinger, E., J. Riley, G. Vogeazopoulos, and G. Andrew. 2003. Juvenile salmoind population monitoring report, Lagunitas Creek, Marin County, California, fall 2003. Marin Municipal Water District (MMWD). Corte Madera, California.

Forest Ecosystem Management Assessment Team (FEMAT). 1993. Forest Ecosystem management: An Ecological, Economic, and Social Assessment. Washington, D.C.: US Department of Agriculture, Forest Service; US Department of Commerce, National Oceanic and Atmospheric Administration, US Department of Interior, Bureau of Land Management, US Fish and Wildlife Service, and National Park Service; and Environmental Protection Agency.

Ferguson, L. 2009. California Regional Water Quality Board, Region 2. Personal communication.

Francis, R. C. and N. J. Mantua. 2003. Climate and extinction risk for salmon populations of the Northeast Pacific, pp. 37-67. In A.D. MacCall and T.C. Wainwright (eds.). Assessing

Extinction Risk for West Coast Salmon. US Department of Commerce, NOAA Technical Memo, NMFS-NWFSC-56, 198 pp.

Ghodrati, F. and R. Tuden. 2005. Pathogens in Tomales Bay Watershed Total Maximum Daily Load (TMDL): Staff Report. Prepared for the California Regional Water Quality Control Board, San Francisco Bay Region. September 14, 2005; amended December 21, 2005. Accessed at http://mcstoppp.org/acrobat/tomalesbaypathogentmdl.pdf.

Gilman, E.F. and D.G. Watson. 1994. *Sequoia sempervirens*, Coast Redwood: Fact Sheet ST-589, A Series of the Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. October 1994.

Green, R.H. 1979. Sampling design and statistical methods for environmental biologists. Wiley and Sons, New York, NY.

Hecht, B., M. Strudley, S. Brown. 2008. Lagunitas Creek Sediment and Riparian Management Plan, Marin County, California: Streambed Monitoring Report, 1995-2007. Prepared by Balance Hydrologics, Inc. for Marin Municipal Water District. November 2008.

Hollings, C. S. 1978. Adaptive environmental assessment and management. John Wiley, New York, NY.

Holtby, L.B. 1988. Effects of logging on stream temperatures in Carnation Creek British Columbia, and associate impacts on the coho salmon (*Oncorhyncus kisutch). Canadian Jorunal of Fisheries and Aquatic Sciences.* 45(3):502-515.

Holtby, L.B., B.C. Andersen, and R.K. Kadowaki. 1990. Impaortance of smolt size and early ocean growth to interannula variability in marine survival of the coho salmon (*Oncorhyncus kisutch). Canadian Jorunal of Fisheries and Aquatic Sciences.* 47(11):2181-2194.

Karl, T.R., J.M. Mellilo, and T.C. Peterson (eds). 2009. Global Climate Change Impacts in the United States. A State of Knowledge Report from the U.S. Global Change Research Program. Cambridge University Press. Accessed at www.globalchange.gov/usimpacts.

Kershner, J.L. 1997. Monitoring and adaptive management, pp. 116-131. In J.E. Williams, C.A. Wood, and M.P. Dombeck (eds). Watershed restoration: principles and practices. American Fisheries Society, Bethesda, MD.

Knutson, K and V. Naef. 1997. Management Recommendations for Washington's Priority Habitats: Riparian. Washington Department of Fish and Wildlife. Olympia, WA.

Johnston, N.T. and P.A. Slaney. 1996. Fish habitat assessment procedures. Watershed Restoration Program, Ministry of Environment, Lands and Parks and Ministry of Forests, British Columbia. Watershed Restoration Technical Circular No. 8.

Laetz, C.A., D.H. Baldwin, T.K. Collier, V. Hebert, J.D. Stark, and N.L. Scholz. 2009. The synergistic toxicity of pesticide mixtures: implications for risk assessment and the conservation of endangered pacific salmon. *Environmental Health Perspectives* 117(3):348-353.

Lisle, T.E. and M. Church. 2002. Water Resources Research. 38(11):1219.

Luers, A.L., D.R. Cayan, G. Franco, M. Hanemann and B. Croes. 2006. Our Changing Climate: Assessing the Risks to California. Prepared by the California Climate Change Center with funding from the California Energy Commission and the California Environmental Protection Agency. CEC-500-2006-077.

MacDonald, L.H., A.W. Smart, and R. W. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. U.S. Environmental Protections Agency. EPA 910/9-91-001, Seattle, WA.

Marin County Code, Title 11 (Harbors and Waterways), Title 18 (Sewers), Title 22 (Development Code), Title 23 (Natural Resource Protection), Title 24 (Development Standards).

Marin County Community Development Agency. 2007. Marin Countywide Plan (CWP). Adopted by the Marin County Board of Supervisors, November 7, 2007.

Marin Municipal Water District (MMWD). 2007. Marin Municipal Water District website: water, current sources, reservoirs. Corte Madera, California.

Mathews, S.B. and Y. Ishida. 1989. Survival, ocean growth, and ocean distribution of differentially timed releases of hatchery coho salmon (*Oncorhyncus kisutch). Canadian Journal of Fisheries and Aquatic Sciences.* 46(7):1216-1226.

Montgomery, D.R. and J.M. Buffington. 1997. Channel reach morphology in mountain drainage basins. *GSA Bulletin* 109(5):596-611.

Mote, P.W., E.A. Parson, A.R. Hamlet, W.S. Keeton, D. Lettenmaier, N. Mantua, E.L. Miles, D.W. Peterson, D.L. Peterson, R. Slaughter and A.K. Snover. 2003. Preparing for climatic change: the water, salmon, and forests of the Pacific Northwest. *Climatic Change* 61:45–88.

Mulder, B.S., B.R. Noon, T.A. Spies, M.G. Raphael, C.J. Palmer, A.R. Olsen, G. H. Reeves, and H.H. Welsh. 1999. The strategy and design of the effectiveness monitoring program for the Northwest Forest Plan. : U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-437. 138 pp.

Murphy, M.L., J. Heifetz, S.W. Johnson, K.V. Koski, and J. F. Thedinga. Effects of clear-cut logging with and without buffer strips on juvenile salmonids in Alaskan streams. *). Canadian Jorunal of Fisheries and Aquatic Sciences.* 43(8):1521-1533.

Napolitano, M. and Ferguson, L. 2009. Personal communication.

National Academy of Sciences (NAS). 2008. Urban stormwater management in the United States. The National Academies Press, Washington, DC.

National Research Council. 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press: Washington, DC.

Newcombe, C.P. and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. *North American Journal of Fisheries Management.* 16:693-727.

NOAA's National Marine Fisheries Service (NOAA Fisheries). 2008. Biological Opinion, Environmental Protection Agency Registration of Pesticides Containing Chlorpyrifos, Diazinon, and Malathion.

NOAA's National Marine Fisheries Service (NOAA Fisheries). In Press. Central Coast California ESU Coho Salmon Recovery Plan. Southwest Regional Office.

O'Connor, M. and B. Rosser. 2006. Lagunitas Creek Fine Sediment Investigation. Prepared for Marin Municipal Water District, Corte Madera, CA. Prepared by O'Connor Environmental. Healdsburg, CA.

Opperman, J.J. 2005. Large woody debris and land management in California's hardwood-dominated watersheds. *Environmental Management* 35(3)266-277.

Opperman, J.J. and A.M. Merenlender. 2007. Living trees provide stable large wood in streams. *Earth Surface Processes and Landforms* 32(8)1229-1238.

Prunuske Chatham, Inc. (PCI). 2006. Salmon Creek Estuary: Study Results and Enhancement Recommendations. Prepared for Salmon Creek Watershed Council and Occidental Arts and Ecology Center.

Quinn, T.P., N.P. Peterson, and S. Spalding. 1996. Effects of instream brush on juvenile coho salmon: response to comment. *Transactions of the American Fisheries Society* 125:151-153.

Ralph, S. C. and G. C. Poole. 2003. Putting monitoring first: Designing accountable ecosystem restoration and management plans. In D.R. Montgomery, S. Bolton and D. B. Booth (eds). Restoration of Puget Sound Rivers. University of Washington Press, Seattle, WA.

Riparian Habitat Joint Venture (RHJV). 2009. Accessed at www.rhjv.org on 27 June 2009.

Ruiz-Jaen, M.C. and T.M. Aide. 2005. Restoration success: how is it being measured? *Restoration Ecology* 13(3):569-577.

Salmon Protection and Watershed Network (SPAWN). 2001. Relocation of stranded fishes from isolated pools in the San Geronimo Creek System 2001. Accessed at: www.spawnusa.org/.../1078182158_Fish_Rescue_Report_2001.pdf.

SPAWN. 2009. Personal communication.

Seavy, N., T. Gardali, G. Golet, F. Griggs, C. Howell, R. Kelsey, S. Small, J. Viers, and J. Weigand. 2009. Why climate change makes riparian restoration more important than ever: recommendations for practice and research. *Ecological Restoration* 27(3):330-338.

Spence, B.C., E.P. Bjorkstedt, J.C. Garza, J.J. Smith, D.G, Hankin, D. Fuller, W.E. Jones, R. Macedo, T. H. Williams, E. Mora. 2008. A framework for assessing the viability of threatened and endangered salmon and steelhead in the north-central California coast recovery domain. US Department of Commerce, NOAA Technical Memo, NOAA-TM-NMFS-SWFSC-423, 115 pp.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. Draft Report No. TR-4501-96-6057. ManTech Environmental Research Services Corporation, Corvallis, Oregon.

Society for Ecological Restoration International Science & Policy Working Group (SER). 2004. The SER International Primer on Ecological Restoration. www.ser.org and Tuscon: Society for Ecological Restoration International.

Stewart-Oaten, A. and J.R. Bence. 2001. Temporal and spatial variation in environmental impact assessment. *Ecological Monographs* 71(2):305–339.

Stillwater Sciences 2009a. San Geronimo Valley Existing Conditions Report. Prepared for Marin County Department of Public Works, San Rafael, CA.

Stillwater Sciences 2009b. Watershed Health Metrics for Evaluating Restoration Progress in the San Geronimo Creek Watershed. Technical memorandum to Marin County Department of Public Works, San Rafael, CA.

Stillwater Sciences. 2008. Lagunitas Limiting Factors Analysis: Limiting Factors for Coho Salmon and Steelhead. Final report. Prepared for Marin County Resource Conservation District, Point Reyes Station, CA.

Stillwater Sciences. 2008a. Lagunitas Creek sediment reduction: sediment budget, SWRCB Agreement No. 06-342-552-0, Final Work Plan.

Taylor and Associates. 2003. Inventory and assessment of Marin County stream crossings with culverts located on anadromous stream reaches.

Tolson. 2007. Personal communication with L. Prunuske.

Underwood, A.J. 1996. On beyond BACI. Sampling designs that might reliably detect environmental disturbances, pp. 151-175. In R.J. Schmitt and C. W. Osenberg (eds). Detecting Ecological Impacts. Concepts and Applications in Coastal Habitats. Academic Press, San Diego, CA.

Walsh, C.J. 2004. Protection of in-stream biota from urban impacts: minimize catchment imperviousness or improve drainage design? *Marine and Freshwater Research* 55:317-326.