Appendix B

Staff Report
(February 8, 2008)

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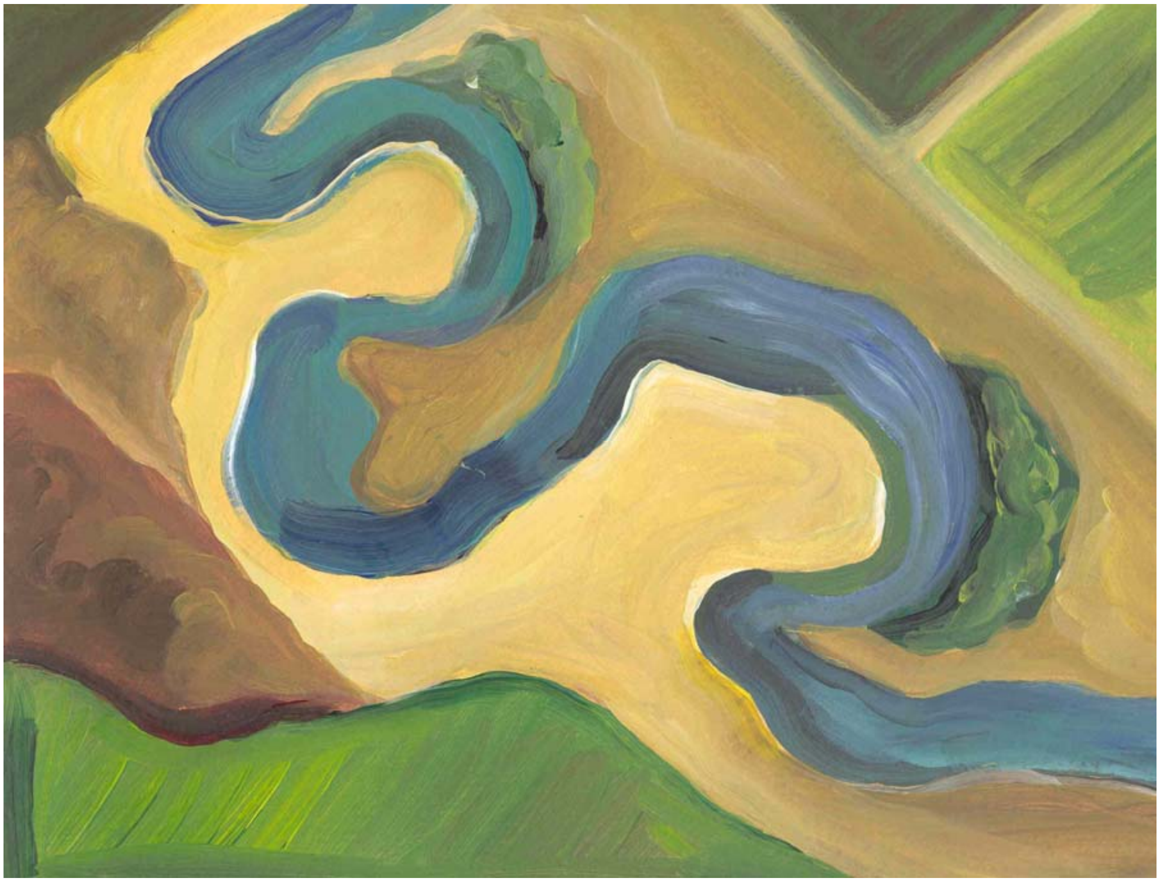
Sonoma Creek Watershed Sediment TMDL and Habitat Enhancement Plan



Draft Staff Report

Public Comment Draft

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California Regional Water Quality Control Board
San Francisco Bay Region

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Chapter 1: Introduction

1.1 Overview

Due to declining native fish populations and evidence of excessive erosion, Sonoma Creek has been officially designated as impaired by sediment since 1996. Staff of the San Francisco Bay Regional Water Quality Control Board (Water Board) propose to address this impairment by amending the Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) to incorporate a Total Maximum Daily Load (TMDL) for sediment and a Habitat Enhancement Plan designed to protect beneficial uses of Sonoma Creek and restore and protect the fishery.

This Staff Report provides the scientific and technical bases for the project. As we explain below, our approach to developing a Basin Plan amendment will entail: 1) confirming the nature of impairment by identifying significant limiting factors for fish using a limiting factors analysis of the Sonoma Creek watershed; 2) evaluating sediment loads and sources; 3) establishing narrative and numeric targets needed to support fish in good condition; and 4) developing an implementation plan to reduce sediment discharges and enhance native fish habitat.

1.2 California Environmental Quality Act

This Staff Report provides the rationale and the technical basis for the required TMDL elements and associated implementation plan. This report meets the requirements of the California Environmental Quality Act (CEQA), including the preparation of a checklist for adopting Basin Plan amendments and serves in its entirety as a substitute CEQA environmental document. It was developed with consideration of stakeholder input including incorporation of the comments received on a Preliminary Project Report dated July 19, 2007 (SFBRWQCB, 2007) and has been updated with this information.

1.3 Project Definition and Objectives

Sonoma Creek is currently listed (in the 2006 version of the Clean Water Act Section 303(d) impaired waterbodies list) as impaired by sediment (as well as pathogens and nutrients). While the TMDL (allowable sediment load per unit time) applies to mainstem Sonoma Creek, the water quality targets, allocations, and implementation plan apply throughout the watershed in order to assure attainment of the TMDL.

The proposed project is a proposed Basin Plan amendment that would establish a sediment TMDL for Sonoma Creek and an implementation plan to achieve the TMDL and related habitat enhancement goals. The bases of the TMDL are numeric targets for streambed permeability, pool filling and substrate composition, selected to be protective of fishery beneficial uses. The TMDL assigns wasteload and load allocations to dischargers that, over time, will ensure the target is reached.

The Project Objectives are to:

- Protect Beneficial Uses of cold water fish spawning and migration, and habitat for rate and endangered species, specifically steelhead trout
- Attain numeric targets to meet water quality standards
- Comply with CWQ requirements to adopt TMDLs for 303(d) listed water bodies
- Avoid imposing regulatory requirements that are more stringent than necessary to meet numeric targets and attain water quality standards
- Complete implementation of the TMDL in as short a time as is feasible

To achieve these project objectives, we have developed the Sonoma Creek Watershed Sediment TMDL and Habitat Enhancement Plan . The following paragraphs describe the rationale and objectives of the Sonoma Creek Watershed TMDL and Habitat Enhancement Plan.

Although reducing fine sediment supply and reversing impacts of channel incision on habitat complexity are necessary, actions in these two areas alone will not be sufficient to recover populations of native fish and aquatic wildlife species in the Sonoma Creek watershed. Therefore in addition to the sediment TMDL, we also have prepared a complimentary habitat enhancement plan. The Habitat Enhancement Plan provides an outline of the actions that may be needed to address other stressors to fish and aquatic wildlife populations[1], including: a) migration barriers; b) lack of woody debris; c) stressful water temperatures; and d) low summer baseflows. The *Napa River Watershed Sediment TMDL and Habitat Enhancement Plan* (SFBRWQCB, 2007) is a detailed example of this two-pronged approach.

The goals of the Sonoma Creek Sediment TMDL and Habitat Enhancement Plan are to:

- Conserve the steelhead trout population
- Restore water quality to meet water quality standards, including attaining beneficial uses
- Enhance the overall health of the native fish community
- Protect and enhance habitat for native aquatic species
- Enhance the aesthetic and recreational values of the river and its tributaries

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[1] In general, the habitat enhancement plan provides an outline of actions identified in the Limiting Factors Analysis as priority restoration measures (in addition to sediment-related measures addressed through regulatory actions identified in the implementation plan for the TMDL). The Limiting Factors Analysis (SEC et al, 2006) and other information relevant to conservation and recovery of native fish and aquatic wildlife species within the watershed (USFWS, 1998) should be reviewed to gain a detailed and specific understanding of restoration priorities. Our intent by including the habitat enhancement plan is to provide a formal recognition by Water Board staff of our intent to support watershed stakeholders and agency partners in their efforts to achieve these restoration priorities.

To achieve these goals, stakeholders in the watershed must work to:

- Reduce sediment loads, and fine sediment[2] in particular, to Sonoma Creek and its tributaries
- Attain and maintain suitable gravel quality in freshwater reaches of Sonoma Creek and its tributaries
- Reduce and prevent channel incision
- Reduce erosion and sedimentation
- Repair large sources of sediment supply (e.g., landslides)
- Enhance channel complexity (e.g., by adding and encouraging retention of large woody debris)

1.4 TMDL Process

A total maximum daily load (TMDL) is a water body-specific cleanup or restoration plan that targets the pollutant causing impairment (in this case sediment). The Sonoma Creek Sediment TMDL defines the allowable amount of sediment that can be discharged into Sonoma Creek, expressed as a mass, and as a percentage of the natural background sediment delivery rate to channels.

The Clean Water Act requires California to adopt and enforce water quality standards to protect San Francisco Bay. The Water Quality Control Plan for the San Francisco Bay Region (Basin Plan) delineates those standards, which include beneficial uses of waters in the Region, numeric and narrative water quality objectives to protect those uses, and provisions to enhance and protect existing water quality (antidegradation). Section 303(d) of the Clean Water Act requires states to compile a list of "impaired" water bodies that do not meet water quality standards and to establish a TMDL for the pollutant that causes impairment. Sonoma Creek has been officially designated as impaired by sediment since 1996. The proposed TMDL and implementation plan are designed to resolve sediment impairment in Sonoma Creek and its tributaries.

The TMDL process includes compiling and considering available data and information, conducting appropriate analyses relevant to defining the impairment problem, identifying sources, and allocating responsibility for actions to resolve the impairment.

[2] In this report, unless otherwise noted, we use the term fine sediment to refer primarily to sand and fine gravel (e.g., ≤ 10 mm in diameter) deposited in or on the streambed in fish bearing reaches of gravel- or cobble-bedded channels. High concentrations of fine sediment in the streambed are associated with: a) poor rates of survival of salmonid eggs from spawning-to-emergence; b) diminished growth and survival of juvenile salmonids during the dry season; and/or c) low rates of survival of juvenile steelhead during the wet season.

In addition, the scientific basis of the Basin Plan amendment is subjected to external scientific peer review. This step is required under §57004 of the Health and Safety Code, which specifies that an external review is required for work products that serve as the basis for a rule, "…establishing a regulatory level, standard, or other requirements for the protection of public health or the environment." The scientific basis of the Sonoma Creek Sediment TMDL, as presented in the Staff Report, was evaluated by two peer reviewers, Dr. Peter Goodwin, and Dr. Susan M. Bolton, who concluded that the scientific basis of the proposed Basin Plan amendment is based on sound scientific knowledge, methods, and practices.

1.5 Report Organization

This Staff Report presents the supporting documentation for a proposed Basin Plan amendment that establishes a Total Maximum Daily Load (TMDL) and Implementation Plan for sediment, and Habitat Enhancement Plan designed to protect beneficial uses of Sonoma Creek. It is organized into chapters that reflect background information, the key elements of the TMDL process, and regulatory analyses required to adopt the amendment.

Chapter 1 introduces the project and discusses CEQA, the TMDL process, organizational layout of the Staff Report, and provides an overview of key elements and goals of the Sonoma Creek Sediment TMDL and Habitat Enhancement Plan.

Chapter 2 presents the physical setting, climate, hydrology, and geology of the Sonoma Creek watershed, and Beneficial Uses, as defined in the Basin Plan, supported by the watershed.

Chapter 3 presents the problem statement that the project is based on and defines the project, habitat conditions, and why it is necessary, its objectives, and describes current fish habitat conditions that may be adversely affecting fish populations.

Chapter 4 provides a discussion of the water quality standards that are applicable to Sonoma Creek and its tributaries.

Chapter 5 presents the derivation of the numeric targets and desired conditions for the watershed.

Chapter 6 presents our understanding of the sources of loading of sediment to Sonoma Creek and its tributaries. Sources and loading are identified as those attributable to natural background and those caused by human activities in the watershed.

Chapter 7 presents the linkage analysis which describes the relationship between sediment sources and the proposed targets, establishes the TMDL, sets allocations, including estimates of the percent reduction from each source's current contribution to the total sediment load. Chapter 7 additionally presents a margin of safety that accounts for any lack of knowledge about the relationship between the pollutant loads and desired receiving water quality.

Chapter 8 presents the Implementation Plan which includes actions and requirements deemed necessary to resolve the sediment impairment, support beneficial uses, and restore a sustainable fishery. It specifies monitoring activities to demonstrate attainment of numeric targets. It also presents an adaptive implementation strategy to review implementation progress and to evaluate any new information generated, which may lead to improved implementation actions, and refinement of the TMDL, the numeric targets or the allocations in the future.

Chapter 9 presents a brief summary of the external scientific peer review, the results of CEQA analyses including an environmental impact assessment, an evaluation of alternatives to the proposed Basin Plan amendment, economic considerations, cost estimates, and discussion on potential source of funding. References, lists all the information sources cited and relied upon in preparation of this report.

Chapter 2: Watershed Description

The Sonoma Creek watershed, in California's Coast Range north of San Pablo Bay (Figure 1), covers an area of approximately 166 square miles (430 km^2). The watershed ranges in elevation from sea level to the peak of Bald Mountain (2,739 ft.). It lies in a valley bounded by Sonoma Mountain to the west and the Mayacamas Mountains to the east. The mainstem of Sonoma Creek flows in a southeasterly direction from headwaters on Sugarloaf Ridge through Sonoma Valley before discharging to San Pablo Bay. Numerous tributaries enter the main stem from the mountains that rise on both sides of the valley (SEC et al., 2004). Figure 1a shows the tributaries and their respective drainage areas. The Sonoma Creek watershed includes about 465 miles of streams mapped by the USGS (SEC et al., 2004).

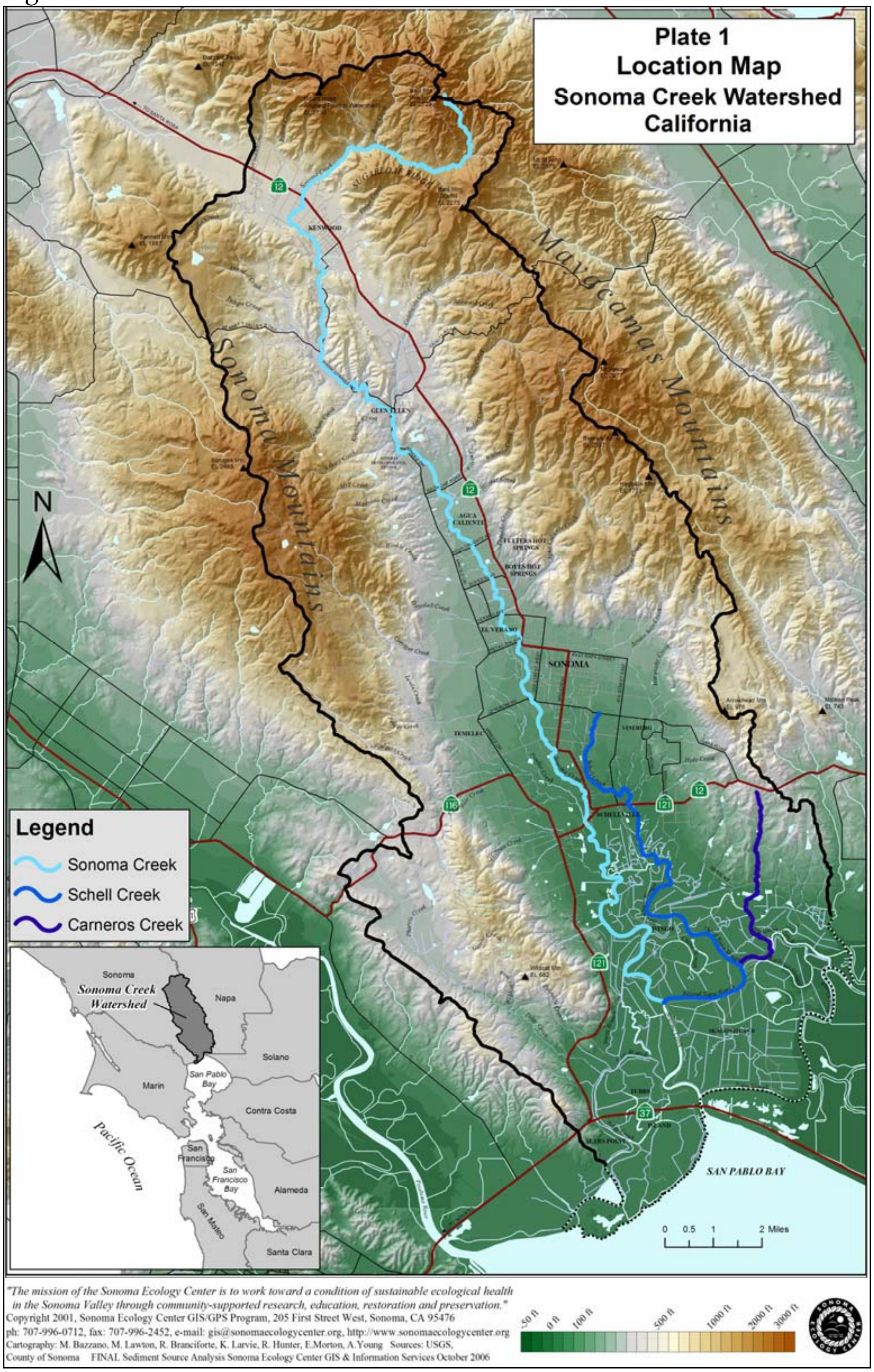
Average rainfall ranges from approximately 23 inches in the lower portions of Sonoma Valley to more than 50 inches on the highest slopes of Sonoma Mountain and the Mayacamas. Most of the rain falls from November through April, with heaviest rainfall occurring from December through February. This rainfall regime results in two distinct seasons in the watershed. During the winter wet season, streamflow and pollutant loading are dominated by precipitation –driven surface runoff. In contrast, groundwater inflow or runoff from human activities dominates streamflow during the dry summer months.

The watershed supports the following Beneficial Uses, as defined in the Basin Plan: cold freshwater habitat (COLD), warm freshwater habitat (WARM), water contact recreation (REC-1), noncontact water recreation (REC-2), fish migration(MIGR), preservation of rare and endangered species (RARE), fish spawning (SPWN), and wildlife habitat (WILD). It provides habitat for several native species of concern, including steelhead trout (*Oncorhynchus mykiss*), Chinook salmon (*Oncorhynchus tshawytscha*), and California freshwater shrimp (*Syncaris pacifica*).

Major land cover types in the watershed are forest (approximately 30 percent), grassland/rangeland (20 percent), agriculture (30 percent—a large portion of this in vineyards), and wetlands and sparsely vegetated land (5 percent). Developed land (residential, industrial, or commercial) accounts for approximately 15 percent of the watershed (ABAG, 2000). Compared to other San Francisco Bay Area streams, the watershed is relatively free of concrete channelization, major flood control projects, and water supply structures (dams). However, historical ditching and draining of the valley floor (see discussion in source analysis that follows) has fundamentally altered the routing of peak flows and sediment in lower Sonoma Creek, with consequent and significant increases in sediment delivery and degradation of aquatic habitat quality.

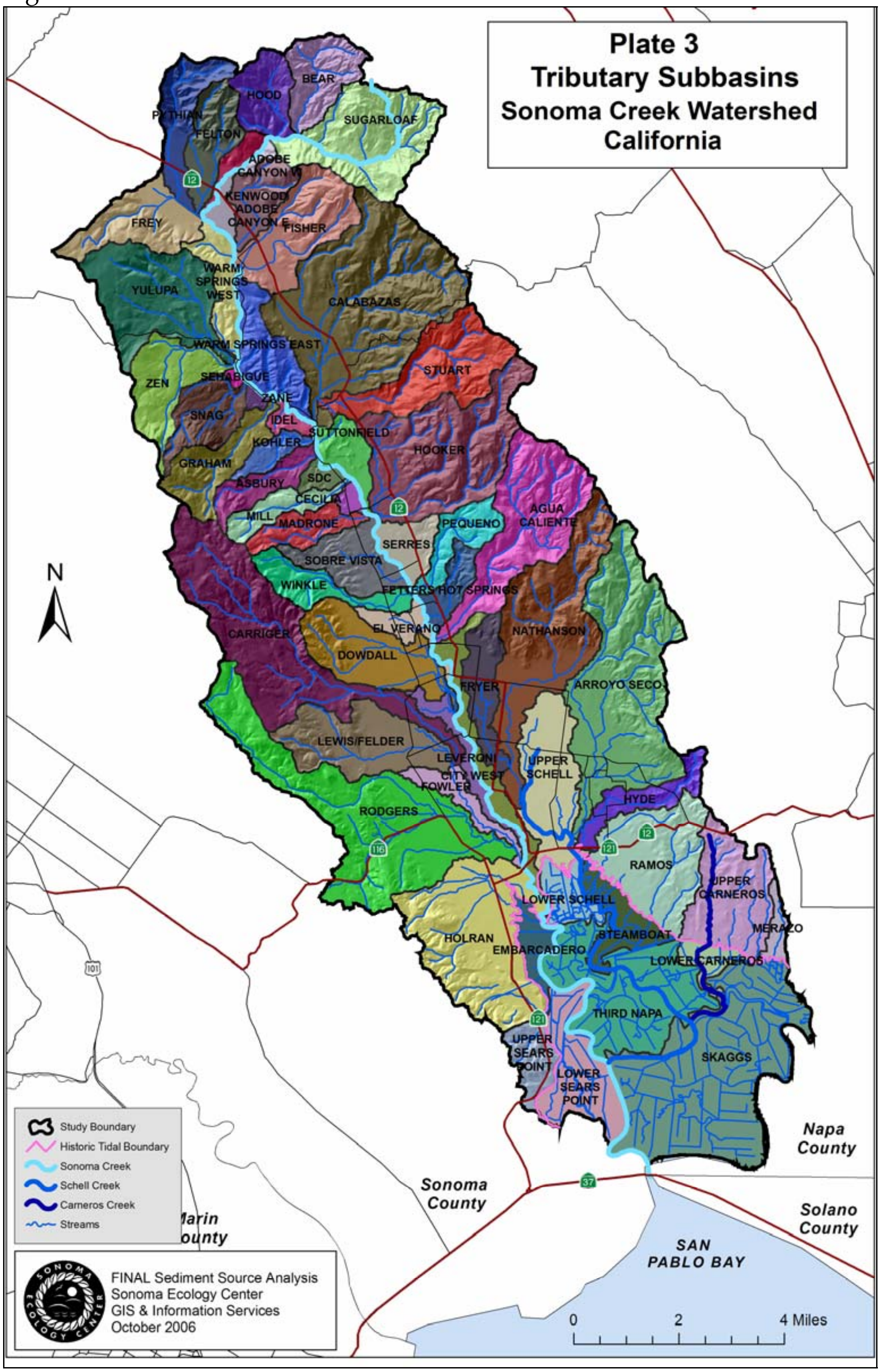
Sonoma Creek is also listed as impaired by nutrients and pathogens. It is likely that actions implemented to reduce sediment loading and enhance habitat will also reduce nutrients and pathogens, and help Sonoma Creek in supporting many of its designated Beneficial Uses.

Figure 1.Location of the Sonoma Creek Watershed



Source: Sonoma Ecology Center el al, 2006

Figure 1a. Tributaries and Subwatersheds in the Sonoma Creek Watershed



Source: Sonoma Ecology Center et al, 2006

Chapter 3: Problem Statement

3.1 Summary

A TMDL problem statement describes the relationships between the identified pollutant, applicable water quality standards, and current water quality conditions in the impaired water body. With regard to the problem of sediment in Sonoma Creek, we find that:

- Populations of steelhead in Sonoma Creek and its tributaries have declined substantially since the 1940's (SEC, 2002).
- Incision and widening of Sonoma Creek and its tributaries are causing significant adverse changes to the complexity, function, and connectivity of its stream, riparian, and flood plan habitats (SEC et al., 2004).
- Excessive amounts of fine sediment have been deposited in the streambed at potential steelhead spawning and rearing sites. Excess fine sediment in the streambed can cause poor incubation conditions for fish eggs, resulting in high mortality prior to emergence. Fine sediment also compromises the quality of pools as rearing habitat, and reduces winter rearing habitat by filling the space between cobbles and boulders.
- Sediment discharge and habitat simplification are occurring, in part due to controllable water quality factors.[3]

A detailed discussion of sediment impairment and habitat conditions in Sonoma Creek follows.

3.2 Habitat Conditions

Sonoma Creek supports a diverse assemblage of native fish species including steelhead/rainbow trout, Pacific lamprey, California roach, sculpin, Sacramento sucker, white sturgeon, Sacramento pikeminnow, Chinook salmon, threespine stickleback, prickly sculpin, riffle sculpin, and staghorn sculpin (Leidy, 2007). Chinook salmon are occasionally found in the lower reaches of Sonoma Creek, but their history and the extent of their habitat in Sonoma Creek are not well understood. Coho salmon have been reported in Sonoma Creek but their origin, abundance, and persistence is not known.

Sonoma Creek supported large numbers of steelhead trout until approximately the late 1940s (SEC, 2002). California Department of Fish and Game surveys indicate an overall decline in fish populations over the last century and a half, a period of increasing land use pressures. Historical land uses and practices introduced by early settlers included heavy grazing, timber harvesting, draining wetlands, diverting tributaries, in-stream

[3] As defined in the Basin Plan, controllable water quality factors are those actions, conditions, or circumstances resulting from human activities that may influence the quality of waters of the state and that may be reasonably controlled.

sand and gravel mining, construction of small dams, and dredging the mainstem of Sonoma Creek (SEC et al., 2004).

In addition to native fish populations, Sonoma Creek and its tributary Yulupa Creek support the California freshwater shrimp (*Syncaris pacifica* Holmes 1895). California freshwater shrimp are found in low elevation (less than 380 ft.) and low gradient (generally less than 1 percent) streams where banks are structurally diverse with undercut banks, exposed roots, overhanging woody debris, or overhanging vegetation Many of the land use activities that affected steelhead populations also threaten the California freshwater shrimp (U.S. Fish and Wildlife Service, 1998).

In the late 1800's, many tributaries became directly connected to the mainstem, likely due to more concentrated surface flows, through the creation of ditches (direct alteration), or a combination of these factors. Formerly, in years of normal rainfall, water in the tributaries would sheet-flow onto alluvial fans, and would only flow into the mainstem channel in wetter years.

These and other human practices have increased sediment loads to the creek, reduced vegetation and wood available to stabilize hillslopes and channels, and accelerated flood flows through the stream system.

The decline in the populations of native fishes in Sonoma Creek and its tributaries is summarized in Table 1. This history of the local fish population is based primarily on the Oral History Project prepared by the Sonoma Ecology Center (SEC, 2002) with funding from CALFED.

Table 1: Summary of fishery conditions and land use changes in the Sonoma Creek Watershed

Time Period	Event	Native Fish Populations	Fishing Limit	Land Use changes
1823	Founding of Sonoma Mission	Abundant*	N/A	Beginning of livestock grazing
1856	Old growth redwood logging completed	Abundant	N/A	Extensive cattle grazing
1860 to 1880	Completion of a dam on Graham Creek	Strong evidence of declining fish population 1860 – 1876	N/A	Large scale reclamation of sloughs and saltwater marshes
1880s	Introduction of German carp	Plentiful	N/A	

Time Period	Event	Native Fish Populations	Fishing Limit	Land Use changes
1890s	Sonoma Creek stocked with trout	Unknown	N/A	Widespread timber harvest by hand equipment
1900s to 1910		Abundant	N/A	Logging Sonoma Mt. by mechanical equipment
1903 to 1920	New regulations and stocking	Possible decline	25 fish	Gravel mining became well established
1920s to 1930s		Abundant	25 fish	10,000 acre fire from Mayacamas to El Verano (1923)
Post-1945	End of World War II	Decline	25 fish	
1950s	Reduced allowable fish catch	Decline	10 fish	Last reported logging of redwoods on Sonoma Mt.
1960s	Dam at Larson Park	Decline	10 fish	Increased urbanization – Major fire (1964)
1970s	Major Drought	Serious decline	Closed	Continued intensification of urban and agricultural uses. Construction of Eldridge Dam
1980s	Major decline in steelhead populations	Serious decline	Open	Expansion of hillside agriculture. Removal of Elridge Dam in 1983
1990s	Effort to restore Sonoma Creek	Slight rebound	Closed	Expansion of hillside agriculture

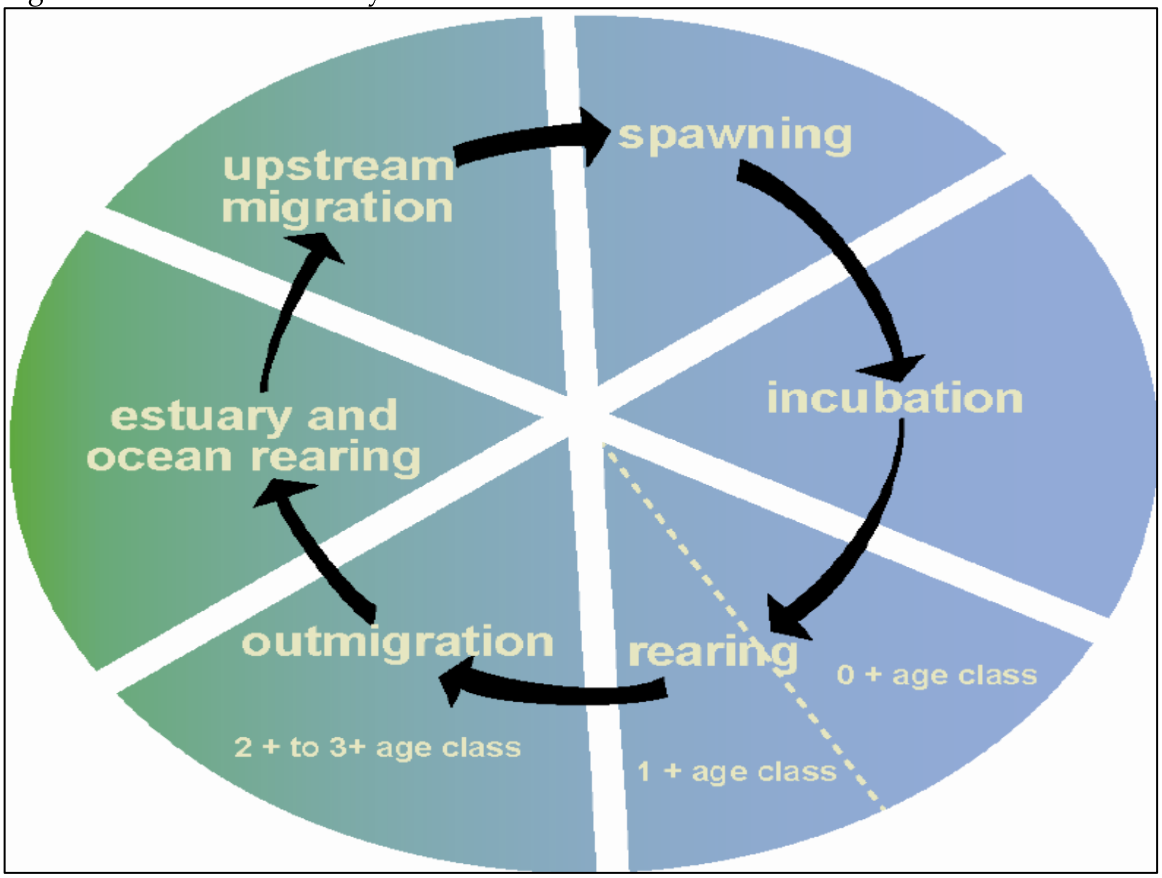
3.3 Salmonid Life Cycle and Water Quality Requirements

Protecting the beneficial uses of Sonoma Creek and its tributaries requires us to understand the salmonid life cycle as well as the habitat and water quality requirements of the watershed's aquatic species. The sediment TMDL and Habitat Enhancement Plan focus on the recovery of salmonid species (particularly steelhead trout) with the intention that efforts to restore and protect this species will benefit all native aquatic species in the watershed, including the California freshwater shrimp[4] (see also Section

[4] According to the California Freshwater Shrimp Recovery Plan (U.S. Fish and Wildlife Service), threats to shrimp population include increased soil erosion, loss of riparian vegetation, adverse bank and channel changes, and modification of the stream bottom due to sedimentation. These

5.4 Potential Responses of Other Aquatic Species). As shown in Figure 2, the salmonid life cycle can be described in six phases: 1) adult upstream migration; 2) spawning; 3) incubation and fry emergence; 4) juvenile rearing; 5) outmigration; and 6) estuary and ocean rearing. The following sections describe each life cycle phase and associated habitat and water quality requirements.

Figure 2. Steelhead Life Cycle



Source: Sonoma Ecology Center, Limiting Factors Analysis (SEC et al., 2004)

Adult Migration

Steelhead return from the ocean to spawn in their freshwater natal stream, usually in their fourth or fifth year (SEC et al., 2004, Appendix A). Steelhead populations are

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are many of the factors that affect steelhead trout. The recommended recovery actions for freshwater shrimp include reducing unnatural rates of deposition in streams. Therefore, the actions set forth and recommended in this sediment TMDL and Habitat Enhancement plan will likely benefit the endangered freshwater shrimp, as well as salmonids.

broadly categorized into two reproductive groups, and are commonly considered to be either winter-run or summer run. Steelhead in the Sonoma Creek watershed are winter-run, meaning they enter freshwater spawning streams from fall through spring and spawn a few months later in late winter or spring (SEC et al., 2004, Appendix A).

Ideal habitat conditions for adult migration include deep pools and backwater channels that provide resting opportunities during the arduous upstream migration (SEC et al., 2004). At this stage, the adult fish need enough flow in the stream channel to create adequate depths for passage, generally on the order or one foot or deeper. Adequate water depth is often lacking in Sonoma Creek watershed because long reaches of spawning streams dry out during the summer and stay dry until the first fall rains.

Spawning

Once adults have reached their natal streams, they search for suitable spawning gravels where they can build a nest (redd), lay their eggs, fertilize them, and then leave them to incubate and hatch. The availability of suitable spawning gravels is critical to spawning success. Spawning gravels should ideally be relatively free of fine sediment, and contain coarse material (gravel) ranging from the size of a pea to an apple. Spawning gravels should also be of sufficient size and depth (at least one foot square and six inches deep) (SEC et al., 2004). If there are not enough patches of spawning gravel, multiple fish may construct redds on top of each other, destroying the previous redd (SEC et al., 2004; McNeil, 1964).

Egg Incubation and Fry Emergence

Steelhead eggs incubate in the redd for 20 to 100 days; Chinook incubate for 40 to 90 days. The fish hatch from the eggs as alevins still attached to their yolk sacks, and remain in the gravels for another two to five weeks before they emerge as fry. During egg incubation, hatching, and emergence, the fish need an adequate supply of oxygen. The stream flow must have adequate dissolved oxygen, and the redds must be low in fine sediment so that dissolved oxygen can reach the developing fish. Too much fine sediment can clog the redd and smother the developing fish, by preventing the water flow from supplying oxygen and carrying away waste.

Juvenile Rearing

Once the fry have emerged from the stream gravels, they are considered age 0+ fingerlings or juveniles. During this stage, they rear (feed and grow) in freshwater streams and in the estuary before out-migrating to ocean waters. For steelhead, this juvenile rearing stage lasts at least a summer and a winter. Chinook salmon rear for only four to seven months before migrating to the sea. Juveniles that are aged 0-12 months are considered 0+ and those that are aged 12-24 months are considered age 1+. Both Chinook and steelhead require summer rearing habitat, while steelhead also requires winter rearing habitat (SEC et al., 2004).

A complex stream structure is critical for successful juvenile rearing. Juveniles must feed, grow, rest, and evade predators. These activities require diverse habitat conditions, from pools to rest and feed, to in-stream shelter to evade predators. Off-channel pools or sheltering backwater habitats, parts of the stream or floodplain that receive flow from the main channel but are protected from high velocities, provide good rearing opportunities.

Pool habitat is important for both summer and winter rearing. Pools provide resting and feeding opportunities, and are essential in summer as water levels drop. Water temperature is also important, as anadromous fish prefer rearing temperatures in the range of 50 to 55 degrees F. Temperatures exceeding 64-68 degrees F are stressful, and temperatures above 75 degrees F may be lethal. (SEC et al., 2004; Sullivan et al., 2000). Whether temperatures above 75 degrees F are lethal depends on the pre-existing health of the fish, how fast the temperature rises, baseline temperatures before the onset of high temperatures, and how long the high temperatures last. An intact riparian corridor with trees providing shade, as well as cold groundwater inflow, is important for maintaining desired temperatures. With all the challenges facing the juveniles, a large percentage do not survive beyond the first year to reach age 1+.

Outmigration

At the end of the freshwater rearing period, steelhead migrate to the ocean as smolts. Smolting involves a physical transformation that prepares the fish for survival in salt water. Some Sonoma Creek steelhead migrate directly to the sea, while others migrate downstream in the spring and rear in the estuary for an additional year before smolting. Steelhead may migrate at ages 2+, 3+, or less frequently at age 1+. It is more common for age 1+ steelhead to rear an additional year in the estuary than for fish age 2+ or 3+.

During migration, steelhead require sufficient flows and a lack of migration barriers or hazards such was culverts and water diversion structures in their path to the estuary and ocean.

Estuary and Ocean Rearing

Steelhead migrating downstream as juveniles may rear in estuaries for six months to a year before entering the ocean (SEC et al., 2004, Appendix A). Even in cases where juvenile steelhead spend much shorter periods there estuaries provide valuable rearing habitat serving to prepare fish for the ocean phase. The majority of steelhead spend one to three years in the ocean, before returning to their natal streams to spawn.

3.4 Limiting Factors Analysis

To improve our understanding of current fish habitat conditions and the significance of sediment pollution relative to other factors (such as temperature, migration barriers, and low summer base-flows) that may be limiting populations of steelhead and salmon, the Water Board provided funding to the Sonoma Ecology Center, in conjunction with

Stillwater Sciences and UC Berkeley, to support development of the Sonoma Creek Limiting Factors Analysis. The goal of the limiting factors analysis was to determine the physical, chemical and biological factors adversely affecting fish and aquatic wildlife populations at all freshwater life stages. Due to limited resources, the limiting factors analysis excluded from consideration limiting factors that affect estuarine and ocean life phases, as well as predation and food-web interactions.

At the onset of the study, three aquatic species of concern were identified: steelhead trout, Chinook salmon, and California freshwater shrimp. Ultimately, the study focused on the physical factors influencing population dynamics of steelhead trout, the most common of the three species in the Sonoma Creek watershed and an excellent indicator of overall aquatic ecological health[5]. The focused studies surveyed Sonoma Creek and its tributaries above the tidally influenced reach (north of Schellville).

The limiting factors analysis included several focused studies, including a steelhead census performed in late summer/fall of 2002 (SEC et al., 2004, Appendix B). The steelhead census estimated a total population of 17,000 steelhead trout within the watershed, using snorkel, electrofishing, and extrapolation methods. The size of the measured fish indicate that approximately 90 percent of the population are age 0+ (0-12 months), while only 10 percent are aged 1+ or older. This indicates a "bottleneck" in the local steelhead population during the juvenile rearing stage. The surveys revealed large numbers of age 0+ fish in most pools selected for sampling, but only a few pools held larger (greater than 4.3-inch) age 1+ fish (classified as between 12 and 24 months of age).

The limiting factors analysis estimates that only 10 percent of the age 0+ fish are surviving to the 1+ life stage. It is possible that the low percentage of age 1+ fish found during the steelhead census may be due to difficulties in finding and counting the fish in complex habitat structures, or due to natural predation. However, both summer- and winter-rearing habitat for age 1+ fish is very limited in Sonoma Creek due to well-documented changes in creek hydrology and geomorphology. Therefore, increasing the survival of fish ages 12-24 months (age 1+) has the potential to increase the total steelhead population by enhancing the number and fitness of smolts that migrate to the ocean and ensuring that enough adult fish spawn, as needed to maintain a sustainable fishery. Taking a precautionary approach, this TMDL will address water quality and

[5] The limiting factor approach is intended to identify the most important constraint (e.g., the bottleneck life stage and key stressor(s)) that controls carrying capacity under current conditions. However, considering the diversity of life history strategies employed by steelhead, climatic variability, and that many stressors interact in a synergistic fashion, such an approach simplifies actual interactions and outcomes. From a conservation standpoint, for a small population like steelhead in Sonoma Creek, it seems essential to address all stressors that contribute to elevated levels of mortality in any life stage in order for the population to persist over the long-term. Harvey et al (2007) and Mobrand et al. (1997) provide additional insights regarding the challenges associated with modeling salmonid population dynamics.

habitat pressures on all steelhead life stages, while focusing on improving habitat and survival for age 1+ juveniles.

Potential limiting factors adversely affecting fish populations are presented in Table 2. Factors found to be adversely affecting steelhead populations in the Sonoma Creek watershed are discussed below:

- Sediment-related impairment, which includes impacts resulting from deposition of excess sediment in the stream bed as well as changes in physical habitat structure as a result of bed and bank erosion
- Stressful water temperatures in the lower reaches of mainstem Sonoma Creek and of Nathanson Creek, likely due to lack of shade, loss of deep pools, and low base flow
- Migration barriers and low summer flows

Table 2: Potential Limiting Factors by Salmonid Life Stage

Life Stage	Limiting Factor
Upstream migration	Physical barriers to passage Insufficient flows Migration corridor hazards
Spawning and egg incubation	Spawning gravel mobility Low spawning gravel permeability Redd de-watering High water temperatures Poor water chemistry
Juvenile rearing	Insufficient summer rearing habitat Insufficient winter rearing habitat Poor pool habitat availability Poor pool habitat quality Insufficient in-stream shelter Stranding by low flows Inadequate riparian cover High water temperatures Suspended sediment concentrations Poor water chemistry Low food availability Predation Competition from native species Competition from introduced species
Out-migration	Corridor hazards Inadequate flows High water temperatures Poor water chemistry Predation

Sediment-Related Impairment

Sediment-related impairment includes impacts resulting from excessive amounts of fine sediment deposited in the streambed at potential steelhead spawning and rearing sites. These conditions result in low gravel permeability, which can cause poor incubation for fish eggs and high mortality prior to emergence.

In addition to reducing spawning habitat, excess sediment can impact in-stream shelter by filling pools, eliminating deep pool habitat where fish rest and feed. Fine sediment fills the spaces between cobbles and boulders needed for winter rearing habitat. Low-quality shelter for juvenile fish may have resulted in increased predation rates and population reductions among of 1+ fish[6], a critical bottleneck in the steelhead population in Sonoma Creek. Numeric targets will be proposed to reduce impacts of fine sediment.

Some of the most important sediment-related impacts result from changes in sediment transport processes that determine the shape, complexity, and hydrology of stream habitats. Both the direct and indirect effects of human activities adversely affect pool/riffle morphology, channel width, channel bank slopes , and in-stream and riparian vegetation.

Low Gravel Permeability and Pool Filling

Low gravel permeability is a significant adverse effect of excess sediment. Using a simple linear regression relationship, gravel permeability can be used to predict survival-to-emergence. With an average gravel permeability of approximately 2000 cm/hr, fine sediment in Sonoma Creek's spawning gravels causes, on average, 70 percent mortality (30 percent survival) of incubating eggs. (SEC et al., 2004; McCuddin 1977; Taggart 1976; Stillwater Sciences and Dietrich, 2002). This mortality rate is higher than in the neighboring Napa River watershed, where egg mortality is estimated to be 60 percent.

The limiting factors analysis also documented pool-filling by fine sediment, with a watershed average of 8.5 percent (meaning that 8.5 percent of pool volume has been lost due to in-filling by sediment). At the documented levels of pool filling, fine sediment blankets much of the pool bottoms, compromising the quality of pools as rearing habitat for juvenile salmonids (SEC et al., 2004). Sediment deposition is also reducing winter rearing habitat by filling cobble-boulder bed interstices.

Physical Habitat Structure

*S*tream channel incision has resulted in sediment/flow relationships that promote the creation of deeper and narrower channels. Many stream channels have scoured down to local bedrock, which in some locations consists of weak sedimentary rocks that are easily eroded and yield large amounts of fine sediment. The result is shallower pools,

[6] Although predation and food-web studies were not conducted due to limited resources, we infer that the lack of good quality rearing habitat (indicated by the low in-stream shelter scores) has contributed to increased predation and lower success for juvenile steelhead.

fine sediment deposition from eroding streambeds and destabilized banks, less access to water and soil support for riparian trees, and less in-stream retention of large woody debris and coarse sediments (gravels, cobbles, and boulder for spawning and rearing habitat). Analysis of in-stream shelter in Sonoma Creek yielded ratings ranging from 8 to 86 out of a maximum of 300, using a standard in-shelter index developed by the California Department of Fish and Game. The average watershed-wide score was 38, which is 13 percent of the maximum score. This indicates low quality of shelter for juvenile steelhead (SEC, et al., 2004), as a minimum in-stream shelter score of 80 is recommended for salmonds (CDFG, 1998). Changes in physical habitat structure in Sonoma Creek have caused a decrease in available habitat for fish to hide and rest, particularly during high flows. This can significantly reduce survival of age 1+ fish, as well as total steelhead population numbers.

Suspended Sediment

Within a certain range, high suspended sediment concentrations during storm peaks is a natural phenomena that fish are adapted to handle. In unimpaired streams within the California Coast Range, even in cases where natural rate of sediment delivery to channels is very high, we would expect streams to clear up within a few days after a storm event. During high flows, native fishes seek shelter to reduce energy expenditure, and to avoid entrainment and exposure to high suspended sediment concentrations, which may cause short- to long-term physiological damage (e.g., gill abrasion) and/or mortality. Once the peak has passed, fish may leave shelter habitats and begin to forage. If streams usually remain cloudy (e.g., turbidity ≥ 20 NTU), for several days after a storm however, then these extended elevated levels of turbidity would result in loss of feeding opportunities, with the potential to cause significant adverse effects on growth and survival. Alternatively, land-use related increases in sediment supply may also increase the magnitude, frequency, and/or duration of peak suspended sediment concentrations during high flows, and consequently the severity of physiological stress to fish, if they are unable to locate habitats where they are protected.

The Sonoma Ecology Center has collected and published suspended sediment concentration and turbidity monitoring data for Sonoma Creek in water years 2002 through 2004 (SEC et al., 2006). The Sonoma Creek monitoring data suggest that the magnitude and duration of suspended sediment concentrations in the water column may at times be severe enough to cause major physiological stress on salmonids including impaired respiration and feeding. Overall, suspended sediment and turbidity were monitored in Sonoma Creek in thirty-seven storms. Based on approach of Newcombe and Jensen (1996), it appears that in four of the thirty-seven storms, documented suspended sediment concentrations could have caused significant physiological stress to juvenile salmonids. Conditions severe enough to cause direct mortality to juvenile salmonids were not documented during monitored storms.

Stressful Water Temperatures

During the late summer, cool streamflows are a precious resource for aquatic species. Stressful temperatures can cause chronic stress in fish and reduce growth rates if food supply cannot keep pace with elevated metabolic rates.

Temperature monitoring indicates that although summer stream temperatures stay relatively cool in upper elevation tributaries, temperatures on lower reaches of the mainstem and lower Nathanson Creek (located in the southern portion of the valley) can become warm enough—for very short periods—to kill fish (SEC et al., 2004). Increasing riparian cover, pool depths, and groundwater recharge rates in these reaches could help keep temperatures lower to increase likelihood of successful fish rearing.

Low Flows and Migration Barriers

Impacts related to low summer base-flow and migration barriers have a significant effect on steelhead population size.

Summer Low-flow Conditions

Low flow conditions cause significant direct mortality to juvenile fish as rearing pools dry out. Low summer flows significantly affect fish age 1+ (12–24 months), and are a key factor limiting the total steelhead population in Sonoma Creek. Many of Sonoma Creek's tributaries begin to dry up as early as June. Dry reaches may extend as long as five miles by the end of the summer.

The majority of streams affected by seasonal drying cut through alluvial fan deposits. (The largest alluvial fans are found in foothills of the Mayacamas and at the base of the Carriger Creek subwatershed.) In these areas stream beds are surrounded by permeable coarse sediments, and low flows tend to become subsurface flows.

The cause of the observed low summer base flows in not known for certain. Low summer flows are likely the result of multiple factors including a Mediterranean climate, geology, groundwater withdrawals, and watershed disturbances leading to incision and a lowering of the water table. While some dry reaches may be naturally occurring, historical maps and accounts dating from the 1820's show evidence that the valley used to be significantly wetter, with summer surface ponding (indicative of a high water table) and abundant springs flowing at the base of the Mayacamas and foothills of Sonoma Mountain (SEC et al, 2004; SEC, 2002).

Perennial flows are more common in primarily bedrock stream reaches, such as the mainstem of Sonoma Creek between Glen Ellen and Kenwood, and higher elevation reaches on many tributaries, such as Bear Creek in Sugarloaf Ridge State Park, Calabazas and Hooker creeks, and upper Carriger Creek (SEC et al., 2004).

Barriers to Fish Passage

Barriers significantly reduce the amount of habitat available to age 1+ fish and are important factors limiting the total steelhead population in Sonoma Creek. Most barriers in the watershed are due to road crossings (e.g., culvert placed too high to allow fish to jump and pass through, or culvert concentrates flows such that fish cannot overcome the current to pass through). In addition to preventing migration passage, barriers can also restrict the ability of rearing juveniles and resident adults to move about in the system to feed, or seek shelter and other resources. Although the impacts of some barriers depend upon flow conditions, species, and life-stage of fish, the Limiting Factors Analysis focused on identifying full barriers (i.e., barriers that prevent even the strongest swimming species presumed present from passing, at all flow conditions) (SEC et al, 2004, Appendix J). Man-made barriers to fish passage cut off available spawning and rearing habitat to approximately 25 percent of stream reaches in the Sonoma Creek watershed (i.e., full barriers cut off 25 percent of stream reaches in the watershed).

Data collected for the limiting factors analysis provide a basis for prioritizing barriers for removal based on upstream habitat (SEC et al., 2004). Restoration goals for in-channel barrier remediation and habitat enhancement features are outlined in the implementation plan.

Chapter 4: Water Quality Standards

Water quality standards, specified in the Basin Plan (SFBRWQCB, 2006), consist of three components:

- A statement of designated uses for a specified body of water (beneficial uses)
- One or more water quality parameters than can be evaluated to determine whether beneficial uses are protected (water quality objectives)
- An anti-degradation policy, which requires that where water quality is better than needed to protect beneficial uses, those superior water quality conditions must be maintained

Water quality objectives related to sediment and aquatic life and relevant beneficial uses for Sonoma Creek and its tributaries are listed in Table 3. Based on the results of the Sonoma Creek limiting factors analysis (discussed in section 3.5 Limiting Factors Analysis), we conclude that the narrative water quality objectives for sediment, settleable material, and for population and community ecology are not attained, and that these conditions are the result of controllable water quality factors including excessive sediment discharge and related processes.

We do not conclude that the narrative objectives for turbidity or suspended sediment are violated. The narrative objective for turbidity states that "Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases from normal background light penetration or turbidity relatable to waste discharge shall not be greater than 10 percent in areas where natural turbidity is greater than 50 NTU." We are not aware of any waste discharges that increase turbidity by more than 10 percent above background or ambient conditions. In addition, monitoring conducted by Sonoma Ecology Center indicates ambient turbidity levels are below 50 NTU. Preliminary analysis of suspended sediment monitoring data indicates that turbidity rises to levels stressful to fish following storms and peak flows. It is possible that feeding opportunities may be impacted if streams do not clear up (to levels at or below 20 NTU) within a day or two following storms. However, there is no clear evidence to support an impairment listing for turbidity under Clean Water Act Section 303(d). Staff recommends continued monitoring of suspended sediment/turbidity (see Section 8.7 Evaluation and Monitoring) to both further assess turbidity levels and potential impacts to fish, as well as to evaluate effectiveness of sediment reduction management practices.

The water quality objectives for sediment, settleable material, are not met because human activities have increased the total supply of sediment delivered to Sonoma Creek and caused the supply to be richer in fine sediment. The excess deposits of sediment cause significant harm to the beneficial uses of cold freshwater habitat (COLD), wildlife habitat (WILD), fish spawning (SPWN), and the preservation or rare and endangered species (RARE). Channel incision harms the physical habitat structure of the creek by reducing the quantity of gravel bars, riffles, and side channels (causing channel simplification); the number and quality of pools; and riparian trees and vegetation. All these impacts threaten steelhead and aquatic wildlife populations. Channel incision is in part a controllable water quality factor that results in a violation of the narrative water quality objective for population and community ecology.

Table 3: Water Quality Objectives and Sediment-Related Beneficial Uses

Water Quality Objectives	Beneficial Uses					
	Cold freshwater habitat	**Warm freshwater habitat**	**Fish spawning**	**Fish migration**	**Wildlife habitat**	**Preservation of rare and endangered species[1]**
Turbidity	✓	✓	✓	✓	✓	✓
Sediment	✓	✓	✓	✓	✓	✓
Settleable material	✓	✓	✓	✓	✓	✓
Suspended material	✓	✓	✓	✓	✓	✓
Population and community ecology	✓		✓	✓		✓

Note: Italicized bold text indicates water quality objective is violated.

[1]Preservation of rare and endangered species listed under state or federal law as rare, threatened, or endangered. Steelhead within the Central California Coast, including the Sonoma Creek and its tributaries, are listed as threatened under the federal Endangered Species Act (ESA). California freshwater shrimp have been found in the lower portion of Sonoma Creek. These shrimp are federally listed as endangered species.

Water Quality Objectives (as defined in the Basin Plan):

Turbidity	**Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases from normal background light penetration or turbidity relatable to waste discharge shall not be greater than 10 percent in areas where natural turbidity is greater than 50 NTU (Nephelometric Turbidity Unit).**
Sediment	**Should not cause a nuisance or adversely affect beneficial uses**
Settleable material	**Should not cause a nuisance or adversely affect beneficial uses**
Suspended material	**Should not cause a nuisance or adversely affect beneficial uses**
Population and community ecology	**The health and life history characteristics of aquatic organisms in water affected by controllable water quality factors shall not differ significantly from those for the same waters in areas unaffected by controllable water quality factors**

Chapter 5: Numeric Targets and Desired Conditions

A TMDL establishes a desired (target) condition that will attain applicable water quality objectives and protect beneficial uses in the watershed. TMDL targets provide measurable environmental management goals and a clear linkage to attaining applicable water quality objectives.

To protect the cold fishery and wildlife habitat uses of Sonoma Creek, we propose the following numeric targets and desired conditions: gravel permeability, substrate composition, and pool filling. The *numeric* targets and desired conditions are watershed-specific interpretations of the *narrative* water quality objectives for sediment, settleable material, and population and community ecology (see Table 3)—objectives which are not currently met. Because the water quality objectives are narrative, we selected three streambed parameters that relate sedimentation to attainment of beneficial uses. Attainment of the target/desired conditions (determined by a weight of evidence approach) will constitute attainment of water quality standards.

The targets were selected based on: a) relevance to biological requirements of salmonids; b) responsiveness to changes in sediment supply; c) degree of measurement reliability; d) amount of effort necessary to obtain a representative sample; and e) availability of baseline data

Table 4: Sonoma Creek Sediment Targets

Parameter	Target
Streambed permeability	Greater than or equal to 7,000 cm per hour at potential spawning sites
Pool filling	Decreasing trend in the volume of fine sediment deposited in pools
Substrate Composition-Percent Fines	Percent of fine sediment less than 0.85 mm in diameter is less than or equal to 14 percent of the total bulk core sample (<14% fines < 0.85 mm)
	Percent of fine sediment less than 6.40 mm in diameter is less than or equal to 30 percent of the total bulk core sample (<30% fines < 6.40 mm)

5.1 Streambed Permeability Target

Streambed permeability (or gravel permeability) refers to the flow rate through the streambed. Permeability is a key factor influencing the survival of incubating salmonid eggs and larvae.

Target

The median value for streambed permeability should be ≥ 7000 cm per hour at potential spawning sites for steelhead and salmon in the Sonoma Creek watershed. We estimate this target value corresponds to approximately 50 percent or greater survival of eggs and larvae from spawning to emergence (Stillwater Sciences and Dietrich, 2002, Figure 6-3). Below find our rationale to support the proposed target.

Background and Rationale

Streambed permeability, or the flow rate of water through the streambed, is a key factor influencing the survival of incubating salmonid eggs and larvae. Streambed permeability is significantly and positively correlated with survival to emergence (Chapman, 1988). Cool, clean water flowing through the streambed is needed to provide and replenish dissolved oxygen and to remove metabolic wastes. Streambed permeability is a function of the size distribution and packing of coarse sediment (gravels) and finer sediment contained in the streambed. Streambed permeability is inversely related to fine sediment concentration, primarily sand grains with diameters ≤ 1 mm that are deposited in the streambed (McNeil and Ahnell, 1964). Figure 3 shows this relationship.

There also is a strong positive correlation between permeability and dissolved oxygen content where the topography of the streambed converges vertically and horizontally, such as at the boundary between the tail of a pool and the head of a riffle (or where bars and/or large woody debris create the same conditions); this topography causes a portion of the streamflow to discharge into the streambed (Tagart, 1976). Steelhead and salmon typically choose these types of sites for spawning. When a large amount of fine sediment is deposited in the streambed, permeability can be reduced by a substantial amount with consequent adverse impacts to the survival of incubating salmon and trout eggs and larvae.

In 2004, the Sonoma Ecology Center measured streambed permeability at eighteen potential spawning sites for steelhead located in mainstem Sonoma Creek and its tributaries and reported a median value of approximately 1800 cm/hr, which corresponds to a predicted value for survival of approximately 30 percent or greater for salmonid embryos from spawning-to-emergence (SEC et al., 2004). The Sonoma Ecology Center also prepared a sediment source analysis to quantify rates of sediment delivery to channels in the Sonoma Creek watershed, and to distinguish natural and human causation. Based on this work, they conclude that human actions have caused an approximate doubling of the sediment supply to Sonoma Creek within the historical period (SEC et al., 2006). Furthermore, many management related sources (e.g., road-related sources, vineyard erosion, construction) are richer in fine sediments (sand, silt, and clay) than most natural sources and are chronically delivered[7], which may further exacerbate the amount of fine sediment (e.g., sand) that remains stored in the channel.

Recent research by Cover et al. (2006) demonstrates that sediment supply and streambed sedimentation levels are strongly correlated when supply is scaled to account for stream power. Consistent with the results of Cover et al. (2006), in the Napa River watershed Water Board staff found a strong negative correlation between streambed permeability and sediment supply scaled for stream power[8] (SFBRWQCB Board, 2007; see Figure 7). The data used to develop the Napa River watershed relationship span a wide range of values for sediment supply rate, permeability, and stream power including the typical ranges for these parameters in stream reaches in the Sonoma Creek watershed that provide potential habitat for salmonids. Based on the relationship between permeability, sediment supply, and stream power (developed in the Napa River watershed), the results of Cover et al. (2006), and the work of McNeil and Ahnell (1964), we conclude that:

- Low permeability values at potential spawning sites in Sonoma Creek and in its tributaries are explained, at least in part, by a high concentration of fine sediment (primarily sands) in the streambed.

- Current values for permeability at potential spawning sites for steelhead and salmon in the Sonoma Creek watershed are lower than natural background values as a result of increases in sediment supply that are related to land use activities.

[7] Chronic refers to repeated sediment delivery every year regardless of whether there is a large storm event or above average precipitation, versus a discrete source, as in the case of most shallow landslides (e.g., debris avalanches), where the bulk of the sediment delivery occurs once at the time of the failure (e.g., during a large storm event) or soon thereafter.

[8] Stream power is defined as the rate of energy expenditure by water, as it flows through a channel. Stream power is directly proportional to the product of streamflow discharge multiplied by water surface slope. In our analysis, we use drainage area as a surrogate for streamflow discharge. Only a fraction of total stream power is available to transport sediment. This is because energy is also expended through internal friction within the fluid, and friction along the channel boundaries caused by grain roughness, large obstructions (like debris jams, bedrock outcrops, bridge piers, etc.), and/or other changes in channel width, depth, and direction of flow encountered along the length of the channel. In reaches where we measured permeability, channel form and substrate sizes varied substantially. Therefore our estimates of total stream power only provide a relative estimate of the fraction of stream power that is available to transport sediment.

We propose a numeric target ≥ 7000 cm per hour as the reach-median value for streambed permeability at all potential spawning sites for salmon and steelhead in the mainstem of Sonoma Creek and its tributaries. We predict that this value corresponds to approximately 50 percent or greater survival of incubating salmon and steelhead eggs and larvae between spawning and emergence[9]. We conclude that the proposed target value is protective and attainable based on the following rationale:

- Quinn (2005, p. 254), based on compilation of 215 studies, reports average survival values of 29 and 38 percent for steelhead and Chinook salmon from the egg-to-fry life stage. These averages account for all factors that may influence survival including permeability, redd scour, entombment, redd superimposition, dewatering, etc.

- Considering the scarcity of potential spawning sites for steelhead in the Sonoma Creek watershed, that most potential spawning sites are comprised of fine gravel (D50 ≤20 mm), and there appear to be a significant number of impediments or barriers to steelhead migration (SEC et. al, 2004), we hypothesize that streambed scour, redd superimposition, and/or redd dewatering also may be significant sources of mortality in the egg-to-fry life stage.

- Applying the empirical relationship between permeability and sediment supply scaled for stream power, it appears the proposed target value may be attained if the total maximum daily load is 125 percent of natural background (see Linkage Analysis).

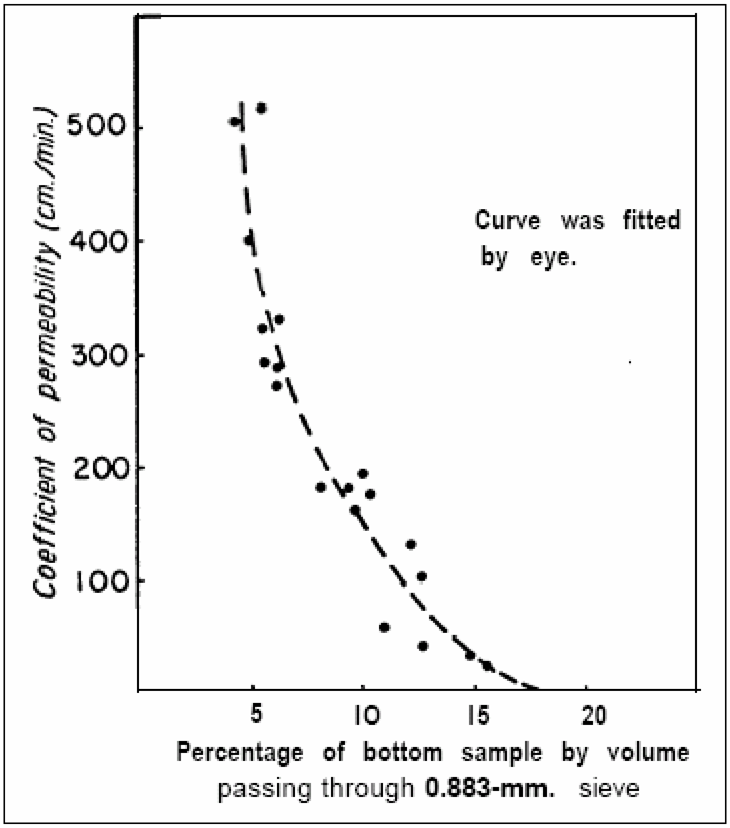
Although egg-to-fry survival does not appear to be the bottleneck life stage for steelhead under current conditions (SEC et. al, 2004) because the population appears to be quite small at present, from a conservation standpoint, it appears prudent to address elevated levels of mortality at all life stages in order for the population to be resilient to natural and anthropogenic disturbances, the relative significance and frequency of which may vary greatly over the longer period of time that will effect persistence of the population.

Finally, we hypothesize that the reductions in chronic sources of fine bed-material associated with land-use activities needed to attain numeric targets for streambed permeability, also will contribute to a substantial enhancement of summer and winter rearing habitat quality for steelhead including: a) lower levels of fine sedimentation in pools; b) higher biomass of vulnerable prey species in riffles; and c) improved quality of

[9] The egg survival-to-emergence index is developed from data relating gravel permeability to survival of coho and/or Chinook salmon eggs. Based on review of Coble (1961), Barnard and McBain (1994), and Rubin and Glimsater (1996), we conclude that steelhead egg survival-to-emergence is 60 percent or greater at a permeability value of 7,000 cm/hr.

winter rearing habitat (e.g., less fine bed-material stored in the void spaces between cluster of cobbles and boulders).

Figure 3. Relationship between streambed permeability and fine sediment deposition



Source: McNeill and Ahnell (1964).

5.2 Pool Filling

Target

There should be a decreasing trend through time in the mean volume of fine sediment deposited in pools in channel reaches where the slope of the streambed is ≤ 5 percent.

Background and Rationale

The Sonoma Ecology Center has documented the amount of fine sediment deposition in pools in Sonoma Creek and its tributaries (e.g., mean value of pool filling = 8.5 percent), and noted that although fine sediment deposition does not cause a biologically significant reduction in pool volume, at the documented levels, fine sediment blankets most of the pool bottoms, thereby compromising the quality of pools as rearing habitat for juvenile salmonids (SEC, 2006). The above observations are consistent with findings of Suttle et al. (2004), who manipulated concentrations of fine sediment in pools within a natural river bed to evaluate effects on growth and survival of juvenile steelhead, and concluded that:

- There is a strong negative relationship between juvenile growth and substrate embeddedness (e.g., the depth to which gravel and larger rocks are buried by adjacent finer bed-material) in pools.
- Even at very low levels of fine sediment deposition, growth and survival of juvenile salmonids is significantly diminished.
- "[T]here is no threshold below which exacerbation of fine sediment delivery and storage in gravel-bed rivers will be harmless."

Suttle et al. (2004) further documented mechanisms to explain decreased growth and survival rates with increasing levels of fine sediment deposition including: a) substantial reduction in the biomass of vulnerable prey species; b) increase in the activity level of individual fish (e.g., amount of time spent swimming); and c) increase in the number of aggressive interactions between fish sharing the same pool. Adverse effects on growth and survival of juvenile steelhead were most pronounced when the amount of fine sediment deposited in (experimentally manipulated) pools corresponded to substrate embeddedness values ≥ 60 percent. Based on observation of Figure 1 in Suttle et al. (2004), we would estimate that at 80 percent embeddedness, the corresponding level of pool filling would be much less than 10 percent.

Mean value for pool filling in Sonoma Creek watershed (8.5 percent) is within the range for other watersheds underlain by bedrock types that do not produce abundant sand and granules (e.g., 3-to-15 percent; Lisle and Hilton, 1999; p. 1294). However, the sediment delivery rate to channels in the Sonoma Creek watershed has increased by a factor of two-or-more as a result of land use activities (SEC et al., 2006). Therefore, we conclude that fine sedimentation in pools is elevated above the natural background level. This conclusion is supported further by the results of Cover et al. (2006) and the relationship between sediment supply and permeability presented in the staff report for the Napa River sediment TMDL (SFBRWQCB, 2007a; Figure 14) which confirm that there is a strong correlation between sediment supply and sedimentation level.

We also hypothesize that because Sonoma Creek has a Mediterranean climate and active tectonic setting, natural sediment loads are highly variable and native biota are adapted to large infrequent sediment inputs associated with natural disturbances (e.g., large storm events, wildfires, and major earthquakes). Native biota are not adapted however to chronic increases in fine sediment load caused by land-use activities that disturb vegetation cover and/or infiltration capacity of soil (e.g., road-related erosion, agriculture, construction, timber harvest, livestock grazing, etc.). Under the natural sediment input regime, fine sediment input would be very low in most years, and the amount of fine sediment stored in the channel would be reduced rapidly following a large natural disturbance event, back to levels favorable for fish spawning and rearing. By this same rationale, significant reductions in the amount of chronic fine sediment input from land- use activities will facilitate a significant reduction in mean values of pool filling. We propose a target for decreasing trend through time in the mean volume of fine sediment stored in pools (expressed as a fraction of the total volume of the pool; see Hilton and Lisle, 1993) as needed to enhance food supply and summer growth and survival of juvenile salmonids and other native fish species.

5.3 Substrate Composition-Percent Fines

Grain size distribution of the streambed is a common measure of salmonid spawning habitat quality because fine sediment grains, called fines, have the potential to impact embryo development and block passage of fry (NCRQCB, 2006). We propose two targets for percent fines in the substrate (% streambed particle sizes < 0.85 mm and % streambed particle sizes < 6.40mm). In general, particles finer than about 1 mm exert a primary influence on incubation success (McNeil, 1964). Particles ranging from 1 mm to 10 mm in size can block fry emergence while still allowing enough water flow through the redds to support embryo development (Kondolf, 2000; NCRWCB, 2006). As such, unless otherwise noted, we use the term fine sediment to refer primarily to sand and fine gravel (e.g., ≤ 10 mm in diameter) deposited in/on the streambed in fish bearing reaches of gravel- or cobble-bedded channels. Fine sediment that impacts embryo development has been defined as particles that pass through a 0.85 sieve (NWQCB, 2006).[10] A high percentage of sand or fine gravel in the streambed also can adversely affect the frequency of streambed scour, biomass of vulnerable prey species in the streambed, and/or suitability in general of summer and winter rearing habitat for salmonids. These issues are summarized in Water Board (2007, p. 8-9)

Targets

The target value for percent fines < 0.85 mm is a substrate composition, where the mean value for percent fines < 0.85 mm as estimated from a representative sample of potential spawning sites is ≤ 14 percent of the total weight of the bulk core sample. The target value for percent fines < 6.4 mm is a substrate composition, where the mean value for percent fines < 6.4 mm as estimated from a representative sample of potential spawning sites is ≤ 30 percent of the total weight of the bulk core sample. These targets are

[10] The specific reference sizes, 0.85 and 6.4 mm (as opposed to 1 and 6 mm), result from the fact that the earliest researchers used US Standard Sieve mesh sizes (e.g., the sieves are machined in English units). They subsequently reported their research results in scientific journals, which use metric units. For comparison purposes, most subsequent researchers have used these same reference sizes.

applicable to potential spawning sites for anadromous salmonids in wadeable[11] streams and rivers with gradient less than 3 percent. Potential spawning sites for anadromous salmonids in the Sonoma Creek watershed can be identified based on occurrence of the following attributes: l) dominant substrate size in the streambed surface layer is between 8 and 128 mm; 2) a minimum surface area of gravel deposit of 0.2 m^2 in tributaries and 1.0 m^2 within the mainstem Sonoma Creek; and 3) location at a riffle head, pool tail, and/or pool margin where streambed slope ≤ 0.03, or where the streambed slope is > 0.03, in pool tails, backwater pools, and/or in gravel deposits associated with flow obstructions (e.g., woody debris, boulders, banks, etc.).

Background and Rationale

Much research has been conducted to relate salmonid survival to emergence with the size of the substrate. Two targets for substrate composition are needed because the size of particles that impact embryo development (0.85 mm in diameter) is smaller than the size of particles impacting emergence from the redd (1 mm to 10 mm). Based on extensive literature review, the North Coast Regional Water Board determined that the salmonid freshwater habitat desired conditions for substrate composition are: a) percent of fine sediment less than 0.85 mm in diameter is less than or equal to 14 percent of the total bulk core sample, and b) percent of fine sediment less than 6.40 mm in diameter is less than or equal to 30 percent of the total bulk core sample (NCRWCB, 2006). As detailed in the North Coast Water Board's Desired Salmonid Freshwater Habitat Conditions for Sediment-Related Indices (NCRWCB, 2006), these targets correspond to a survival-to-emergence rate of 50 percent. Some of the studies evaluated for the desired condition were conducted in salmonid streams, while others were conducted in an experimental setting where the substrate was manipulated to study the effect of substrate size on survival-to-emergence.

The targets (for percent fines in the substrate) complement the proposed streambed permeability target because they provide a direct measure of the fine sediments affecting streambed permeability. These targets are attainable because they are met at several sites where recent spawning had been observed—Sonoma Ecology Center measured fine sediment content at eight known spawning sites (gravels) and the results indicate the proposed percent fines targets are met at these locations (SEC, 2001)[12]. A monitoring

[11] A wadeable stream is one which an average human can safely cross on foot during the summer, low flow season while wearing chest waders.

[12] The results of a preliminary study of the suitability of spawning gravel (summarized in Appendix G of SEC et al., 2006) indicate that both of the proposed targets for percent fines were attained at known sites of spawning, where successful incubation also was inferred based on subsequent presence of juvenile salmonids in the same reaches. Because only known spawning sites with inferred successful incubation were sampled, we do not think the preliminary provides a basis for inferring whether or not spawning substrate quality is suitable in general at potential spawning sites throughout the watershed.

program that includes a larger number of sampling sites and a stratified random site selection scheme is needed to reach conclusion with regard to the suitability in general of the full population of potential spawning sites within the watershed.

As with the streambed permeability target, we hypothesize that the reductions in chronic sources of fine bed-material associated with land-use activities needed to attain numeric targets for substrate composition-percent fines will also contribute to enhancement of summer and winter rearing habitat for steelhead.

5.4 Potential Responses of Other Aquatic Species

Expected responses of other fish and aquatic wildlife species to actions to reduce fine sediment supply and enhance habitat complexity are as follows:

Species	Expected change in relative abundance	Hypothesized mechanism(s)
Riffle Sculpin	Small to Moderate Increase	Increase in riffle area and frequency; decrease in embeddedness; increase in large woody debris
Sacramento Pikeminnow	Neutral to Moderate Increase	Increase in floodplain habitat and large woody debris contributing to higher rates of over-winter survival; decrease in deep-pool run habitat leading to less competition with largemouth bass for prey
Sacramento Sucker	Neutral to Small Increase	Increase in area of shallow/slow backwater habitat and large woody debris leading to increases in survival during early fry rearing stages
California Freshwater Shrimp	Neutral to Small Increase	Increase in relative abundance is dependent upon an increase in proportion of channel length where channel is free to form its own bed and banks, and specifically at outside bends to form deep pools with undercut banks and overhanging roots
Largemouth Bass, Bluegill, and Green Sunfish	Small Decrease	Decrease in deep-pool run habitat area may reduce relative abundance of these introduced predators

Expected fish species responses summarized above are predicated on large scale implementation of stream and riparian habitat enhancement projects (e.g., similar in scale to those being considered along the mainstem and tributaries of the Napa River;

see Section 6.5 of Water Board, 2007 for additional discussion), and life history requirements for above fish species as described in Moyle (2002). For California freshwater shrimp, expected response is based primarily on association of freshwater shrimp with deep pools with undercut banks and overhanging roots, and a review of its life history and ecology as described in the *Recovery Plan for California Freshwater Shrimp* (USFWS, 1998).

Chapter 6: Source Analysis

6.1 Summary

A TMDL must identify pollutant source categories and estimated loads associated with each. To do so, we rely on the Sonoma Creek Watershed Sediment Source Analysis (SEC et al, 2006), with minor refinements presented later in this chapter. SEC et al. (2006) used a "rapid sediment budget approach" to identify significant processes that deliver sediment to Sonoma Creek and its tributaries, and to estimate rates of sediment input to the channel network.[13] Reid and Dunne (1996) define a sediment budget as follows:

> "A sediment budget is an accounting of the sources and disposition of sediment as it travels from its point of origin to its eventual exit from a drainage basin." (p.3)

Based on extensive field surveys and review of available information, SEC et al. (2006) identified five significant sources/categories of sediment delivery to channels:

- Colluvial bank erosion[14] (natural process)
- Landslides (natural process and human actions)
- Channel incision and gully erosion (natural process and human actions)
- Surface erosion (natural process and human actions)
- Road-related erosion (human actions)

Average annual rates of sediment delivery to the channels in the Sonoma Creek watershed from all of the above sources were estimated, summed, and assumed equal to the total sediment yield to Sonoma Creek in its estuary[15]. Rates of sediment delivery from colluvial bank erosion are assumed to be equal to rates of soil creep, which are estimated based on literature review. Rates of sediment delivery from channel incision, gully erosion, and landslides are derived from extensive field surveys in stream channels, and interpretation of recent and historical aerial photographs, topographic maps, and channel cross-sections at bridges. Rates of sediment delivery from roads and

[13] A rapid sediment budget is a measurement technique that can be performed over a short period of time to provide approximate estimates of rates of sediment input to channels.
[14] Colluvial refers to hillslope soil. Where channel banks are hillslopes, colluvial bank erosion delivers sediment to channels.
[15] Sonoma Creek watershed is defined to include all land above the confluence of Sonoma Creek with San Pablo Bay, including Carneros and Schell creeks, which join in its estuary. Alluvial channel reaches are incised and disconnected from floodplains; there is a paucity of large woody debris in channels; and no evidence of significant local aggradation. Therefore, SEC et al. (2006) assume an approximate balance between sediment delivery to channels and yield to the estuary.

surface erosion were estimated by modeling. Estimated rates of sediment delivery to channels in the Sonoma Creek watershed are presented in Table 5.

6.2 Watershed Changes affecting Sediment Delivery

An important characteristic of this watershed is that the physical stream system is now significantly different from pre-settlement times. As described in the Problem Statement section, many tributaries were historically disconnected from mainstem Sonoma Creek in normal water years. Water from the tributaries flowed onto alluvial fans and infiltrated into groundwater. The tributary channels ended in alluvial fans where all of the sand and gravel carried by the stream was deposited, as was some of the fine sediment in the fan and/or natural flood basins located on the valley floor. During higher flows, the tributaries would directly flow into the mainstem. However, European settlers connected many of those tributaries to the mainstem, causing more sediment to be deposited in the creek. The altered condition of the watershed poses a challenge to determining the appropriate sediment load (TMDL) to Sonoma Creek, because while some sediment from tributaries is generated naturally, more sediment is deposited in the creek due to human-caused alteration of the physical stream system (i.e., connection of tributaries to the mainstem).

Sediment sources to Sonoma Creek before Europeans settled the area-when indigenous people were the only human inhabitants-were surface erosion and natural channel processes associated with the local geology (erosion, landslides, and soil creep).

Native American land management practices included periodic burning to clear land and increase opportunities for hunting and encourage germination of fire-evolved plant species. Indigenous people also practiced planting, pruning, and coppicing (cutting vegetation to form grove-like stands). Early surveys, journals, and land grant data post-1800 indicate that upland areas of the Sonoma Valley had less dense vegetation cover than exists today, perhaps due to the cessation of native burning practices. Prior to European settlement (circa 1800), local vegetation probably consisted of a mosaic of oak woodland, redwood forest, grassland, chapparal, and riparian vegetation. The valley floor had expanses of oak savannah, oak woodland, grassland, and large areas of fresh and tidal marsh (SEC et al., 2006, Appendix A). At this time, there were no major levees, marsh draining, or ditching.

Table 5 summarizes our estimates of sediment loads to Sonoma Creek under current conditions. Sediment delivery from "natural processes" is calculated based on estimated sediment loads in the period before European settlement, or circa 1800.

Consistent with our practice in developing the Napa River[16] sediment TMDL, we define all sediment delivered to tributary channels by natural processes within the category of

[16] As was the case in Sonoma Creek, prior to European settlement many of the tributaries of the Napa River were naturally disconnected from the mainstem.

natural sediment load to Sonoma Creek, whether or not a given tributary was naturally disconnected. Based on review of available information regarding the impacts of sedimentation on beneficial uses, we do not conclude that it is necessary to restore natural disconnections in order to achieve water quality objectives for sediment. With regard to achievement of other watershed management objectives, including flood management and habitat enhancement goals in lower Sonoma Creek, the specific nature and extent of restoration actions should be determined through a cooperative process.

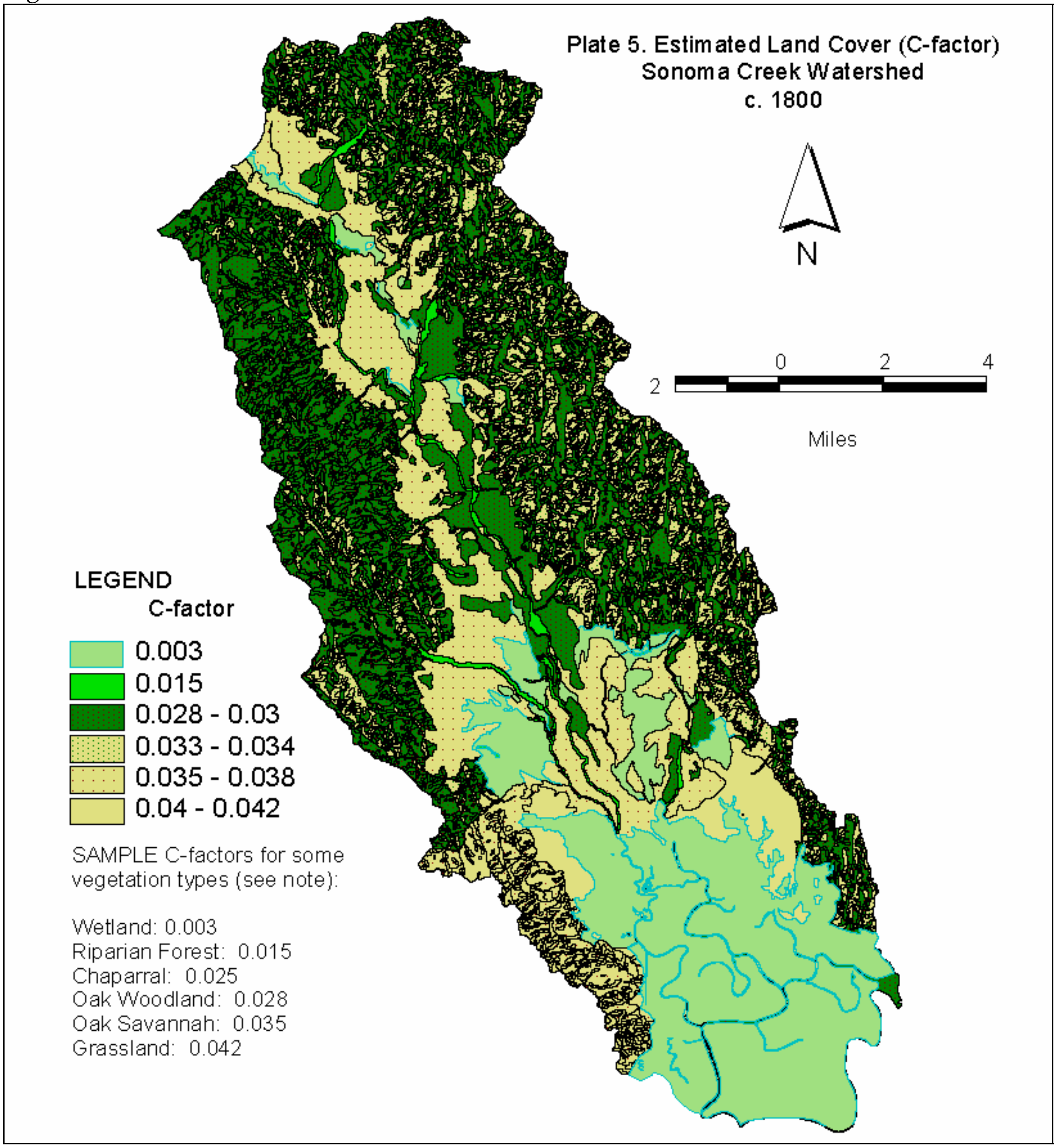
Table 5: Sediment Delivery to Sonoma Creek (tons/year) [a]

Source Categories	Current Condition
Natural Processes	
• Channel erosion, Incision	25,000
• Landslides	4,000
• Colluvial Bank Erosion	17,000
• Surface erosion	6,000
Total- Natural Processes	52,000
Human Actions	
• Channel Incision and Gully Erosion	43,000
• Landslides	1,000
• Surface erosion from vineyards, other row crops, and rangelands	9,000
• Urban Stormwater runoff	1,000
• Roads and stream crossings	11,000
Total- Human Actions	66,000
GRAND TOTAL	118,000
[a]Sediment delivery rates are rounded to the nearest thousand.	

6.3 Soil Creep

The blue-line stream channel network was extended to include headwater channels that could be detected on recent aerial photographs. The length of channels on hillsides was assumed to correspond to the length of channels with colluvial banks. Based on review of literature and discussions with Professor Bill Dietrich (Collins, personal communication, 2007), SEC et al. (2006) assumed an average creep velocity of 3 mm per year and the average depth of colluvium is assumed to equal 3 feet. Bulk density is assumed equal to 1.6 tons per cubic yard. Based on this approach, the estimated rate of sediment delivery from colluvial bank erosion is 17,000 tons per year, or 115 tons per square mile per year.

Figure 4. Estimated Land Cover, 1800



Source: Surface Erosion Study, of the Sonoma Creek Sediment Source Analysis, Appendix A (SEC et al., 2006)

6.4 Channel Incision, Gully Erosion, and Landslides

Summary and Results

Channel-based sources discharge directly into the channel, or are generated within the channel. Sediment delivery from these sources is assumed to be 100 percent. These sources include channel bed incision, bank erosion, and landslides and gullies within the channel corridor. Channel incision was identified as a significant sediment delivery process along mainstem Sonoma Creek and in alluvial reaches of its tributaries where they traverse the valley floor. Gully erosion and landslides also were identified as significant sources of sediment delivery along tributaries in upland reaches. Channel processes produce the majority of human-caused sediment loading to Sonoma Creek and its tributaries. Approximately 50 percent of the volume of sediment delivered from channel processes is fine sediment, which is particularly problematic for spawning habitat.

The total sediment delivery from channel bed incision, bank erosion and gullies is approximately 69,000 tons/year (42,000 tons/year from mainstem Sonoma Creek, and 27,000 tons/year from tributaries). SEC et al. (2006) estimates the average annual sediment delivery between 1850 and 2005 from gully erosion and channel incision caused by land-use activities was approximately 43,000 tons per year. For gully erosion sites on hillsides, where no obvious association with current and/or historical land-use activities was identified, natural causation was inferred. Such sites are estimated to have delivered approximately 25,000 tons per year (see Table 5, Natural Processes- Channel erosion, incision) during the 1850 through 2005 period. Sediment delivery to channels from landslides is much less significant, and estimated at approximately 5,000 tons per year during the past 70 years, the period for which rates can be estimated via interpretation of historical and recent aerial photographs and/or field surveys. Approximately 20 percent of the sediment delivered from landslides, 1,000 tons per year, is classified as human caused.

Methods

As part of the Sediment Source Analysis, Watershed Sciences (SEC et al., 2006, Appendix C) performed a geomorphic study to assess channel-based sources and rates of sedimentation. The methods are described in detail in Appendix C of the Sediment Source Analysis, and are summarized here. They used a combination of methods to derive sources, and the percent due to anthropogenic sources:

- Field methods
    - Continuous measurements along tributaries of sediment delivery processes including landslides, channel bed incision and bank erosion
    - Discrete measurements at 68 stations along mainstem Sonoma Creek
- Analysis of historical and current maps including storm drainage system maps

- Analysis of aerial photography
- Mapping of geomorphic units to correlate sediment supply with morphology

These methods are further described below.

Channel-based Sediment Supply from Mainstem Sonoma Creek

Watershed Sciences inspected the mainstem channel at 68 stations along more than 18 miles of channel above the Highway 12 crossing. These stations were selected based on accessibility; the average distance between them was 0.25 miles. Measurements taken at each station included total incision, bed width, bankfull width, bankfull depth, floodprone width, left and right bank retreat distances, and left and right bank retreat heights. Measurements for segments between sampled reaches were interpolated from the field measurements. To calculate sediment supply along the channel, Watershed Sciences used aerial photos to assess active bank width, maximum bank width, and to interpolate active bed width over distance intervals of 200-250 ft.

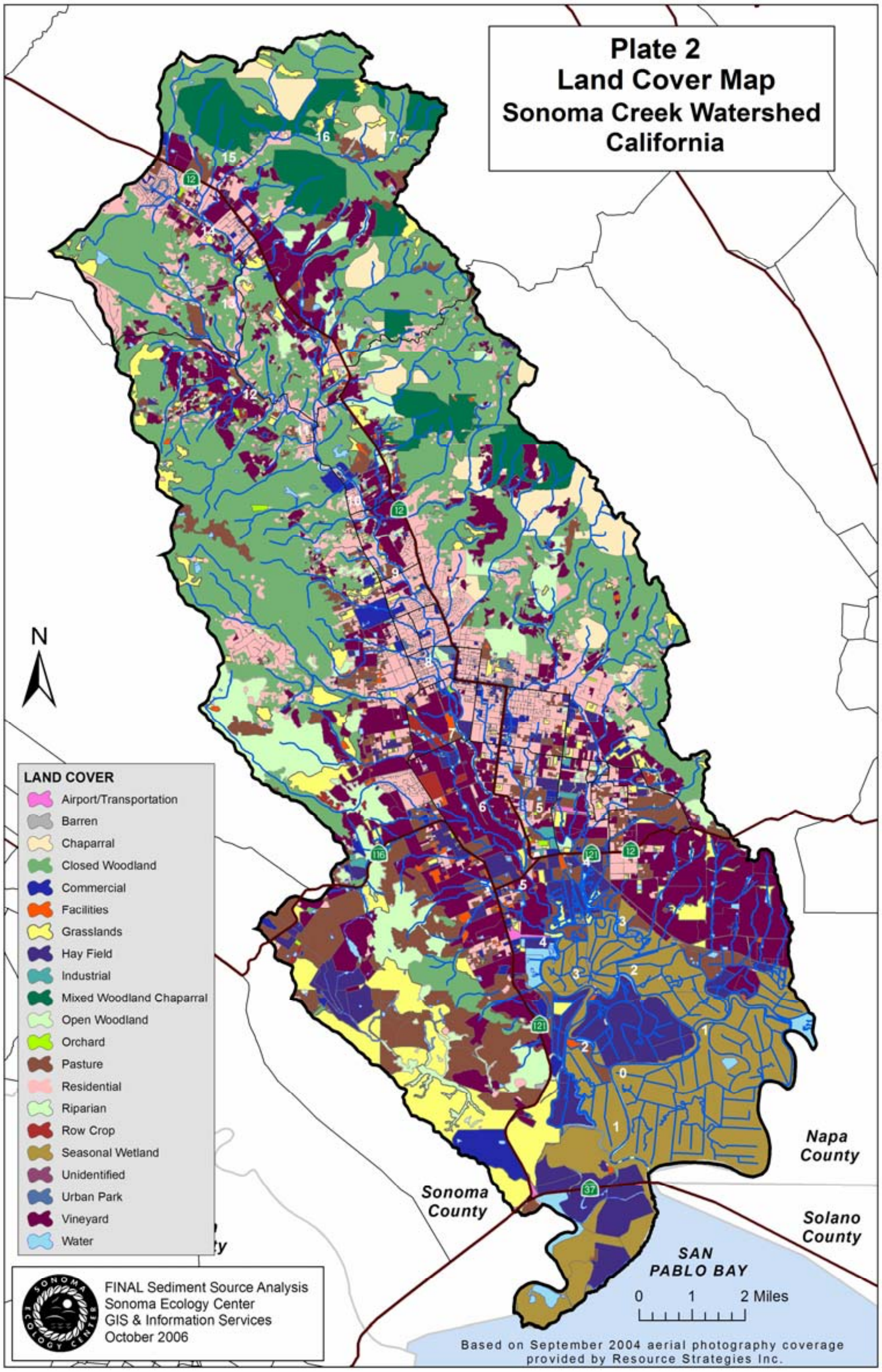
Sediment supply due to incision was calculated for each distance interval as the product of incision depth, active bed width, and distance interval. The sediment supply from all the intervals was summed together to estimate the total supply over the 18-mile mainstem survey area (SEC et al., 2006, Appendix C). The total sediment supply from mainstem Sonoma Creek is 42,000 tons/year.

Channel-based Sediment Supply from Tributaries

One of the first steps to estimating sediment supply from tributaries was to develop a comprehensive stream channel map. Watershed Sciences used existing GIS maps provided by the Sonoma Ecology Center as the base map, and additional channels were added based on analysis of aerial photographs. Documented storm drains and ditches and culverts observed in the field were also added to the stream map. Aerial photographs were also used to estimate landslides.

Continuous measurements were taken along tributaries by walking along the channels and measuring the amount of channel bed incision, bank erosion, landsliding, gullying, or dry raveling (sediment sloughing off in dry conditions) occurring within the channel corridor. To estimate the time period over which the sediment loss occurred, they considered multiple factors, including the freshness of bank escarpments, age of trees or other vegetation within erosional features, and the depth of incision below structures such as retaining walls or bridge abutments. The amount of sediment supplied to a reach was normalized to calculate sediment supply per unit length, in order to allow comparisons between channels. The percent of erosion caused by human activity was estimated in the field based on whether there were obvious signs of human actions, such as culverts or roads. The percent of fine sediment from erosional features was estimated visually.

Figure 5. Current Land Cover in the Sonoma Creek Watershed



Source: Sonoma Ecology Center et al., 2006, Appendix A

In order to test whether sediment supply could be correlated with geomorphic attributes such as landform unit and the length of the upstream drainage network, Watershed Sciences mapped geomorphic units using both USGS topographic maps and geologic maps. For each geomorphic unit, sediment supply (expressed as cubic feet per foot of channel) was plotted against upstream drainage length. Figure 6 shows this plot. To evaluate the correlation between sediment supply and drainage for each geomorphic unit, the R-squared values were analyzed. With R-square values between 0.5 and 0.97, the correlations were reasonably good and allowed sediment delivery from unsampled reaches to be extrapolated. Not surprisingly, the analysis shows that geology plays a large role in determining sediment supply. The sediment supply from tributaries, estimated as described above, is 27,000 tons/year due to erosion/incision, and 5,000 tons/year due to landslides.

Discussion of Channel-based sediment delivery

Based on the above described analyses, SEC et al. (2006) documented that there have been one or more episodes of channel incision (depending upon location) that have occurred along Sonoma Creek and the lower alluvial reaches of its tributaries approximately between the 1880s and 1950s. Also, based on extensive historical research, the Sonoma Ecology Center documented a suite of large-scale land-use disturbances in the watershed between 1823 when Mission Sonoma was established, and the late nineteenth century (SEC, 2002a, 2004a). Documented direct-and-indirect disturbances to channels include the following:

- Connection of naturally disconnected tributary channels to the mainstem
- Straightening of mainstem and lower tributary reaches
- Draining of hundreds of acres of freshwater (flood plain) wetlands
- Logging of the redwood forests and intensive and widespread livestock grazing

Gravel mining and dredging operations (to support reclamation of tidal marshes for agriculture) also were large scale by the early twentieth century. More recently, an extensive urban storm drainage network (more than 20 miles in length) has been constructed in Sonoma, and a large number of box culverts have been installed at road crossings on tributary channels. Each above listed land use or development activity could cause significant increases in the amount of energy exerted on the bed and banks of Sonoma Creek during a typical high flow event, and/or create local discontinuities in channel slope and sediment supply (e.g., gravel mining and dredging) that would facilitate downcutting of the channel bed[17].

[17] For example, extensive upland land-cover disturbances (e.g., logging and intensive grazing), draining of freshwater marshes, and/or connection of naturally disconnected tributaries, would increase the volume and peak rates of runoff conveyed in the mainstem channel.

Although significant shifts in climate or large tectonic events also have the potential to initiate channel downcutting, these types of natural disturbances did not occur in the watershed in the historical period. Therefore, we conclude that historical land-use disturbances appear to be primary causes for multiple episodes of incision on Sonoma Creek and in the lower alluvial reaches of its tributaries.

Following incision, the mainstem and lower alluvial tributary reaches of Sonoma Creek have continued to adjust. Local experts who have evaluated substrate conditions and channel dynamics along the mainstem of Sonoma Creek, and Schell and Nathanson creeks have observed high concentrations of fine sediment (sand and finer-sized particles) in the streambed at potential spawning sites for salmonids in reaches that are hypothesized to be actively incising and/or widening (Collins, 2008; Micheli, 2008). Co-occurrence of active incision and streambed fining may result from a variety of causes including:

a) During flows above bankfull stage, high rates of bank erosion on banks with abundant fine sediment and/or stream bed incision (that occurs within fine-particle-sized bedrock formations that are exposed or become exposed) provide a chronic supply of fine sediment that is subsequently deposited at flows below bankfull stage on the falling limb of the hydrograph (Micheli, 2008; Collins, 2008).
b) In the lower gravel-bedded reaches of Sonoma and Shell creeks, fine sediment deposition can be associated with backwater flooding caused by the coincidence of high tides and large flood events (Collins, 2008).

Other causes also may explain co-occurrence of active incision and elevated fine sedimentation. This topic represents a key data gap that should be filled through additional monitoring and analysis, to aid channel management and habitat enhancement efforts.

6.5 Surface Erosion

Surface Erosion circa 1800- Natural Background

The Revised Universal Soil Loss Equation (RUSLE, see below) was used to estimate the volume of sediment eroded from surface areas. Estimating surface erosion rates requires mapping the vegetative cover during the period of interest. The Sonoma Ecology Center and Talon Associates compiled and analyzed information from all available sources, including a heritage oak census, General Land Office surveys, Father Altimira's journal, Land Grant records, historical photographs, and modern soil maps, to develop a picture of the vegetative cover in the watershed, circa 1800 (see Figure 4).

To estimate erosion rates in the year 1800, researchers assigned land cover factors (C-factors) derived from the vegetation map as inputs to the RUSLE model. The land cover factor is the ratio of soil loss under specified field conditions to the corresponding loss from the standard soil plot. This factor takes into account the protection offered to the soil surface by the vegetative canopy. C-factors were determined for the different vegetation classifications in Sonoma Valley using the Natural Resources Conservation Service guide. Figure 4 shows the estimated landcover of the Sonoma Creek watershed circa 1800. The Sonoma Ecology Center developed a GIS model that implements the Universal Soil Loss Equation (USLE), a model developed by the U.S. Department of Agriculture to predict soil erosion of soil from agricultural fields. The Revised Universal Soil Loss Equation, which uses the same empirical principles as USLE, includes improvements such as monthly rainfall factors. The model incorporates the major factors contributing to surface erosion in the Sonoma Valley, including vegetative cover, rainfall erosivity, and the length and slope of the eroding surface. Because RUSLE only predicts local erosion rate and not delivery to a channel, it was also necessary to estimate sediment delivery ratio: the fraction of the eroded sediment that actually reaches a channel. For sheetwash erosion this was estimated by comparing sediment delivery from all other sources to estimated yield from Sonoma Creek (as follows):

Sheetwash Delivery = (Sonoma Creek Yield) – (Sum of All Other Sediment Delivery Sources)

Sediment Delivery Ratio = Sheetwash Delivery ÷ Sheetwash Erosion.

Water Board staff refined the model results by excluding surface erosion from closed woodland land covers, because sheetwash erosion is only possible where overland flow occurs and it generally does not occur in undisturbed and heavily vegetated and canopied areas. With this refinement, the estimated sediment delivery to Sonoma Creek from surface erosion (assuming a sediment delivery ratio of 5 percent, calculated as described above) in year 1800 was 6,000 tons/year. Therefore, we assume the natural background sediment delivery from surface erosion is 6,000 tons/year.

Sediment Loads from Surface Erosion: Current Conditions

Land management practices and the amount of vegetative cover on the land significantly impact the volume of sediment that enters the creek. For example, a vineyard with full protection including cover crop will produce much less sediment than a vineyard without soil protection. Figure 5 presents current vegetative cover in the watershed.

Sonoma Ecology Center and Talon Associates used aerial photography and interviewed local landowners to estimate soil protection and develop land cover factors for use in the RUSLE model. As with the year 1800, GIS analysis and RUSLE were used to estimate current sediment delivery from surface erosion. Land cover GIS data from the Sonoma Ecology Center was used to determine C-factors for the different cover types existing currently.

Water Board staff refined the model results by making the following adjustments:

1) Excluding surface erosion from closed woodland land covers, because sheetwash erosion is only possible where overland flow occurs, and it generally does not occur in heavily vegetated and canopied areas

2) Adjusting the sediment delivery ratio for areas in agricultural land uses (i.e., pasture, orchards, grasslands, vineyards, hayfields) to 25 percent (from the original assumption of a 5 percent sediment delivery ratio
3) Assuming that approximately one-third of potentially grazed lands are actively grazed
4) Revising cover values for vineyards and grazing lands

With these adjustments, the estimated current sediment delivery rate from surface erosion is 15,000 tons/year. The human-caused portion of the total surface erosion is calculated by subtracting the baseline (1800) surface erosion sediment delivery rate from the 2005 rate. Therefore, the estimated human-caused sediment delivery due from surface erosion is (15,000 – 6,000) 9,000 tons/yr. The refinements made to the surface erosion model are detailed in the following section.

Surface Erosion- Refinement of Model Assumptions

In our review, we discovered that RUSLE was applied over the entire watershed area. Considering the land cover types found within the watershed, we conclude that overland flow (e.g., sheetwash erosion) is only common over construction sites, roads, farms, rangelands, landfills, and quarries, or areas where activities cause soil compaction and/or reduction in ground cover and organic matter content18. Removing from the model the land-cover type where sheetwash erosion is unlikely (closed woodland) results in a significant reduction in total estimated surface erosion rate.

Modeled rates of surface erosion also are quite sensitive to the values selected for the cover parameter, which accounts for the influence of vegetation cover in resisting erosion (USDA, 1978). SEC et al. (2006) reviewed literature sources to estimate an average cover value of 0.37 for vineyards, and 0.15 for grazing areas. Based on field reconnaissance in the Sonoma Creek watershed, it appears that winter cover crops are a common BMP in vineyards. Considering this observation, and based on review of USDA Natural Resources Conservation Service (1994), we think that a value of 0.2 for the cover factor in vineyards may be more accurate. Similarly, stocking densities in grazing areas within the Sonoma Creek watershed appear to be very low at present, and vegetation cover is close to continuous at rangelands sites that can be observed from public roadways, therefore we think that a cover value of 0.02 may be more appropriate for rangeland sites in Sonoma Creek watershed. Applying these adjustments, would result in an approximate 1.8 fold reduction in the amount of predicted surface erosion from vineyards, and a 7.5 fold reduction in the amount of predicted surface erosion from rangelands19.

[18] Overland flow also would be common on paved surfaces in urban areas; however the pavement precludes significant erosion of the underlying soil.
[19] This value should be further reduced to account for the fact that most potential rangelands within the watershed are not managed at present to provide forage for livestock. In the adjacent Napa River watershed, we estimate that only 1/3 of the potential rangeland is utilized by

Appendix A in SEC et al. (2006) states that the estimated values for slope length and steepness factor were based on the approach of Fernandez et al. (2003), which can be calculated from the upslope contributing area estimated from a digital elevation model. This approach seems reasonable for most areas of the watershed, except for hillside vineyard sites, where widespread application of drop inlets and drainage pipes, interception of sheetflow from upslope areas in diversion ditches, and/or terraces are commonly installed to reduce soil erosion. Application of these BMPs would reduce calculated average values for the length-slope factor at hillside vineyards by an unknown but significant amount.

As can be surmised from the above discussion, there can be a considerable amount of uncertainty associated with modeling of surface erosion rates. This uncertainty is further magnified when attempting to determine the sediment delivery ratio (SDR), or the proportion of eroded sediment that actually is delivered to a channel, since the models only estimate local erosion. SEC et al. (2006) estimated a watershed-wide average value for sediment delivery ratio from surface erosion (from all sources) at 5 percent based on calculation of a residual, where all other key delivery sources and yield are estimated.

We refined the estimate of sediment delivery by assuming sediment delivery ratios validated in the adjacent Napa River watershed. Based on conditions observed during watershed reconnaissance and field surveys, we assumed an average sediment delivery ratio from vineyards equal to 0.25, and average sediment delivery ratio from rangelands equal to 0.50. The vineyard sediment delivery ratio is lower because most hillside vineyards have approved erosion control plans, and sediment delivery ratio from valley floor vineyards is very low considering the gentle topography, widespread application of winter cover crops, and common occurrence of human-made levees where vineyards are located near water courses. In contrast, rangelands are typically located on steeper slopes, and there are no erosion control regulations at present for rangelands.

Also, in Napa we had a partial basis for evaluating accuracy of our estimated sediment delivery ratio for vineyards. At two sites where essentially all upslope areas draining into reservoirs were developed for hillside vineyards, we estimated the input rates for all significant sediment delivery processes (absent surface erosion), and also estimated reservoir sedimentation rate and trap efficiency. Comparing estimated sediment delivery rates from surface erosion in the two vineyards, which are 0.8 tons per acre per year and 1.0 tons per acre per year, to surface erosion rates which we estimate at 1.3 tons per acre per year1 leads to the calculation of an average sediment delivery ratio of 0.67 for hillside vineyard sites. Assuming a value of 5 percent for sediment delivery ratio from valley floor vineyards results in a watershed wide average sediment delivery ratio (for vineyards) that is calculated as follows:

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livestock at present. Assuming a similar ratio in Sonoma, would reduce the estimated erosion rate further by a factor of three.

Fractional area (hillside vineyards) x SDR (hillside vineyards) + Fractional area (valley floor vineyards) x SDR (valley floor vineyards) = (1/4 x 0.67) + (3/4 x 0.05) = 0.21.

This value is very close to 0.25 suggesting 0.25 is a reasonable estimate for sediment delivery ratio from surface erosion at hillside vineyards in the Napa River watershed.

Applying the above suggested adjustments to cover values, and a sediment delivery ratio of 0.25, results in an estimated sediment delivery rate from surface erosion in the Sonoma Creek watershed of approximately 23,000 tons per year, or approximately 1.6 tons per acre per year. This delivery rate per acre is twice as high as the estimate for vineyards in the adjacent Napa River watershed (SFBRWQCB, 2007a). However the surface model for Sonoma Creek watershed does not account for the effects of diversion ditches, drop inlets and drainage pipes, and/or terraces, which substantially reduce the slope length and/or steepness at hillside vineyard sites. To address this issue, we conclude that sediment delivery from vineyards for sites in the Sonoma Creek watershed should be reduced further by a factor of two. Applying this adjustment, the revised estimate for sediment delivery from vineyard surface erosion in the Sonoma Creek watershed is approximately 11,500 tons per year, or 0.8 tons per acre per year. We then estimate that approximately 1/3 of the sediment delivery is naturally occurring[20] (i.e. some sediment delivery occurred on the land before it was a vineyard), resulting in an estimate of 7,600 tons/year of sediment delivery from vineyards due to human actions.

With regard to rangeland surface erosion, applying adjustments to account for revised estimate of cover factor, 1/3 occupancy of rangelands, and a sediment delivery ratio of 0.5 results in an estimated total of approximately 800 tons per year, or 0.2 tons per acre per year. We than estimate that approximately 1/3 of the sediment delivery is naturally occurring20 (i.e. some sediment delivery occurred on the land before it was domestically grazed), resulting in an estimate of 500 tons/year of sediment delivery from rangelands due to human actions.

With regard to orchards and other row crops, applying a sediment delivery ratio of 0.25 results in an estimated total sediment delivery of 1,100 tons/year. Taking account the amount of sediment delivery that is naturally occurring results in an estimate of 700 tons/year of sediment delivery from orchards and other row crops.

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[20] Assumption that 1/3 of sediment delivery from managed areas is derived as follows: Surface erosion due to human causes = Total current sediment delivery from surface erosion- Natural Background surface erosion= 15,000 tons/year- 6,000 tons/year = 9,000 tons/year Surface Erosion due to human causes. Current (modeled) sediment delivery from surface erosion from managed areas = 13,400 tons/year. Therefore, naturally occurring sediment delivery from current human land uses = 4,400 tons/year = 1/3 (4,400/13,400) of modeled sediment delivery from surface erosion from management lands.

6.6 Roads and Stream Crossings

Upland field surveys conducted in fall 2005 (SEC et al., 2006, Appendix B) measured sediment input to stream channels from road-related sources, making observations at 43 sites throughout the watershed. Trso (SEC et al., 2006, Appendix B) estimated that 50 percent of sediment delivered to streams from roads is coarse sediment (2-11.2 mm gravel), and the other 50 percent is fines (sand, silt, or clay). According to field surveys, about 50 percent of the road segments near the stream-road crossings had inboard ditches, and 100 percent delivery to the stream of the road cutslope sediment over distances of 25-60 meters.

Trso (SEC et al., 2006) used a road erosion/sediment delivery model - SEDMODL2 (NCASI, 2002) - to estimate sediment delivery to channels from surface erosion processes acting on the road tread, inboard ditch, cutslope and fillslope. Methods, assumptions, data input, and results are described in Appendix B of SEC et al. (2006). Because the streams data layer used in the model was not of high enough resolution to include headwater channels, staff performed an analysis to refine the initial estimate of sediment delivery from roads and stream crossings. The initial estimate and the refinements performed are discussed below.

Initial Estimate- Results

Trso's modeling (see below) estimated sediment delivery from roads (due to road tread erosion and cutslope erosion) in the watershed to be 5,250 tons/year, or approximately 5 tons per mile of road. The typical rates of sediment delivery across the 61 sub-watersheds Trso modeled range from 0.01-0.09 tons/acre/year. Modeling predicts significantly higher rates, ranging from 0.10-0.19 tons/acre/year, in the following sub-watersheds:

- Adobe Canyon West
- Felton
- Fisher
- Fryer
- Kenwood
- Lewis/Felder
- Pythian
- Schell North
- Skaggs North
- Third Napa North

The model predicts that roads in the Kenwood area have relatively high erosion rates. The highest sediment delivery segments are located near the top of the tributary watershed alluvial fans, likely due to higher road cut heights and unpaved road surfaces.

Initial Estimate- Methods

Trso used road data (from both existing GIS information and field surveys conducted as part of the sediment source analysis) to group roads into categories: 1) vineyard roads, 2) dirt roads, 3) presumed direct roads, and 4) paved roads. He categorized the percentage of eroded sediment that is actually delivered to the watercourse (“delivery ratio”) by the distance of the road to a watercourse, as follows:

- Road segments directly delivering sediment deliver 100 percent of eroded sediment to streams.
- Road segments within 100 feet of a stream deliver 35 percent of eroded sediment to the stream.
- Road segments within 100-200 feet of a stream deliver 10 percent of eroded sediment to the stream.
- Road segments further than 200 feet from a stream are assumed to contribute no sediment to the stream.

Trso estimated road surface erosion and delivery using SEDMODL2, a GIS-based model developed by Boise Cascade to identify road segments that deliver sediment to streams from road treads and road cuts, and the relative amount of sediment delivered. The model developed to estimate sediment delivery from roads in the Sonoma Creek watershed incorporated the following information, which was entered into GIS layers:

- 10-meter digital elevation model
- Land use
- Simplified geology, with geologic material stratified into five units based on potential for erosion
- Road network
- Stream channel network
- Data from field surveys and aerial photographs

The model calculates the total sediment delivery from each road segment as the sum of road tread and cutslope erosion. The calculation is based on road erosion factors as shown below:

Road Tread Erosion (tons/yr) = Geologic Erosion Rate x Tread Surfacing Factor x Traffic Factor x Segment Length*Road Width x *Road Slope Factor x Precipitation Factor x Delivery Factor

Road Cutslope Erosion (tons/yr) = Geologic Erosion Rate x Cutslope Cover Factor x Segment Length x Cutslope Height x Delivery Factor

Trso assumed that 100 percent of sediment produced from fluvial (river-related) erosion at stream-road crossings is delivered to the stream. Road and stream channel network data developed for the model indicates that there are 1,677 stream crossings in the watershed. From field observations, Trso estimated that most of the observed fluvial erosion at crossings has occurred in the last 10 years. From his field observations he estimates an average erosion rate at stream-road crossings of 0.2 tons per road crossing per year. Therefore, he estimates that stream crossings contribute 336 tons of sediment to stream channels annually (SEC et al., 2006, Appendix B).

Refinement of Initial Estimate

Estimated sediment delivery rate from road surface erosion is quite sensitive to the resolution/accuracy of road and channel mapping (e.g., accuracy of the GIS layers) (NCASI, 2002; pp. 3-4). For the road surface erosion analysis in the Sonoma Creek watershed, the USGS 1:24,000-scale blue-line streams layer was used to approximate the complete channel network. Also, 1:24,000 digital ortho-photographs were interpreted to extend the network. Considering the scale and resolution of the ortho-photographs however, we would conclude most headwater channels are not included in the network. If so, this is a significant limitation because headwater channels typically represent two-thirds-or-more of total channel network length (Leopold et al., 1964; p. 142); this relationship has been confirmed locally in the Napa River watershed (Dietrich et al., 2004).

Considering the data sources and approach used to construct the GIS channel network layer, we conclude that actual proximity of most road segments to channels is closer than modeled. All other factors being equal, this would result in significant underestimation of sediment delivery to channels from road-related erosion. The degree to which sediment delivery may be underestimated is illustrated by the following comparison. The model calculates that 19 percent of road length delivers sediment directly to a channel, whereas field surveys conducted as part of the study indicate approximately 50 percent of the road length is directly connected (via inboard ditch) to a channel (SEC et al., 2006; Appendix B, p.5). The 50 percent value is similar to a median value for percent of road length directly connected to channels in four adjacent watersheds (median = 58 percent), where extensive field surveys have been conducted (Water Board, unpublished data, 2007). The above comparison suggests the model may underestimate sediment delivery from road surface erosion by a factor of two-or-more.

Similarly, using the channel network input to the model, SEDMODL2 identifies 1677 road crossings in the Sonoma Creek watershed, or an average frequency of 1.7 crossings per mile of road. The average frequency of road crossings in four adjacent watersheds, based on field surveys, is 4.9 crossings per mile of road (also, the median value = 4.9 crossings/mile; range = 3.5 to 6.3 crossings/mile). Assuming the actual value for road crossing frequency in Sonoma Creek watershed is similar to the average value in the four adjacent watersheds then sediment delivery from road crossing erosion also may be underestimated by a factor of two-or-more.

Based on the above review, we conclude that estimated rates of road surface and crossing erosion should be increased by a factor of two. The revised estimate for sediment delivery rate from road surface erosion is 10,500 tons per year. The revised estimate for sediment delivery rate from road crossing erosion is 672 tons per year. Combining these values together, roads are estimated to deliver approximately 11,000 tons per year of sediment to channels. Considering only dirt roads within the watershed (519 miles), and assuming that surface erosion process are active over a road corridor (e.g., the cutslope, inboard ditch, tread, and fillslope) that average 20 feet in width, then above delivery rate would correspond to approximately 9 tons per acre per year.

6.7 Accuracy of Sediment Delivery Rates

Based on our review of SEC et al. (2006), and published comparisons for sites where sediment yields have been estimated from both rapid sediment budgets and reservoir sedimentation surveys or measurement of sediment transport in channels (Reid and Dunne, 1996, pp. 136-137), we provide the following evaluation of the accuracy of estimated rates of sediment delivery to channels by source category.

Estimated average annual rates of sediment delivery to channels from landslides, gullies, and channel incision are derived from intensive field survey and measurement supplemented by interpretation of time-sequential aerial photographs and repeat surveys of bridge cross-sections. Therefore, we would conclude that estimated average annual sediment delivery rates for these processes appear to be accurate within 50 percent of actual rates for the time periods that were evaluated: 1850 through 2005 for channel incision and gully erosion, and 1937 through 2005 for landslides. SEC et al. (2006) also have developed correlation equations for each geomorphic unit that relate total sediment delivery rate from channel incision, gullies, and landslides to total upslope channel length (Appendix C, p. 17). R-squared values range from 0.43 to 0.94, with most terrain units having values greater than 0.6, leading us to conclude that the sediment delivery rates estimated for these processes at sites that were surveyed are representative of the values for the watershed as a whole.

Rates of sediment delivery from road-related erosion, and surface erosion processes are derived from empirical models developed elsewhere (RUSLE and SEDMODL2). Rates estimated by the model correspond to average annual rates considering current management practices and modern climate conditions. The range of site conditions found in the Sonoma Creek watershed however, does not overlap completely with the range of conditions used to develop these models (e.g., some hillside vineyards are developed on slopes that are steeper than the range of conditions in soil plots analyzed to develop the RUSLE model; SEDMODL2 was developed in forested watersheds in the Pacific northwest where logging and/or rural residential land uses predominate, and average annual precipitation typically is greater). Therefore, we conclude that these estimates (for roads and surface erosion) are accurate within a factor of four (e.g, if the estimate rate is 100 tons per year, the actual rate may be 25-to-400 tons per year). Similarly, because sediment delivery from soil creep (e.g., colluvial bank erosion) relies on the assumption that colluvial bank erosion rates are approximately equal to long-term[21] average rates of soil creep, and average values for creep velocity and depth are

[21] Long-term, with regard to landform change, refers to a period of several thousand years or longer.

based on regional studies, we would conclude that this rate is accurate within a factor of four.

Finally because sediment delivery rates for key sources including channel incision gully erosion, and soil creep are averaged over the historical period (for channel incision and gully erosion), and/or millennial-or-longer time periods (for colluvial bank erosion), it is not possible to develop quantitative estimates for sediment delivery rates from these processes during recent decades. Considering the documented history of land use activities, and timing of channel incision events (the most recent incision event started in the 1950s), it is reasonable to hypothesize that average annual sediment supply from channel incision was much lower in recent decades than in the 1950s or 1960s.

It is also important to mention that human causation for channel incision, gully erosion, and landslides was only inferred at sites where human made structures and/or land uses were documented as overlapping in space/time with observed erosion, and the activity/structure provided a plausible mechanism for the observed erosion. Therefore, we think that the estimate of percent human caused sediment delivery represents a minimum value.

Considering the above factors that may influence accuracy of rates and attribution of a natural or human cause for erosion, we conclude that human actions, primarily historical land-use activities have caused a significant increase in the total sediment supply to Sonoma Creek. Half or more of the current total sediment supply is likely the result of human actions.

Finally, considering the effects of: a) channel incision and connection of naturally disconnected tributaries on storage of fine sediment in alluvial fans and/or floodplains; and b) the significance of surface erosion from roads and farms, and bank erosion as sources of sand and finer sediments, we also conclude that chronic supply of fine bed material (primarily sand) and wash load (primarily clay and silt) to Sonoma Creek has increased to an even greater degree.

6.8 Urban Stormwater Runoff

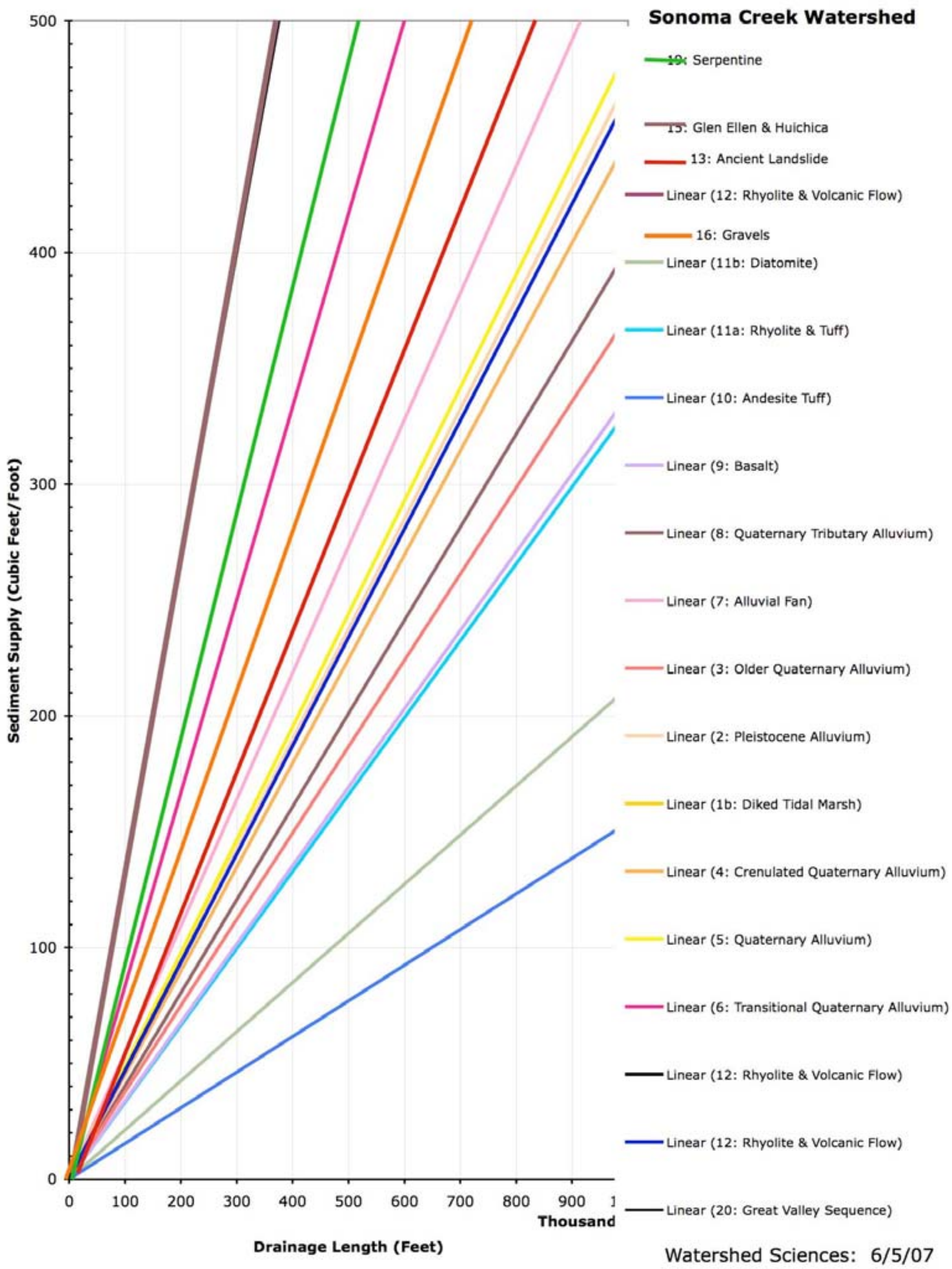
In estimating sediment supply from urban stormwater runoff, we considered inputs from construction activities, industrial facilities, and highways and road maintenance activities. We did not consider inputs from wastewater treatment facilities because the single wastewater discharger in the watershed, Sonoma Valley County Sanitation District, discharges to the tidal portion of Schell Slough (i.e., no discharge to freshwater). In estimating sediment supply from construction activities for structural development projects, we have assumed a typical sediment delivery ratio of 50 percent (e.g., 50 percent of the eroded sediment is actually delivered to a stream channel). Using best professional judgment, we assume, on average, ground disturbance associated with construction is 50 acres per year and average soil erosion rate is 10 tons per acre from construction sites with Best Management Practices in place. Using these values, we calculate that average annual sediment supply to Sonoma Creek or its tributaries from construction activities is approximately 250 tons per year. Sediment supply from the remaining urban stormwater runoff dischargers is estimated based on applicable factors such as rainfall, runoff coefficients, suspended sediment concentrations, and the acreage in different land uses (i.e. industrial, highways). Table 5b presents the estimated sediment supply from point sources, and provides the basis for the estimates.

Table 5b. Sediment Delivery from Urban Stormwater Runoff

Point Source Category	Assumptions/Data	Estimated Mean Annual Delivery Rate (tons/yr)[a]
Construction Stormwater	Ground disturbance: 50 acres Sediment delivery rate: 50% Average soil erosion rate: 10 tons/acre	300
Municipal Stormwater	Acreage of urban land use: 12,195 acres[b] Runoff coefficient: 0.2 (typical urban coefficient is 0.35 (BASMAA, 1996; however Sonoma Creek watershed is highly vegetated with low directly-connected impervious area) Average rainfall: 30 inches/yr. TSS concentration: 100 mg/L[c] Sediment delivery rate: 50%[d]	600
Industrial Stormwater	Acreage of industrial land use: 250 acres[b] Average rainfall: 30 inches/yr. TSS concentration: 100 mg/L (EPA benchmark) Runoff coefficent: 1	100
Caltrans	Acreage of Caltrans roads: 1400 acres[b] TSS concentration: 100 mg/L[e] Runoff coefficient: 1 Average Rainfall: 30 inches/yr.	500

[a]Rounded to nearest hundred.
[b]Source: Land cover data provided by Sonoma Ecology Center
[c]WEF Manual of Practice No. 23/ASCE Manual No. 87, assumes median urban site (WEF and ASCE 1998)
[d]Assumes half of sediment is retained on land or removed via culverts, detention basins, etc.
[e]Approximation based on *Storm Water Monitoring & Data Management Discharge Characterization Study Report* (California Department of Transportation, 2003)

Figure 6: Correlation between Sediment Supply and Drainage Length



Source: Excerpt from Appendix C of Sediment Source Analysis, Technical Memo on Sediment Source Analysis in Sonoma Creek (SEC et al., 2006, Appendix C)

Chapter 7: TMDL, Linkage Analysis and Allocations

7.1 Introduction

The total maximum daily load (TMDL) is the *total* sediment load that can be discharged into Sonoma Creek and its tributaries without violating water quality standards. When the TMDL is achieved, the impairment due to sediment will be eliminated. As part of the scientific justification for the Basin Plan amendment, each TMDL Staff Report includes a "linkage analysis" that explains Water Board staff's reasoning in arriving at its TMDL strategy. The linkage analysis conveys our understanding of the relationships between the pollutant of concern, current habitat conditions, and our determination that the TMDL will resolve the problem.

In this section, we evaluate linkages between sediment inputs and impacts of those sediment contributions on habitat conditions and establish sediment load allocations each source category must meet in order to achieve the TMDL.

7.2 Approach to Development of the Linkage Analysis

Most total maximum daily loads for sediment in natural stream channels are expressed in terms of mass per unit area per unit time. We propose an alternative approach of expressing the TMDL as a percentage of the natural background rate of sediment input to channels. We have taken this approach because:

- The Sonoma Creek watershed has a Mediterranean climate and active tectonic setting. Therefore, natural sediment loads are highly variable and native stream biota are adapted to large infrequent sediment pulses associated with natural disturbances (e.g., large storm events, wildfires, and major earthquakes).
- Native stream biota are not adapted, however, to the chronic increases in fine sediment load caused by human land use activities that disturb vegetation cover and/or infiltration capacity of soil (e.g., road-related erosion, agriculture, construction, timber harvest, livestock grazing, etc.). Under a natural sediment input regime, fine sediment input would be very low in most years, and the amount of fine sediment stored in the channel following a large disturbance would return relatively rapidly to levels favorable for fish spawning and rearing.

In order to emulate natural sediment dynamics and allow adaptations of native biota to infrequent pulse disturbances (but not to chronic human-caused disturbances), we propose to express the TMDL as a percentage of natural input rate to channels.

7.3 Establishing the TMDL

Linking channel conditions to sediment supply is challenging because channel form and sediment deposits depend upon the processes of sediment supply into and transport through stream channels, both of which vary depending on time and location. In addition to sediment supply, channel transport capacity and storage are influenced by: a) magnitude, duration, and frequency of high flows; b) channel slope and depth; and c) channel roughness, or the presence of features that concentrate or disperse flow energy. For these reasons, time lags between sediment input and discharge may be several years or decades, and specific changes in the channel due to changes in sediment supply may vary substantially from one reach to another. These challenges acknowledged, the following approaches to linking sediment inputs and channel attributes have been pursued for developing natural stream channel sediment TMDLs:

- Selecting for comparison a "reference" watershed or time period, where all water quality objectives are met and salmonid populations are robust
- Comparing sediment supply to channel attributes related to sediment supply, i.e., comparing sediment supply to gravel permeability
- Comparing current values for channel attributes related to sediment supply to numeric targets

In order to determine what percentage above natural background sediment load will be needed to attain sediment-related water quality standards, we reviewed previously adopted sediment TMDLs for stream channels in the California Coast Range, and found two sediment TMDLs that have been adopted where the TMDL is expressed as a percentage of natural background load. The North Coast Water Board developed these TMDLs based on comparison to either a reference watershed or reference time-period where water quality standards are/were attained:

- The sediment TMDL for Redwood Creek in Humboldt County (Region 1) used a reference watershed. The TMDL is set at 117 percent of natural background sediment load.
- The sediment TMDL for the Noyo River on the Mendocino Coast used a reference time period. The TMDL is set at 125 percent of natural background.

In both cases, a reference state was identified where salmonid populations are/were robust, and inferentially, where water quality objectives for sediment-related parameters are/were attained. Similar to the Sonoma Creek TMDL, the primary goal of these TMDLs is the recovery of native salmonid populations.

Of the two watersheds, Noyo shares more common attributes with Sonoma Creek, including a similar uplift rate, similar average annual rainfall, and predominance of channel incision and erosion and gullies as significant human-caused sediment sources. Therefore, Noyo River under historical conditions—circa 1940s—when there was a modest increase in sediment load (e.g., 125 percent of natural background) and robust steelhead and salmon runs—appears to be a suitable reference watershed for evaluating Sonoma Creek's assimilative capacity for sediment.

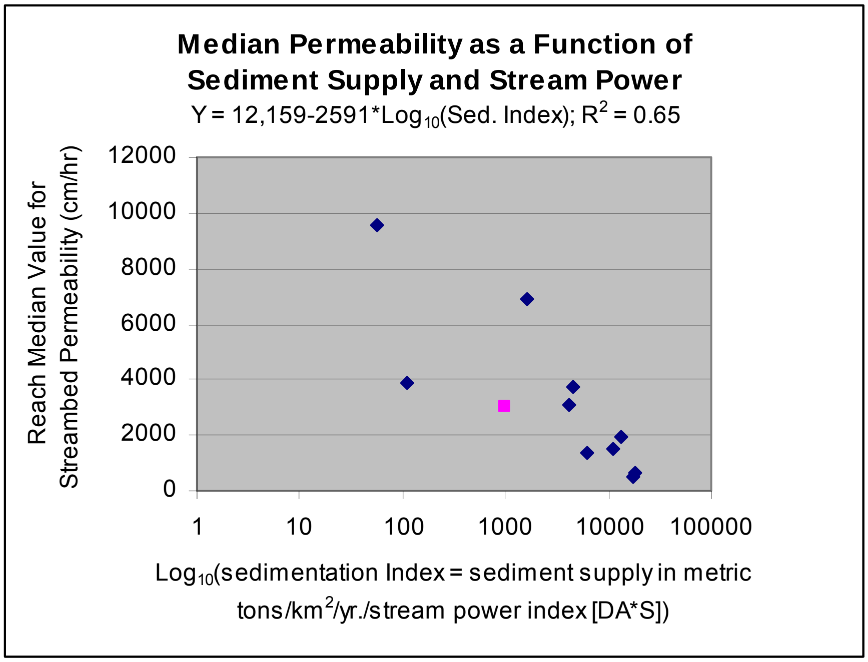
Therefore, we find that a sediment load of 125 percent of natural background to Sonoma Creek, together with restoration of desired habitat conditions, should be supportive of a healthy steelhead population and result in attainment of the numeric target/desired condition. A TMDL of 125 percent of natural background would also assure attainment of the water quality objective for turbidity because the required reduction in sediment loads will lower fine sediment input, thereby lowering suspended sediment and turbidity. The proposed TMDL would reduce total sediment supply from a best estimate of approximately 225 percent of natural background at present to 125 percent of natural background. This large reduction in sediment input (particularly fine sediment) should reduce turbidity from current conditions (where it is unclear whether there is a violation of the turbidity objective), to levels where we can be confident that beneficial uses are protected.

To further evaluate whether a TMDL of 125 percent of natural background will support attainment of the numeric target, we correlate sediment supply with streambed permeability. In the Napa River watershed, we found a strong negative correlation between streambed permeability and sediment supply scaled for stream power[22] (see Figure 7). The data used to develop this relationship span a wide range of values for sediment supply rate, permeability, and stream power including the typical ranges for these parameters in stream reaches in the Sonoma Creek watershed that provide potential habitat for salmonids. The methods used to develop this regression relationship between spawning gravel permeability and sedimentation index are described in the *Napa River Watershed Sediment TMDL and Habitat Enhancement Plan* staff report (SFBRWQCB, 2007). A TMDL of 125 percent of natural background equates to an annual sediment supply of 180 metric tons (or 200 tons) per km^{2}. . Inputting this load into the regression relationship, we calculate that the median value for spawning gravel permeability in Sonoma Creek at Agua Caliente would be 5800 cm/hr, which is very close to the proposed numeric target for gravel permeability. Given the inherent variability of the data used to develop the relationship, as well as the unavoidable uncertainty in estimating sediment loads, the predicted median gravel permeability (at a sediment load equal to the TMDL) very nearly matches the proposed numeric target. In addition, a gravel permeability of 5800 cm/hr corresponds to an approximately 47 percent survival of eggs and larvae from spawning to emergence (very close to the 50 percent predicted by the numeric target for gravel permeability), using the empirical relationship between permeability and survival-to-emergence (discussed in the background and rationale for the streambed permeability target in Section 5. Numeric

[22] Stream power is defined as the rate of energy expenditure by water, as it flows through a channel. Stream power is directly proportional to the product of streamflow discharge multiplied by water surface slope. In our analysis, we use drainage area as a surrogate for streamflow discharge. Only a fraction of total stream power is available to transport sediment. This is because energy is also expended through internal friction within the fluid, and friction along the channel boundaries caused by grain roughness, large obstructions (like debris jams, bedrock outcrops, bridge piers, etc.), and/or other changes in channel width, depth, and direction of flow encountered along the length of the channel. In reaches where we measured permeability, channel form and substrate sizes varied substantially. Therefore our estimates of total stream power only provide a relative estimate of the fraction of stream power that is available to transport sediment.

Targets and Desired Conditions). Therefore, we conclude that this analysis provides strong indication that the TMDL will attain the water quality targets.

Figure 7. Streambed permeability as a function of sediment supply and transport[1].



[1]Data were collected from the Napa River Watershed. Diamond symbol corresponds to tributary measurement site. Square corresponds to Rutherford Reach in mainstem Napa River.

7.4 Allocations

Consistent with the approach used in other northwestern California streams, the Sonoma Creek sediment TMDL is established as 125 percent of the natural background , which equals 65,400 tons of sediment per year. Allocations by sediment source categories are also specified as a percentage of the natural background. Table 6 summarizes these allocations. Overall, discharges from human-caused sources of sediment must be reduced from current (2005) levels by approximately 82 percent, in order to achieve the TMDL of 125 percent of natural background.

Table 6. Sonoma Creek Sediment Load and Wasteload Allocations[a] (tons/year)

Source Category	Current Condition	Allocation	
		tons/year	Percent Natural Background
LOAD ALLOCATIONS			
Natural Processes			
• Channel Erosion, Incision	25,400	25,400	49
• Landslides	4,100	4,100	8
• Soil Creep	16,600	16,600	32
• Surface Erosion	6,200	6,200	12
Total- Natural Processes	52,300	52,300	100
Human Actions			
• Channel Erosion, Incision	43,300	7,800	15
• Landslides	900	200	0.4
• Surface Erosion, including vineyards, grazed lands, unmanaged areas, and minor agriculture	8,600	1,600	3
• Roads and stream crossings	11,200	2,000	4
Total-Human Actions (Load Allocations)	64,000	11,600	22
Total-Load Allocations		63,900	122
WASTELOAD ALLOCATIONS			
Construction Stormwater- NPDES Permit No. CAS000002	300	300	0.6
Municipal Stormwater- NPDES Permit No. CAS000004	600	600	1
Industrial Stormwater - NPDES Permit No. CAS000001	100	100	0.2
Caltrans Stormwater- NPDES Permit No. CAS000003	500	500	1
Total- Wasteload Allocations		1,500	3
TOTAL ALLOCATIONS= TMDL		65,400	125
[a]Sediment Loads and Allocations are rounded to the nearest hundred.			

TMDL attainment will be evaluated at the limit of tidal influence in the Sonoma Creek watershed, which approximates the downstream boundary of freshwater habitat for steelhead. Sonoma Creek has several tributaries that join the mainstem below the tidal limit; therefore, several points will be used to evaluate TMDL attainment. These points are: mainstem Sonoma Creek just downstream of the Fowler/Carriger Creek confluence, and the freshwater portions (above tidal influence) of Schell, Ramos, Carneros, and Merazo Creeks. Figure 1a shows these tributary creeks and the tidal limit boundary. Attainment of the TMDL equates to a sediment load in Sonoma Creek and its freshwater tributaries of approximately 200 tons (180 metric tons) per km^2 per year.

It is important to note that the allocations in the TMDL are not directly enforceable. To demonstrate attainment of applicable allocations, responsible parties must demonstrate that they are in compliance with required implementation measures and any applicable waste discharge requirements (WDRs), waiver conditions, or NPDES permits.

7.5 Margin of Safety

The Clean Water Act, Section 303(d) and associated regulations at 40 CFR § 130.7 require that a TMDL includes a margin of safety that accounts for any lack of knowledge about the relationship between the pollutant loads and desired receiving water quality. The margin of safety may be employed implicitly by making conservative assumptions (USEPA, 1991). For the Sonoma Creek sediment TMDL, we employed conservative assumptions in setting targets for substrate composition (percent fines). The targets for percent fines composition are those recommended by the North Coast Water Board, and are based on literature reviews of studies linking percent fines in the substrate to survival rate of salmonids from spawning to emergence. In developing their recommended conditions for substrate composition, the North Coast Water Board made a conservation assumption because it gave greater consideration to studies which focused on coho salmon, which has a lower emergence success rate compared to steelhead trout. This conservative assumption provides a margin a safety.

Similarly, an implicit margin of safety for sediment-related water quality standards is also provided through implementation actions designed to address other key stressors of steelhead populations in the Sonoma Creek watershed, including actions to protect and/or enhance baseflow, fish passage, and habitat complexity, as described in the implementation plan (Chapter 8).

7.6 Seasonal Variation and Critical Conditions

The TMDL must describe how seasonal variations were considered. Sediment input to channels in the Sonoma Creek watershed and its effects on beneficial uses inherently vary on seasonal, annual, and longer timeframes. The TMDL and allocations are designed to apply to the sources, and are expressed as a percentage of the natural load.

In the California Coast Range, almost all sediment delivery to channels occurs during the wet season. Although rainfall patterns vary on seasonal, inter-annual, and longer timeframes, most precipitation occurs between the months of October and April. Sediment input to channels from natural processes is positively correlated to precipitation volume and/or intensity. Shallow landslide failures, whether caused by natural processes or land use activities, typically occur during high intensity rain events occurring when the soil is already saturated by previous storms.

Most channel incision and associated bank erosion occurs during large infrequent runoff events (e.g., recurrence intervals greater than 10 years, or "10-year storms" or greater), and/or in years of average or above normal runoff that immediately follow such events. Other land-use related sources, such as sheetwash erosion associated with vineyards and/or roads, are chronic, occurring during the wet season almost every year, with erosion rates being proportional to precipitation.

Critical conditions with regard to flow are addressed through implementation actions designed to protect or enhance baseflow as described in Chapter 8. Other critical water quality parameters are also addressed by including the improving trend target for pool filling. In the summer low flow months, some reaches have little flow and pools are critical rearing habitats for steelhead. Pool filling compromises the quality and quantity of that habitat. Achieving the water quality target for pool filling will improve summer rearing habitat. The recommended habitat enhancement measures to enhance habitat complexity (measured by the habitat complexity water quality indicators) will address both summer (low flow) and winter (high velocity) conditions. The recommended measures include increasing riparian canopy, large woody debris, and pool habitat (both frequency and depth). Increasing riparian canopy will help lower temperatures (particularly in the valley floor where temperatures are higher than ideal) and decrease water loss through evaporation, resulting in fewer strandings due to low flow. Increasing large woody debris and pool habitat will improve winter rearing conditions by providing shelter from high flows.

Chapter 8: Implementation Plan

8.1 Introduction

A TMDL implementation plan is a detailed description of actions stakeholders need to take to achieve the TMDL, support beneficial uses, and restore a sustainable fishery.

The goals of the Sonoma Creek Sediment TMDL and Habitat Enhancement Plan are to:

- Conserve the steelhead trout population
- Enhance the overall health of the native fish community
- Protect and enhance habitat for native aquatic species
- Enhance the aesthetic and recreational values of the river and its tributaries

To achieve these goals, stakeholders in the watershed must work to:

- Reduce sediment loads, and fine sediment in particular, to Sonoma Creek and its tributaries
- Attain and maintain suitable gravel quality in freshwater reaches of Sonoma Creek and its tributaries
- Reduce and prevent channel incision
- Repair large sources of sediment supply (i.e. landslides)
- Enhance channel complexity (i.e., by adding and encouraging retention of large woody debris)

In this section we describe actions recommended to reduce sediment supply and enhance stream habitat, as needed to achieve the above stated goals. In addition to actions needed to resolve sediment, we conclude that progress is also needed toward resolution of other factors limiting steelhead productivity and survival in the Sonoma Creek watershed. Therefore, we recommend additional management actions to address other significant factors limiting steelhead, as part of a broader habitat enhancement plan discussed at the end of this chapter.

8.2 Key Considerations Regarding Implementation

Total sediment delivery to channels associated with human and land use activities needs to be reduced by approximately 82 percent from current values in order to meet the proposed targets and allocations for sediment and achieve the TMDL. The best solutions to sediment supply and habitat quality issues in this watershed are those “owned” by stakeholders. Therefore, we support collaborative stewardship efforts that select and implement the most effective and appropriate best management practices described later in this section. Specifically, we support cost-effective sediment source reduction by sediment source-control “cooperatives” that could be administered by local public agencies or other capable and interested groups.

Implementation measures and efforts should build upon existing programs, such as those led by Sonoma County, the Southern Sonoma Resource Conservation District (RCD), and the Sonoma Ecology Center. These entities currently work on programs geared towards assisting landowners implement effective erosion control and good stewardship best management practices.

8.3 Legal Authorities and Requirements

The Water Board's legal authorities to require dischargers of sediment to implement water pollution control actions are derived from the federal Clean Water Act and California's Porter-Cologne Water Quality Control Act. As explained above, the Clean Water Act requires states to list polluted waterbodies and address impairments through TMDLs. Porter Cologne gives Water Boards authority to issue discharge prohibitions, waste discharge requirements (WDRs), and/or waiver conditions, in order to control actual and potential discharges of pollutants from point and nonpoint sources into waters of the state (California Water Code section 13000 et seq.). California also regulates and controls nonpoint source pollution as specified in the *Plan for California's Nonpoint Source Pollution Control Program* (State Board and California Coastal Commission, 2000) and the Policy for Implementation and Enforcement of California's Nonpoint Source Pollution Control Program (State Board, 2004). These policies require all current and future nonpoint sources to be regulated under waste discharge requirements or waivers, and/or waste discharge prohibitions (California Water Code 13369). Under these policies, waivers of waste discharge requirements must be conditioned on a monitoring program to ensure that water quality is protected.

8.4 Implementation Strategy

To achieve our goals, the Sonoma Creek Watershed Sediment TMDL and Habitat Enhancement Plan will include implementation measures both to control sediment and to restore stream complexity and habitat (see Tables 7 through 14). In addition to regulatory controls on land uses that add sediment to Sonoma Creek, our strategy also includes collaborative, multi-stakeholder actions to address habitat issues such as lack of in-stream shelter and large woody debris, channel incision, and low summer baseflows. The plan to address sediment sources will build upon local, existing efforts such as landowner-assistance programs led by Sonoma Ecology Center, the Southern Sonoma RCD, and UC Cooperative Extension. Likewise, the habitat enhancement plan will rely in large part on local, collaborative restoration projects and programs.

8.5 Sediment Reduction and Control/New Regulatory Programs

The sediment control plan includes recommended actions for each major source category (channel incision, roads, grazing, vineyards, and urban stormwater). For each source category, we summarize relevant existing plans, policies, or regulations, and discuss approaches to further reduce sediment loads through new regulatory programs, or through expansion and improvement of existing programs.

As discussed above, state policies require all current and future nonpoint sources to be regulated under waste discharge requirements or waivers, and/or waste discharge prohibitions. Significant sediment sources that are not currently regulated will be regulated by new regulatory programs. We expect new regulatory programs to address sediment discharges from roads, vineyards, and grazing lands. In addition, we anticipate existing programs will be expanded to address hydromodification and further reduce sediment.

Channel Incision

We use the term channel incision to refer to the progressive lowering over time of streambed elevation as a result of net erosion[23]. Channel incision typically results from some combination of: a) a significant increase in peak runoff flow rates and durations (e.g., energy available to erode the bed and banks is greater than the ability of the channel to resist erosion); b) a significant decrease in the supply of coarse sediment (e.g., incision occurs because capacity to transport sediment is greater than supply); and c) direct disturbances that reduce resistance to erosion or focus energy along the banks or bed. There are a number of ways to address the causes of channel incision, including attenuating increases in peak runoff rates and durations associated with new- and re-development of structural and agricultural projects; maintaining/restoring riparian corridors; and limiting direct disturbances to channels may accelerate natural recovery. Active and direct interventions, such as reach-based channel restoration projects may also be effective provided that the causes for channel instability and habitat simplification are addressed. To address channel incision in Sonoma Creek and its tributaries, we will rely on multiple approaches, including regulatory programs to: a) attenuate runoff flows and durations, and b) avoid direct impacts[24] to the stream corridor. Also, we will rely on collaborative/non-regulatory efforts including stream restoration and habitat enhancement projects (see the Habitat Enhancement Plan section of this report) to reverse some of the adverse impacts of channel incision on water quality and habitat integrity.

Attenuation of Peak Flow Rates and Durations/ Hydromodification Management

The Water Board considers increases in runoff flow rates and durations a form of pollution, in that the increased energy from these flows can cause erosion of stream bed and banks, resulting in the loss of beneficial uses in the receiving water body. In urban areas of the San Francisco Bay Area, NPDES Phase I Municipal Stormwater Permits

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[23] Incision is distinguished from "streambed scour." Streambed scour is local in space and/or time and balanced by fill, provided there is a balance between channel sediment transport capacity and supply.

[24] Example projects that may cause significant direct disturbances to channel stability include building and/or agricultural development within channels or riparian corridors, road crossings, outfalls, bank stabilization projects, flood control structures, vegetation and/or woody debris maintenance activities.

require permittees to control increases in runoff associated with new and redevelopment.

Attenuation of peak flow rates and durations from new and redevelopment projects, to the maximum extent practical (MEP), is essential to the success of the TMDL, in order to avoid new sources of channel incision-related sediment supply as future development projects increase the amount of impervious surface across the Sonoma Creek watershed.

We consider MEP to be those standards specified in the Phase I Municipal Regional Stormwater Permit Tentative Order (NPDES Permit No. CAS612008, provision C.3) (SFBRWQCB, 2007b), excerpted below:

> Stormwater discharges from (new and redevelopment projects of one acre or more impervious surface) shall not cause an increase in the erosion potential[25] of the receiving stream over the pre-project (existing) condition. Increases in runoff flow and volume shall be managed so that post-project runoff shall not exceed estimated pre-project rates and durations, where such increased flow and/or volume is likely to cause increased potential for erosion of creek beds and banks, silt pollution generation, or other adverse impacts on beneficial uses due to increased erosive force.

The Tentative Order further specifies the elements required for the demonstration that post-project stormwater runoff does not exceed estimated pre-project runoff rates and durations.

Sonoma County and its municipalities are regulated by NPDES Phase II Municipal Stormwater requirements of the Clean Water Act, under the General Permit for the Discharge of Storm Water from Small MS4s (Small MS4 Stormwater Permit) (WQ Order No. 2003-0005-DWQ). As with Phase I, the Small MS4 Stormwater Permit contains requirements related to treating runoff from new and redevelopment projects. However, the current Small MS4 Stormwater Permit does not require attenuation of runoff peak flows and durations (such requirements are being considered for a future reissuance of the Small MS4 Stormwater Permit. Because increased runoff rates and durations caused by new impervious surfaces will exacerbate the known water body impairment caused by sediment in the Sonoma Creek watershed, the Water Board will use one (or more) of the following mechanisms to implement attenuation of peak flow rates and durations from new and redevelopment projects in the Sonoma Creek watershed:

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[25] The erosion potential (Ep) of increased flows and durations of flows from new/redevelopment projects indicates the impact of these flows on stream stability. Ep is expressed as the ratio of post-project to pre-project "work done" on the stream by the increased flows and durations of flows. Using the Ep index as a point of reference, the management objective is: all of the project discharge point.

1. The statewide Small MS4 Stormwater Permit (the reissued permit may include requirements for attenuation of peak flow rates and durations)
2. The regionwide Municipal Regional Stormwater Permit (MRP) (the Water Board could expand it to include Sonoma Creek watershed municipalities)
3. An individual stormwater permit for Sonoma Creek watershed municipalities
4. The statewide Construction General Permit, which is currently in the reissuance process (the reissued permit is anticipated to include requirements for post-construction control of increased stormwater runoff flows and durations.

Protection of Stream Corridors

The Stream Protection Policy now under development by the Water Board is intended to further clarify Water Board authorities and to provide regulatory and non-regulatory incentives for landowners and local government agencies to protect and restore stream and riparian habitats. In channel reaches that are actively incising and/or widening, projects that are intended to stabilize a stream bank (but are only evaluated locally at an erosion site and do not consider the primary causes for instability that may be related to reach- or watershed-scale phenomena) are often ineffective, or may transfer erosion problems to other sites. Similarly, many of the disturbances that are causing channel instability are also contributing factors to the chronic flooding and habitat degradation along the mainstem and lower tributary reaches of Sonoma Creek. Therefore, projects undertaken at the reach-scale to address multiple objectives including flood management, habitat restoration, and channel stability have a much greater potential to be effective in achieving all of these goals. This topic is discussed in further detail below in Section 8.6.

Channel Incision Impacts

Sediment produced by channel incision will be the TMDL's highest priority for source reduction and control because this sediment is produced adjacent to the streambed, and is likely to have a greater effect on fine sediment deposition at spawning and rearing sites in Sonoma Creek than more remote sources of sediment delivery. In addition to being a significant sediment source, channel incision devastates the physical habitat structure of the creek by disconnecting the creek from its floodplain, destabilizing streambanks and riparian vegetation, and eliminating pools, riffles, and in-stream shelter. Channel incision problems along Sonoma Creek and its tributaries result from multiple historic and ongoing disturbances, some of which are local and/or direct, and others that are indirect and farther away.

Roads and Stream Crossings

Sonoma County does not currently have written policies on road construction and maintenance or stream crossings (UC Berkeley Extension, 2001). The FishNet 4C guidelines, which are already being implemented in San Mateo and Santa Cruz Counties, could form the basis for future County or Water Board regulatory programs regarding roads. As shown in Tables 7-10, Water Board staff recommends development of regulatory programs to reduce sediment discharges from roads, to meet a performance standard of a 20-year average sediment delivery rate of 6 tons per road mile per year.

According to GIS data developed by Sonoma County and the Sonoma Ecology Center, there are 1,565 km (972 miles) of roads in the watershed, of which 454 miles are known or presumed to be unpaved (SEC et al., 2006, Appendix B). In addition there are an estimated 1,677 stream crossings in the watershed. (See section 6, Sources.)

Erosion of unpaved roads, which can continue to erode as long as they are in use, can supply large amounts of sediment to streams. Roads can also concentrate and direct runoff onto un-vegetated areas, causing additional erosion. On the other hand, road designs that disperse runoff are less likely to cause erosion or create landslides. Similarly, culverts that are adequately sized and appropriately placed are less likely to concentrate flow and cause blow-outs, or plug or destabilize the stream. Storm-proofing[26] roads can significantly reduce sediment delivery from roads by addressing: 1) road surface drainage (e.g., roads are hydrologically disconnected from stream channels); 2) stream crossings; and c) unstable fill slopes (i.e., unstable fills slopes are treated to minimize sediment delivery and flow is directed away from unstable slopes).

FishNet 4C , a coalition of six central California coastal counties (Mendocino, Sonoma, Marin, San Mateo, Santa Cruz, and Monterey) formed in response to Endangered Species Act listings of coho and steelhead in central California, has developed *Guidelines for Protecting Aquatic Habitat and Salmon Fisheries for County Road Maintenance* (FishNet4C et al., 2004*)*. These guidelines address selection, design, and maintenance of best management practices for roads and stream crossings.

Vineyards

Development of a Regulatory Program for Vineyards

The Water Board will develop a regulatory program (likely a Waiver of Waste Discharge Requirements) for discharges from vineyards. The details, including compliance schedule and appropriate management practices, will be determined during the waiver development progress, which includes stakeholder participation. Many vineyards, including over 6,000 acres in the Napa River watershed, are enrolled and certified by the Fish Friendly Farming Program (FFFP). The FFFP is an incentive-based voluntary program that provides for compliance with state and federal water quality laws, federal Endangered Species Act and pesticide and local regulations. The Water Board, along with the county Agricultural Commissioner's Office and the National Marine Fisheries Service provide certification of each site. A future regulatory program would recognize certification by the FFFP, such that a vineyard owner or operator could either apply for

[26] Storm-proofing consists of specific road upgrading and maintenance practices designed to minimize stream crossing and fill slope failures, and to reduce both episodic and chronic sediment delivery (FishNet 4C et al., 2004)

coverage under the waiver program, or become certified through a third-party certification program such as FFFP. Through either a third party certification program or a waiver program, staff expects that vineyard owners and/or operators will be required to:

1. Complete a comprehensive inventory and assessment of natural resources, agricultural lands, and management practices. This includes documenting slopes, soil types, all sediment sources and evaluating stream and river riparian corridors and water bodies.
2. Inventory and assess all best management practices being implemented including: cover crops, winterization practices (such as densely seeding field roads), vineyard drainage system, and repair of eroding areas such as gullies. Vineyard drainage systems should be designed so as to not increase peak stormwater discharge over pre-project conditions by more than 10-15 percent for the 2, 5, and 10-year events (California Land Stewardship Program, 2003).
3. Identify where changes to management practices are necessary to control erosion, or where new Best Management Practices (BMPs) are needed.
4. Assess the condition of roads on the property, evaluate current management and maintenance methods. Following the assessment, the vineyard owner/operator should create a road repair and improvement program.
5. Develop an implementation schedule for actions identified during the site inventory and assessment.

Vineyard owners/operators who are already implementing best management practices to control sediment and protect creeks and riparian areas, to the maximum extent, would continue their good stewardship and provide documentation. Vineyard owners/operators who currently do not have BMPs in place will be required to develop a plan and schedule to implement adequate BMPs.

Background

Vineyards, particularly those located on hillsides with highly erodible soils, can be significant sources of sediment to streams. Erosion and sediment control can be accomplished by measures such as soil protection (i.e., cover cropping, mulching, or revegetation); and stormwater management (i.e., with drainage bioswales, wide vegetative filter strips, and sediment basins). The Southern Sonoma RCD has developed *The Vineyard Manual* to educate growers on vineyard best management practices, including erosion control. In addition, the RCD provides technical assistance and in-field consultations to landowners regarding erosion and sediment control practices.

New vineyard plantings and replantings are regulated by Sonoma County via the Sonoma County Vineyard Erosion and Sediment Control Ordinance, administered by the County Agricultural Commissioner. This ordinance prohibits new vineyard plantings on land steeper than 50 percent slope. It further categorizes plantings by "level."

- Level I plantings (on lands with highly erodible soils with slopes less than 10 percent, or lands with less erodible soils with slopes less than 15 percent) require notification to the County Agricultural Commissioner.
- Level II vineyard plantings, on highly erodible soils with slopes between 10 percent and 15 percent, or on land with less erodible soils with slopes between 15 percent and 30 percent, require erosion and sediment control plans. These erosion and sediment control plan must be reviewed and certified by a county-recognized civil engineer, or prepared by such an engineer.
- Level III plantings, on lands with highly erodible soils with slopes of 15 percent to 50 percent, or land with less erodible soils with slope of 30 percent to 50 percent, must be prepared by a qualified civil engineer or professional, and be reviewed and certified by a county-recognized civil engineer.

Another important requirement of the ordinance is the stream setback requirement: 25-ft. setback for Level 1, and 50-ft. setback for Levels II and III. Setbacks not only decrease sediment loads from erosion, but also aid natural stream recovery and may slow or decrease channel incision.

Each County-required erosion and sediment control plan must describe all best management practices to be used to protect disturbed areas, manage stormwater runoff, and minimize the discharge of sediment from the vineyard site (Sonoma County, 2001). The levels and requirements for vineyard replantings are similar to those for new plantings, except that the allowable slopes are slightly steeper.

Anticipated Water Board Regulation of Vineyards

Existing vineyards not undergoing replanting are not currently regulated. Additional measures that may achieve needed sediment reductions include expanding or creating regulatory programs to address existing vineyards, and incorporating performance measures such as controlling runoff so as not to increase peak flow rates and durations in streams.

While regulatory programs will be needed to control sediment, effective implementation of best management practices may depend on providing incentives and technical assistance to landowners. Third-party certification programs, such as the Fish Friendly Farming program, can provide incentive-based, collaborative methods for complying with state and federal water quality laws, including those related to sediment. Farmers who participate in the program complete a Farm Conservation Plan that addresses water quality and environmental issues holistically. The Fish Friendly Farming program has been very successful in the Napa Valley, with about 6,000 acres of vineyards covered under the program. We support expansion of this program into Sonoma Valley.

Many growers interviewed as part of the Interview Report on Best Management Practices in Sonoma Valley (Sonoma Valley Vintners & Growers Alliance, 2005) stated that the cost of erosion control was “recouped by not having to spend money fixing erosion problems.” In addition, growers stated that they received assistance from the

RCD or Agricultural Commissioner in designing and implementing an erosion control strategy. Many vineyards already have best management practices in place, and we expect that those that are already effectively controlling erosion and sedimentation, attenuating peak flows and durations, and avoiding impacts to the stream corridor, will only be required to document their good practices in order to be in compliance with the TMDL.

Livestock Grazing

Development of Waiver of Waste Discharge Requirements for Discharges from Grazing Lands

In addition to sediment, grazing lands are also sources of nutrients and pathogens, pollutants for which Sonoma Creek is also listed as impaired. The Water Board will develop waivers of Waste Discharge Requirements for Discharges from Grazing Lands, and the waiver conditions will require control of sediment, nutrients and pathogens. The details, including compliance schedule and appropriate management practices, will be determined during the waiver development process, which includes participation and input from local stakeholders. The Water Board is currently developing a waiver program for discharges from grazing lands in the Tomales Bay watershed, and staff expects a similar program to be developed for the remaining watersheds impaired by sediment, nutrients, and/or pathogens, including Sonoma Creek. Based on available information regarding the waiver program currently being developed for the Tomales Bay watershed, the requirements of the Policy for Implementation and Enforcement of California's Nonpoint Source Pollution Control Program and the Water Code, and the recently adopted waiver for grazing operations in the East Walker River Watershed in the Lahontan region, staff expects the waiver for grazing lands will have the following elements:

1) *Submittal of a Report of Waste Discharge*. This requirement would be met by completing an application to be covered under the waiver program. On the application, owners and/or operators of grazing lands will provide contact information and general information regarding the facility, including the number of animals and the name of the receiving water (e.g. stream, river, or lake the facility discharges to);
2) *Development of a Ranch Water Quality Plan (RWQP).* Elements of the RWQP would include a ranch facility map, an inventory of water resources on the property, an assessment of the ranch facility conditions identifying controllable discharge points for pathogens, nutrients, and sediment; identification of sediment legacy discharge points (if appropriate), and a description of the RWQP objectives. The RQWP should also include a detailed description of practices currently implemented, and a detailed description of newly selected management practices at all identified points of pollutant discharge;

3) *Implementation Schedule*. The RWQP is to include a schedule of implementation for all management practices described or proposed in the RWQP.
4) *Minimum Standards*. Management Practices must be selected, implemented, and maintained to achieve the following sediment-related minimum standards: a) minimize delivery of sediment from ranching lands to surface waters; b) manage animal use areas to minimize sediment-laden runoff to watercourses; c) construct and maintain access and ranch roads to minimize erosion; d) manage existing grazing activities to prevent additional erosion of legacy sediment delivery sites; and e) control and design animal crossings to minimize discharge of sediment-laden runoff to watercourses.
5) *Compliance Monitoring and Reporting*. At a minimum the landowner/operator will need to conduct visual inspections to verify that management practices are being implemented and that the minimum standards are being met, and to maintain records of the inspections including any actions taken to eliminate potential sources of sediment.

The information above reflects staff's current expectations with regard to a waiver program for grazing lands in the Sonoma Creek watershed. Although development of the grazing waiver program applicable to Sonoma Creek has not begun, staff expects requirements for grazing lands to be consistent with those in the Tomales Bay watershed, and throughout the region. In all watersheds, ranchers who have already completed RWQPs will not be required to duplicate efforts, but will instead review the waiver conditions and supplement their RWQPs if needed. Ranchers who are already implementing management practices and are controlling sediment, nutrients, and pathogens to the maximum extent would continue their good stewardship and provide documentation.

Background

The State Water Board and the California Coastal Commission (2004) have identified management measures to address nonpoint source pollution from grazing activities. In response to nonpoint source pollution concerns, livestock industry representatives and members of the public formed the Range Management Advisory Committee . The Committee developed a California Rangeland Water Quality Management Plan, which recommends that ranchers complete rangeland Water Quality Management Plans for their respective ranches.

Grazing livestock can cause "sheetwash erosion," which is characterized by less concentrated flows than gully erosion, but nevertheless can move a significant volume of soil downslope in a rainstorm. An effective means of reducing sheetwash erosion from livestock grazing could involve adopting livestock and/or range management practices that result in sufficient plant material being left on the ground to effectively resist sheetwash erosion. One such approach of this type, that has been successfully applied to control soil erosion at many California rangeland sites, is a residual dry matter standard or target, with residual dry matter being defined as "the old plant material left standing or on the ground at the beginning of a new growing season" (University of California, 2002). Other measures that could control sediment, as well as reduce sediment loads from gullies and landslides, include: modification of grazing strategies and locations, exclusion fencing that keeps livestock out of creeks and away from creek banks, planting of native woody vegetation, diversion or dispersion of concentrated runoff from roads, and construction of alternative water supplies for livestock. The Natural Resource Conservation Service Field Office Technical Guide also provides guidance on selection and implementation of management practices.

The University of California Cooperative Extension (UCCE) and the RCD are currently engaged in a number of programs focused on grazing management practices. Water Board staff are interested in working collaboratively with these and other interested groups to develop appropriate performance measures (such as a target for the percentage of residual dry matter target), as well as incentive programs to accelerate natural recovery of gullies and landslides. Incentives for proactive participation by ranchers could involve grant funding for rangeland and sediment source inventories and implementation actions, or waivers of waste discharge requirements.

Urban Stormwater Runoff

Sediment sources related to urban stormwater runoff in the Sonoma Creek watershed include construction sites, industrial sites, municipal stormwater conveyance systems, and state highways. These sources are regulated under the Clean Water Act by National Pollutant Discharge Elimination System (NPDES) permits, which require control of stormwater discharges, including sediment-laden discharges. Details of the state and regional Water Boards' programs to regulate urban stormwater runoff can be found at http://www.swrcb.ca.gov/stormwtr/index.html.

Sediment wasteload allocations for these urban sources will be implemented and achieved primarily via erosion and sedimentation controls (BMPs) required in existing permits. The erosion and sedimentation control (BMPs) requirements in these permits constitute water quality based effluent limitations. Continued compliance with these existing permits is largely expected to achieve allocations. The following is a general overview of these existing programs.

Construction Stormwater Program

Property owners or developers whose projects disturb one or more acres of soil, or whose projects disturb less than one acre but are part of a larger common plan of development that in total disturbs 1 or more acres, are required to obtain coverage under the statewide *General Permit for Discharges of Storm Water Associated with Construction Activity* (Construction General Permit, 99-08-DWQ). Construction activity subject to this permit includes clearing, grading and disturbances to the ground such as stockpiling and excavation. It does not include regular maintenance activities performed to restore the original line, grade, or capacity of a facility.

The Construction General Permit requires development and implementation of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP should contain a site map(s) showing the construction site perimeter, existing and proposed buildings, lots, roadways, storm water collection and discharge points, general topography both before and after construction, and drainage patterns across the project. The SWPPP must also list best management practices (BMPs) that the discharger will use to minimize storm water runoff, and the placement of those BMPs. Additionally, the SWPPP must contain a visual monitoring program; a chemical monitoring program for "non-visible" pollutants to be implemented if there is a failure of BMPs; and a sediment monitoring plan if the site discharges directly to a waterbody listed on the 303(d) list as impaired by sediment. Section A of the Construction General Permit describes the elements that must be contained in a SWPPP and implemented at the construction site.

The statewide Construction General Permit is presently in the reissuance process, and State Board staff intends to add requirements for post-construction control of increased stormwater runoff flows and durations. These anticipated requirements would help prevent additional channel incision, erosion, and associated impacts to Sonoma Creek and its tributaries.

Industrial Stormwater Program

Facilities in the Sonoma Creek watershed that are permitted under the statewide *Industrial Stormwater General Permit* include properties involved in wine production.

The Industrial General Permit (order 97-03-DWQ) regulates discharges associated with 10 broad categories of industrial activities. It requires implementation of management measures that will achieve the performance standard of “best available technology economically achievable” and the “best conventional pollutant control technology.” It also requires development and implementation of a Storm Water Pollution Prevention Plan (SWPPP) and a monitoring plan. The SWPPP must identify sources of pollutants as well as the means to manage them to reduce stormwater pollution, including sediment pollution. An annual report and runoff sampling/analyses data are required each July 1.

The facility operator must submit a formal “Notice of Intent” for each industrial facility that is required by U.S. Environmental Protection Agency (U.S.EPA) regulations to obtain a storm water permit. The required industrial facilities are listed in Attachment 1 of the General Industrial Permit and are also listed in 40 Code of Federal Regulations Section 122.26(b)(14). The facility operator is responsible for carrying out the stormwater runoff control activities required by the General Industrial Permit.

Municipal Stormwater Program

Municipal stormwater conveyance systems are regulated through permits issued to entities that own/operate municipal separate storm sewer systems (MS4s). Under federal regulations, MS4 permits were issued in two phases:

- Under Phase I, which started in 1990, the Regional Water Quality Control Boards have adopted NPDES storm water permits for medium (serving between 100,000 and 250,000 people) and large (serving 250,000 people or more) municipalities. Most of these permits are issued to a group of co-permittees encompassing an entire metropolitan area. These permits are reissued as the permits expire (every five years).

- As part of Phase II, the State Water Resources Control Board adopted a statewide General Permit for the Discharge of Storm Water from Small MS4s (Small MS4 Stormwater Permit) (WQ Order No. 2003-0005-DWQ) to provide permit coverage for smaller municipalities and "non-traditional small MS4s", which include facilities such as military bases, public campuses, and prison and hospital complexes.

In general, MS4 permits require municipalities to develop and implement a Storm Water Management Plan/Program with the goal of reducing the discharge of pollutants to the maximum extent practicable (MEP, the performance standard specified in Section 402(p) of the Clean Water Act). Management plans or programs specify the best management practices that will be used to address particular program areas, including public education and outreach; illicit discharge detection and elimination; construction and post-construction site management; and good housekeeping practices for municipal operations.

In the San Francisco Bay Area, Phase I MS4 permits also include provisions requiring municipalities to control increases in runoff associated with new and redevelopment. As development projects pave or otherwise cover/compact natural surfaces, less rainwater infiltrates into the ground. Development also increases the connectivity of paved surfaces and the storm drain system: roof downspouts, curbs, streets, and drainage pipes all flow directly to storms drains, which discharge directly to streams (rather than allowing runoff to flow over longer, slower surfaces before reaching the stream). So, not only does more water flow to creeks, but the pavement and storm drains speed the delivery of the increased runoff into the creeks. This results in a significant modification of the creek's hydrograph, which has been termed "hydromodification." Hydromodification can result in:

- Increased erosion of stream bed and banks
- Increased sediment deposition
- Loss of habitat
- Flooding
- Loss of riparian corridor and vegetation
- Loss of property.

A full discussion of the Phase I MS4 requirements to control increased runoff flow rates and durations from development projects is included in the Channel Incision section under Section 8.5 above. As stated in that section, the Water Board will use one (or more) of the following mechanisms to implement attenuation of peak flow rates and durations from new and redevelopment projects in the Sonoma Creek watershed: 1) the statewide Small MS4 Stormwater Permit (the reissued permit may include requirements for attenuation of peak flow rates and durations); 2) the regionwide Municipal Regional Stormwater Permit (MRP) (the Water Board could expand it to include Sonoma Creek watershed municipalities); 3) An individual stormwater permit for Sonoma Creek watershed municipalities; and 4) the statewide Construction General Permit, which is currently in the reissuance process (the reissued permit is anticipated to include requirements for post-construction control of increased stormwater runoff flows and durations).

State Highways Stormwater Program

The California Department of transportation (Caltrans) is responsible for runoff from state highways and associated construction activities. Discharges from state highways are regulated via a Statewide Stormwater Permit issued to Caltrans.

8.6 Habitat Enhancement Plan

In Sonoma Creek, as well as in many Bay Area watersheds, reducing the rate of fine sediment delivery to channels is a necessary action to support conservation and recovery of the steelhead fishery. In addition to reducing fine sediment supply, specific actions (including but not necessarily limited to the following) also are needed to:

- Prevent and reduce channel incision
- Enhance the physical habitat structure of mainstem Sonoma Creek and its tributaries by: a) increasing in-stream shelter, pools, and large woody debris; and b) by reversing the adverse impacts of channel incision on habitat complexity and connectivity
- Enhance summer baseflows
- Address fish barriers

The Habitat Enhancement Plan provides a framework that supports and integrates local restoration efforts (by watershed groups, landowners, and local agencies) to address key factors impacting salmonid species in the Sonoma Creek watershed. The Limiting Factors Analysis (SEC et al., 2006) and other information relevant to conservation and recovery of native fish and aquatic wildlife species in the watershed (USFWS, 1998) provide more detailed guidance on restoration measures and priorities.

Key goals of the Habitat Enhancement Plan are to increase habitat complexity and make progress towards a balanced sediment budget in Sonoma Creek and its tributaries. The water quality indicators we propose to measure progress towards these goals are described below.

Habitat Complexity

Water Quality Indicators

We propose the following water quality indicators that correspond to an improving trend in habitat complexity, and progress toward achievement of a balanced sediment budget (e.g., the amount of fine and coarse sediment input to a given channel reach is equal to the amount that is transported downstream). There should be an increasing trend through time in the percent of the length of mainstem of Sonoma Creek, and in the lower alluvial reaches of its tributaries, that attain the following conditions:

1. The bankfull channel width-to-depth ratio is ≥ 12:1, as needed to support formation of alluvial gravel bars (Jaeggi, 1984).

2. The average spacing between alluvial and/or forced gravel bars within the active channel is ≤ 7 times the width of the bankfull channel (Leopold, Wolman, and Miller, 1964).

3. Available shear stress at bankfull does not exceed the amount required to initiate motion of the streambed by more than approximately 20 percent; consistent with values in natural, stable gravel-bedded channel with low bedload sediment supply (Andrews, 1984).

4. Floodplain width is ≥ 4 times bankfull channel width, as defined above, consistent with the requirement for freely formed bed and banks for a sinuous wandering gravel-bed channel.

Also, there should be:

1. An increasing trend through time in the mean area and frequency of riffles and gravel bars within the mainstem channel; and

2. A decreasing trend through time in the percent of the length of the mainstem of Sonoma Creek and in the lower alluvial reaches of its tributaries, where banks or bed are hardened, and/or where constructed levees contribute to channel instability.

Background and Rationale

Accelerated rates of bed and bank erosion, as a consequence of channel incision, are the dominant human-caused sources of sediment that are delivered to Sonoma Creek (SEC et al., 2006), and the primary agent for habitat simplification of mainstem Sonoma Creek and in the lower alluvial reaches of its major tributaries (SEC et al., 2004). As a consequence of incision, the frequency and area of riffles and gravel bars has been greatly diminished, and the mainstem has been decoupled from its floodplain and side channels.[27] These changes greatly diminish the suitability of stream-riparian habitats for native fish and aquatic wildlife species. Also, such changes may cause substantial damage to streamside property, and present a significant risk of damage to key public works and streamside buildings, as the channel attempts to re-establish stability.

Although it may be possible to achieve a substantial reduction in bed and bank erosion rates through an engineering approach relying on structures to harden banks and control bed elevation (e.g., grade control), such an approach would present a significant risk of further damage to habitat complexity. Also, it is unclear whether such an approach ultimately would be effective in reducing erosion rates, and it would be quite costly to construct and maintain. Furthermore, such an approach has the potential to contribute to the persistence of chronic downstream flooding within the estuarine reach.[28]

In contrast, using a geomorphic approach to reduce bed and bank erosion rates has the potential to be effective both in reducing erosion rates and in partially reversing some of the impacts to habitat complexity that have occurred as a result of incision. However, adopting a geomorphic approach to restore channel stability probably also would have a greater impact on the land uses that could occur near the channel, and as such, potentially significant social, political, and economic constraints may influence feasibility.

Considering the degree to which habitat has been simplified by incision, from the standpoint of the attainment of water standards[29] the only feasible approach for reducing bed and bank erosion, is to adopt an approach that results in at least partial reversal of the adverse changes to habitat.

Strategy

We expect that watershed-based collaborative efforts, supported by incentive and funding programs, will accomplish many of the habitat enhancement actions needed to restore a healthy fishery. Groups and agencies such as the Sonoma Ecology Center, Parks Departments (State and County), RCD, and Sonoma County Water Agency have

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[27] Most of the valley floor was an active floodplain prior to incision during the historical period. The floodplain was inundated on an annual basis or more frequently. Side channels conveyed a large portion of the runoff and sediment supply to Sonoma Creek. Many of these side channels are now filled or perched above the mainstem, and therefore under current conditions, are no longer significant conduits for runoff or sediment transport.

[28] Loss of floodplains, simplification of channel form, and/or persistence of accelerated rates of bed and/or bank erosion, all may contribute to exacerbation of downstream flooding through less detention and/or faster routing of runoff and increased sediment load which has the potential to fill channels, and thereby reduce flood conveyance capacity.

[29] These include attainment of the water quality objective for population and community ecology, and the rare and cold freshwater habitat beneficial uses.

strong interest and history in implementing stream restoration, habitat enhancement, and landowner stewardship/education programs . The Sonoma Ecology Center and RCD are working collaboratively with an advisory committee to update the Sonoma Creek Watershed Enhancement Plan (WEP), which was first completed in 1997. Covering a wide range of watershed issues, the WEP identifies natural resource issues concerning residents, recommends a course of action to address those issues, and identifies information needs. The WEP shares common goals with the Habitat Enhancement Plan, including conserving and improving stream habitat. While the WEP update is currently in progress (anticipated to be completed in late 2009), we expect that it will incorporate the goals and implementation measures of the TMDL and Habitat Enhancement Plan. Such an updated and comprehensive WEP could provide a planning tool to develop and implement specific habitat enhancement projects.

The limiting factors analysis and habitat surveys identify several restoration priorities and potential projects, and these recommendations provide a good foundation for further developing restoration and habitat enhancement projects. In addition, habitat enhancement holds many benefits beyond restoring a healthy fishery, including easing long-standing flooding problems and enhancing recreational values and tourism.

Water Board staff are interested in working together with local stakeholders and agency partners in the Sonoma Creek watershed to explore the potential to plan and implement projects that will lead to a healthier creek. There are several grant programs administered by the Water Board that could provide partial funding to support stakeholder involvement, planning, research, and construction of channel enhancement projects. The next opportunity should be the Agricultural Water Quality Grant Program. We expect the State Board to release a request for proposals for the Agricultural Water Quality Grant Program in the spring of 2008.

Preventing and Reducing Channel Incision

At this time we do not intend to propose a regulatory permitting program to require channel restoration and resolve the many adverse ecological and water quality impacts of channel incision. However, channel incision supplies more than half of the sediment load to Sonoma Creek, and much of the load is fine sediment. Therefore, to achieve the TMDL, progress must be made in reducing sediment loads from channel incision.

Channel incision is a complex process, and solutions will require multiple approaches. We expect that existing and future permitting programs will help prevent additional incision as they require practices that will accelerate natural recovery (such as maintaining setbacks and preserving riparian corridors).

Existing channel incision must be addressed in a holistic way, on a reach basis, rather than property-by-property in most cases. Because stream processes work to balance energy, flow, and sediment, incision repair work on one bank or in one isolated section of a creek can have unintended and negative impacts on adjacent, crossbank, or downstream areas. Channel restoration must be done in a coordinated fashion, and it will be important to bring together all available technical expertise. Two reach-based landowner groups have formed recently in the adjacent Napa River watershed that are examining opportunities to enhance channel stability, water quality, and habitat conditions throughout approximately 12.5 miles of the mainstem of the Napa River. The first phase of project construction in the 4.5-mile long Rutherford reach is projected for the summer of 2009. Scientific studies and outreach to landowners and public agencies are underway in the 8-mile long Oakville-to-Oak Knoll reach to develop a conceptual plan for channel enhancement that will be completed before the end of this year. Although Napa River and Sonoma Creek differ in some important aspects, these projects may provide insights that could be applied to channel enhancement efforts in Sonoma Valley.

To control channel incision in a way that enhances habitat for fish and aquatic species, we recommend and support cooperative and coordinated actions by multiple landowners, planned and executed over significant distances along the river. To make efficient use of resources, projects should be planned and designed to provide multiple benefits, such as floodwater retention (by restoring floodplains), enhancing habitat (by encouraging pool formation), and bank stabilization. By creating stable banks, large-scale channel restoration project can also stabilize landslide areas and reduce sediment loads from landslides. Such large-scale, multi-benefit projects should be very competitive for grant funding as well as easier to manage.

The geomorphic analysis performed as part of the Sediment Source Analysis (SEC et al., 2006, Appendix C) provides useful information regarding the degree of channel incision and the amount of fine sediment exposed in stream banks. This analysis includes a map showing areas of high incision in the watershed, and estimates of percent fines in specific locations. This information could help to identify top priority sites for channel restoration.

Projects designed to Enhance Physical Habitat Structure

A high priority for restoring the steelhead fishery in Sonoma Creek is enhancing physical habitat structure, which would greatly increase the success of the juvenile rearing stage. (The need for enhancing physical habitat structure is also discussed in the Problem Statement section.) Enhancing physical habitat structure includes increasing: (1) riparian canopy; (2) large woody debris (both volume and frequency); and (3) frequency and depth of pools.

In the limiting factors analysis, SEC et al. (2006), identify installation of large woody debris structures and enhancement natural riparian vegetation along stream corridors as priority restoration measures. Installation of large woody debris structure is a more immediate means of improving pool habitat and increasing retention of gravels and cobbles, while stream revegetation constitutes a longer-term strategy for large woody debris recruitment and channel complexity. These measures are proposed because: a) recent surveys indicate a paucity of large wood in channels, low frequency of pools, and poor quality (depth and cover); and b) the very low amount of large woody debris documented in the habitat surveys is inferred to be substantially below natural reference values[30].

With regard to the restoration priorities identified in limiting factors analysis, it appears that large woody debris structures may be most effective in reaches where wood would be an effective agent for pool and bar formation under natural conditions, and where channel attributes are otherwise favorable for rearing steelhead. Therefore, a logical focus might be to enhance the homogeneous and simple habitat found in plane-bed channel reaches where flow is perennial and riparian canopy cover is good. Well-designed debris jams installed in plane-bed reaches should be effective in enhancing pool frequency and quality (e.g., pool depths are larger and more variable in wood-formed pools), and for enhancing retention of gravel by forcing a complimentary bar or backwater deposit (Buffington et al., 2002). Engineered debris jams also may be effective in pool-riffle reaches where they can increase frequency and quality of pools and sediment storage in bars. Although it is possible to design structures that could remain stable in deeply incised channels, such sites present several additional challenges.

The above discussion regarding the positive effects of adding wood with regard to increasing average pool volume and frequency also implies that adding wood may reduce the mean fraction of pool volume filled by fine sediment (Lisle and Napolitano, 1998). Or in other words by adding wood, the effects of fine sediment deposition in pools may be ameliorated. Similarly, adding wood as described above would increase retention of gravel, and therefore increase quantity of spawning habitat. It is difficult to evaluate how adding wood may influence the concentration of fine sediment in the streambed at potential spawning sites. However, by increasing the number of potential spawning sites, there should be more sites where substrate conditions are favorable. In summary, well-conceived additions of large wood also may have the potential to accelerate natural recovery of substrate conditions.

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[30] In central California stream channels, where riparian corridors are dominated by hardwoods, the amount of large woody debris in channels on public lands is on average is twice as high as the amount in channels on private lands (Opperman, 2007). In comparing frequency of wood documented in Sonoma Creek watershed habitat surveys to average values for similar channels surveyed by Opperman, we conclude there is a substantial deficit of woody debris in the Sonoma Creek watershed. Much lower amounts of woody debris in channels on private land surveyed by Opperman was explained by intensive efforts by landowners to cut or remove large debris from the channel, as it is perceived to cause bank erosion and flooding problems. Although these problems can occur in some locations, the larger scale effect of more natural rates of woody debris storage in channels are to enhance channel stability and habitat complexity (Montgomery et al., 2003). Considering the potential significance of management decisions by private landowners, an effective public outreach and education program, together with technical assistance should be considered as part of the longer-term effort to restore wood loading and functions in the Sonoma Creek watershed.

We are confident that physical habitat enhancement can be successfully planned and implemented through collaborative stakeholder efforts, because of the accomplishments already achieved. There is already a complete habitat inventory of Sonoma Creek, as a result of the work of Sonoma Ecology Center, Southern Sonoma RCD, and the California Department of Fish and Game. The results of the habitat surveys have been analyzed to identify top restoration priorities. Queries have been performed on the habitat survey data to identify potential restoration sites for increasing riparian canopy, increasing scour depth and shelter in pools, and increasing pool connectivity (SEC, 2003; SEC, 2007).

We recommend that interested landowners, groups, and agencies—such as the Water Board, Parks departments, DFG, Sonoma Ecology Center, and the RCD work together to take the existing data and develop a prioritized restoration plan to address the physical habitat-related factors limiting the steelhead population. Interested groups could pull their resources together to provide technical expertise, assist with landowner education, and seek or provide funding.

Enhance Summer Base Flows

Many of Sonoma Creek's tributaries dry up in the summer, resulting in long reaches of dry stream and direct mortality to fish as pools dry up. Stranding by low flows (or no flow) has created the greatest source of mortality directly observed in the course of habitat surveys, with surveyors observing thousands of dead fry in dry pools (SEC et al., 2004).

We do not know of any major exports of Sonoma Creek water outside of the watershed. It is likely that in-watershed groundwater use, creek and stream diversions, and increased impermeable surfaces within the watershed have contributed to low summer flows. Enhancing summer base flows will require collaboration among many interests in the watershed. Two ways of increasing summer base flows are: 1) decreasing groundwater use, and 2) increasing groundwater recharge.

The Basin Advisory Panel (a collaborative group represented by local agriculture, government, business, dairies, and environmental interests) guided the development of the Sonoma Valley Groundwater Management Plan (SCWA, 2007), which was adopted by the Sonoma County Water Agency in late 2007. We support those elements of the groundwater management plan that address stream base flow. The objectives of the plan include managing groundwater resources by: 1) maintaining groundwater levels for the support of beneficial uses, 2) increasing water recycling and conservation in order to enhance summer base-flows, 3) identifying and protect groundwater recharge areas, 4) enhancing the recharge of groundwater where appropriate; and 5) protecting against adverse interactions between groundwater and surface water flows. (Sonoma County Water Agency website, http://www.scwa.ca.gov/projects/svgroundwater/management_plan.php)

We support and look forward to participating in collaborative efforts to conserve water and enhance groundwater recharge. One of the first steps may be to identify potential groundwater recharge areas and develop pilot projects.

Address Fish Barriers

Man-made barriers to fish passage prevent adult steelhead and Chinook salmon access to approximately 25 percent of the watershed stream length, according to the limiting factors analysis (SEC et al., 2004, Appendix J). The study identified 22 full barriers that cause an estimated 21,000 acres (170 miles of stream length) to be inaccessible to fish. In addition, there are 48 identified partial (flow-dependent) barriers (*ibid*.).

In the Sonoma Creek watershed, most barriers are due to road crossings and removing barriers can be achieved by retrofitting or replacing problem structures. Approaches for retrofitting culverts include reducing the height fish need to jump to enter the culvert, and increasing flow depths inside the culvert. During replacement of structures, guidance from DFG or FishNet 4C (FishNet 4C et al., 2004) should be followed to ensure that the new crossing is not a barrier to fish passage. High priority barriers for removal/replacement include those that have the best upstream habitat that would otherwise be available to fish, those where barrier removal is consistent with local management priorities, and barriers where removal is feasible and habitat disturbance can be minimized.

There exists in the watershed momentum and experience in fish passage barrier removal projects. Barrier removal projects are already being undertaken in the watershed. Sonoma Ecology Center has initiated barrier removal projects on Asbury, Mill, and Calabazas Creeks. In addition the Southern Sonoma Resource Conservation District has removed a partial barrier on Carriger Creek. Sonoma County also has an active program to make sure replacement structures are fish friendly (SEC et al., 2004).

To continue to make progress in removing fish passage barriers, we recommend a collaborative approach. The Water Board and other interested groups should work together to prioritize barrier removals, provide technical assistance, and provide or seek funding opportunities. Because Sonoma Creek is designated as a Critical Coastal Area[31], additional resources and funding may be available.

[31] "The Critical Coastal Area (CCA) Program, part of the state's NPS Plan, is a non-regulatory planning tool to coordinate the efforts of multiple agencies and stakeholders, and direct resources to CCAs. The program's goal is to ensure that effective NPS management measures are implemented to protect or restore coastal water quality in CCAs. CCA identification supports the acquisition of grant funding by prioritizing protection efforts." –Critical Coastal Areas website: http://www.coastal.ca.gov/nps/Web/cca_project.htm

Table 7. Proposed Trackable TMDL Implementation Measures for Sediment Discharges Associated with Vineyards

Sources and Performance Standards	Actions	Implementing Parties	Completion Dates
Surface Erosion associated with vineyards: Comply with the Sonoma County Vineyard Erosion and Sediment Control Ordinance (Sonoma County Code, Chapter 30, Article V) and minimize erosion from existing vineyards; **and** **Roads**: Road-related sediment delivery to channels ≤ 120 tons per road mile per 20-year period[3,4]; **and** **Gullies and/or shallow landslides:** Promote natural recovery and minimize human-caused increases in sediment delivery from unstable areas; **or** Implement farm plan certified under Fish Friendly Farming Environmental Certification Program or other farm plan certification program approved as part of WDRs waiver conditions.	Submit a Report of Waste Discharge[1] to the Water Board that provides, at a minimum, the following: a description of the vineyard; identification of site-specific erosion control measures needed to achieve performance standard(s) specified in this table; and a schedule for implementation of identified erosion control measures.	Vineyard owner and/or operator	June 2014
	Comply with applicable waste discharge requirements (WDRs) or waiver of WDRs.	Vineyard owner and/or operator	As specified in applicable WDRs or waiver of WDRs
	Report progress on implementation of site specific erosion control measures.[2]	Vineyard owner and/or operator	As specified in applicable WDRs or waiver of WDRs

[1] Or compliance with applicable conditional waivers of WDRs that may be adopted by the Water Board.
[2] Reports may be submitted individually or jointly through a recognized third party.
[3] To achieve 82 percent reduction, from current estimate of 34 tons per mile per year, as needed to meet the sediment load allocation for road-related sediment delivery.
[4] Performance standard for road-related sediment delivery of 120 tons per mile per 20-year period, is equivalent to a 20-year average rate of 6 tons per mile per year.

Table 8. Proposed TMDL Implementation Measures for Sediment Discharges Associated with Grazing

Source(s) and Performance Standard(s)	Actions	Implementing Parties	Completion Dates
Surface erosion associated with livestock grazing: Attain or exceed minimal residual dry matter values consistent with University of California Division of Agriculture and Natural Resources guidelines; **and** **Roads**: Road-related sediment delivery to channels ≤ 120 tons per road mile per 20-year period[3,4] **and** **Gullies and/or shallow landslides**: Promote natural recovery and minimize human-caused increases in sediment delivery from unstable areas	Submit a Report of Waste Discharge[1] to the Water Board that provides, at a minimum, the following: description of the property; identification of site-specific erosion control measures to achieve performance standard(s) specified in this table; and a schedule for implementation of identified erosion control measures.	Landowner and/or ranch operator	June 2014
	Comply with applicable waste discharge requirements (WDRs) or waiver of WDRs.	Landowner and/or ranch operator	As specified in applicable WDRs or waiver of WDRs
	Report progress on implementation of site specific erosion control measures.[2]	Landowner and/or ranch operator	As specified in applicable WDRs or waiver of WDRs

[1] Or compliance with applicable conditional waivers of WDRs that may be adopted by the Water Board.
[2]These reports may be prepared individually or jointly or through a recognized third party.
[3]To achieve 82 percent reduction, from current estimate of 34 tons per mile per year, as needed to meet the sediment load allocation for road-related sediment delivery.
[4]Performance standard for road-related sediment delivery of 120 tons per mile per 20-year period, is equivalent to a 20-year average rate of 6 tons per mile per year.

Table 9. Proposed TMDL Implementation Measures for Sediment Discharges Associated with Rural Lands [1]

Sources and Performance Standards	Actions	Implementing Parties	Completion Dates
Roads: Road-related sediment delivery to channels ≤ 120 tons per road mile per 20-year period[4,5]; **and** **Gullies and/or shallow landslides**: Promote natural recovery, and minimize human caused increases in sediment delivery from unstable areas.	Submit a Report of Waste Discharge[2] to the Water Board that provides, at a minimum, the following: description of the property; identification of site-specific erosion control measures to achieve performance standard(s) specified in this table; and a schedule for implementation of identified erosion control measures.	Landowners	June 2014
	Comply with applicable Waste Discharge Requirements (WDRs) or waiver of WDRs.	Landowners	As specified in applicable WDRs or waiver of WDRs
	Report progress on implementation of-site specific erosion control measures.[3]	Landowners	As specified in applicable WDRs or waiver of WDRs

[1]Rural lands include: non-farmed and non-grazing portions of parcels >10 acres that contain one or more residences, and/or a winery; vacant residential parcels >10 acres; and/or portions of 10-acres or larger parcels with secondary vineyard, orchard, and/or grazing.
[2] Or compliance with applicable conditional waivers of WDRs that may be adopted by the Water Board
[3] These reports may be prepared individually or jointly or through a recognized third party.
[4]To achieve 82 percent reduction, from current estimate of 34 tons per mile per year, as needed to meet the sediment load allocation for road-related sediment delivery.
[5]Performance standard for road-related sediment delivery of 120 tons per mile per 20-year period, is equivalent to a 20-year average rate of 6 tons per mile per year.

Table 10. Proposed TMDL Implementation Measures for Sediment Discharges associated with Parks and Open Space, and/or Municipal Public Works

Landowner Type	Sources and Performance Standards	Actions	Implementing Parties	Completion Dates
PARKS AND OPEN SPACE AND PUBLIC WORKS	**Roads**: Road-related sediment delivery to channels ≤ 120 tons per road mile per 20-year period[3,4]; **and** **Gullies and/or shallow landslides**: Promote natural recovery, and minimize human caused increases in sediment delivery from unstable areas.	Submit a Report of Waste Discharge[1] to Water Board that provides, at a minimum, the following: description of the road network and/or segments; identification of erosion and sediment control measures to achieve performance standard(s) specified in this table; and a schedule for implementation of identified control measures. For paved roads, erosion and sediment control actions could primarily focus on road crossings to meet the performance standard. Adopt and implement best management practices for maintenance of unimproved (dirt/gravel) roads, and conduct a survey of stream-crossings associated with paved public roadways, and develop a prioritized implementation plan for repair and/or replacement of high priority crossings/culverts to reduce road-related erosion and protect stream-riparian habitat conditions.	Sonoma County Stormwater Management Program (SWMP) State of California, Department of Parks and Recreation State of California, Department of Transportation County of Sonoma Transportation and Public Works	June 2014
		Comply with applicable Waste Discharge Requirements (WDRs) or waiver of WDRs.	Landowners	As specified in applicable WDRs or waiver of WDRs, and/or the SWMP

Landowner Type	Sources and Performance Standards	Actions	Implementing Parties	Completion Dates
		Report progress on development and implementation of best management practices to control road-related erosion.[2]	Landowners	As specified in applicable WDRs or waiver of WDRs, and/or SWMP

[1] Or compliance with applicable conditional waivers of WDRs that may be adopted by the Water Board.
[2]These reports may be prepared individually or jointly or through a recognized third party.
[3]To achieve 82 percent reduction, from current estimate of 34 tons per mile per year, as needed to meet the sediment load allocation for road-related sediment delivery.
[4]Performance standard for road-related sediment delivery of 120 tons per mile per 20-year period, is equivalent to a 20-year average rate of 6 tons per mile per year.

Table 11. Proposed TMDL Implementation Measures for Sediment Discharges associated with Urban Land Uses

Source	Performance Standards	Actions	Implementing Parties	Completion Dates
Construction Stormwater Runoff	Control and minimize sediment and erosion from construction sites through appropriate use of Best Management Practices.	Comply with the requirements of the *General Permit for Discharges of Storm Water Associated with Construction Activity* (NPDES Permit No. CAS000002) or updated versions of the Construction General Permit. Develop, maintain, and implement a Storm Water Pollution Prevention Plan (SWPPP) that describes BMPs to be used to control erosion and sedimentation. Develop and implement a sediment monitoring plan if the construction site discharges directly to Sonoma Creek or its tributaries.	Owners or Operators of Sites under Construction	As specified in the Construction General Permit (NPDES Permit No. CAS000002)
Industrial Stormwater Runoff	Control discharges from industrial facilities to the standard of "best available technology economically achievable" and the "best conventional pollutant control technology."	Comply with the *Industrial Stormwater General Permit* (NPDES Permit No. CAS000001). Develop a SWPPP and monitoring plan to identify sources of pollutants (including sediment) and the means to control them to reduce stormwater pollution.	Owners or Operators of Industrial Facility Sites	As specified in the Industrial Stormwater General Permit (NPDES Permit No. CAS000001)

Source	Performance Standards	Actions	Implementing Parties	Completion Dates
Municipal Stormwater Runoff	Reduce discharge of pollutants, including sediment, to the maximum extent practicable (MEP).	Comply with approved stormwater management plans. Comply with Municipal Stormwater Permit (NPDES Permit No. CAS000004).	Sonoma County Water Agency, County of Sonoma, City of Sonoma, Sonoma Developmental Center, and any other designated entities	As specified in approved stormwater management plan and in applicable NPDES permit (NPDES Permit No. CAS000004).
	Attenuate peak flows and durations from new and redevelopment projects to MEP standards.	Amend and implement stormwater management plans to control peak flow rates and durations	Sonoma County Water Agency, County of Sonoma, City of Sonoma, Sonoma Developmental Center, and any other designated entities	No later than June 2014
State Highways Stormwater Runoff	Control runoff from state highways and associated construction activities.	Comply with the *Statewide Stormwater Permit* (NPDES Permit No. CAS000003).	California Department of Transportation (Caltrans)	As specified in applicable NPDES permit (NPDES Permit No. CAS000003).

Table 12. Recommended Actions to Reduce Sediment Load and Enhance Habitat Complexity in Sonoma Creek and its Tributaries

Recommended Action	Management Objective(s)	Actions	Implementing Parties	Completion Dates and Notes
Prevent and Reduce Channel Incision	Reduce rates of sediment delivery (associated with incision and associated bank erosion) to channels, by 80 percent Enhance channel habitat as needed to support self-sustaining run of steelhead and enhance the overall health of the native fish community. Stabilize channel banks and riparian areas to reduce sediment loads from landslides	1.1 Develop and prioritize channel restoration projects to address unstable areas, based on level of incision and/or landslide instability	Landowners and/or designated agents, and reach-based stewardships	Comply with conditions of Clean Water Act Section 401 certifications
Enhance Physical Habitat Structure	Enhance quality of rearing habitat for juvenile salmonids by increasing riparian canopy, large woody debris, and frequency and depth of pool habitat.	1.2 Develop, prioritize, and implement plans to increase channel complexity, including increasing riparian canopy, pool habitat, and large woody debris	Landowners and/or designated agents, and reach-based stewardships	

Table 13. Recommended actions to protect or enhance baseflow

<table>
<tr><th>Recommended Action</th><th>Management Objective</th><th>Action(s)</th><th>Implementing Parties</th><th>Schedule/Notes</th></tr>
<tr><td rowspan="2">Enhance Summer Base Flows</td><td rowspan="2">Maintain suitable conditions for juvenile rearing, and smolt migration to Sonoma Creek estuary</td><td>2.1. Implement a groundwater management plan to: 1) maintain groundwater levels for the support of beneficial uses, 2) increase water recycling and conservation in order to enhance summer base-flows, 3) identify and protect groundwater recharge areas, 4) enhance the recharge of groundwater where appropriate; and 5) protect against adverse interactions between groundwater and surface water flows.</td><td>Sonoma County Water Agency, Valley of the Moon Water District, City of Sonoma, Basin Advisory Panel[1], and interested collaborators</td><td>The Sonoma Valley Groundwater Management Plan[2] was adopted by the Sonoma County Water Agency in November 2007. The plan includes an implementation schedule to achieve actions 2.1 and 2.2.</td></tr>
<tr><td>2.2. Identify potential groundwater recharge areas and develop pilot projects</td><td>Sonoma County Water Agency, Valley of the Moon Water District, City of Sonoma, Basin Advisory Panel[1], and interested collaborators</td><td>As described above</td></tr>
<tr><td colspan="5">[1]The Basin Advisory Panel was formed to act as the groundwater management plan stakeholder group for the Sonoma Valley Basin
[2] The Sonoma Valley Groundwater Management Plan (developed by the Sonoma County Water Agency, Valley of the Moon Water District, and City of Sonoma) is a non-regulatory plan aimed at locally managing, protecting, and enhancing groundwater resources.</td></tr>
</table>

Table 14 Recommended Actions to Restore to Fish Passage

Recommended Action	Management Objective(s)	Action(s)	Implementing Parties	Schedule/Notes
Address Fish Passage Barriers	No significant structural impediments to salmonid migration or passage in mainstem or key tributaries Reduce the number of stream miles inaccessible to fish	3.1 Design, replace or retrofit road crossings to allow fish passage according to fish-friendly guidance such as those developed by FishNet 4C , Department of Fish and Game, or other appropriate entity with expertise in salmonid habitat restoration.	Local public agencies, watershed groups and landowners	
		3.2. Develop, prioritize, and implement plans to remove identified barriers to fish passage	Local public agencies, watershed groups, and landowners	

8.7 Evaluation and Monitoring

In collaboration with stakeholders[32] in the watershed, Water Board staff will develop a detailed monitoring program to assess progress of TMDL attainment and provide a basis for reviewing and revising TMDL elements or implementation actions. As an initial milestone, by fall 2011, the Water Board and watershed partners will complete monitoring plans to evaluate: a) attainment of water quality targets; and b) suspended sediment and turbidity conditions. Initial data collection, based on the protocols established in these monitoring plans may begin in the winter of 2011-2012.

As a whole, the objectives of the monitoring program are to:

1. *Assess channel response and progress towards achieving water quality targets*. In-channel effectiveness monitoring[33] will be conducted to evaluate: a) progress toward achieving water quality targets, and b) channel response to management measures and natural processes. Parameters that will be monitored to assess progress toward achieving water quality targets are streambed permeability, pool filling, and percent fines composition of the substrate. The number of sites to be monitored will be selected based on availability/presence of the applicable habitat feature (i.e. spawning gravels and pools), as well as the number of samples needed to have a high degree of statistical confidence in estimated values. Frequency of monitoring should be once every five years, at a minimum, for streambed permeability and pool filling. If resources are available, desired monitoring frequency for all TMDL target parameters is once every two to three years. Pool filling should be monitored every two to three years to allow a trend analysis. The Water Board may propose alternative water quality parameters and/or numeric target values at a future date as part of the adaptive implementation process, when/if information becomes available to conclude with a high degree of confidence that one or more alternative parameters or target values provide a superior basis for determining attainment of water quality objectives for sediment, and the protection of fisheries-related beneficial uses.
2. *Further evaluate potential impacts of suspended sediment and related turbidity*. To further study potential impacts of suspended sediment and related turbidity, monitoring of turbidity should continue. The Sonoma Ecology Center maintains a continuous and automated monitoring station at the Sonoma Valley Watershed Station in Eldridge, CA. Monitoring of suspended sediment should continue to further understanding of turbidity and suspended sediment concentrations in ambient conditions, and during and after storms. Turbidity/suspended sediment data should be analyzed to determine the length of time it takes for turbidity levels to drop to pre-storm levels (or 20 NTU or below) after a storm event. We would then compare Sonoma Creek's clearing times to what we would expect in

[32] Ideally, the monitoring plan would be developed in partnership with: a) local experts (e.g., Sonoma Ecology Center, Southern Sonoma RCD) who have familiarity with watershed conditions, monitoring expertise, and cooperative relationships with landowners; and b) other public agencies whose policies and actions may be affected by the results of the TMDL monitoring program (e.g., County of Sonoma, California Department of Fish and Game, and National Marines Fisheries Service)

[33] Effectivness monitoring is used to assess whether the sediment control measures had the desired effect.

an unimpaired stream, which is that streams clear to pre-storm levels, approximately 20 NTU, within a day or two. In addition, turbidity/suspended sediment data should be analyzed using the Newcombe and Jensen severity index method, which relates exposure to various suspended sediment concentrations to impact on fish (Newcombe and Jensen, 1996).

We expect that as sediment reduction and habitat enhancement measures (including reducing channel incision) are undertaken, suspended sediment concentrations and turbidity levels will decrease. This expectation should be confirmed with continued turbidity monitoring. In addition, turbidity monitoring can provide information regarding the effectiveness of sediment reduction measures because it is a sensitive measure of the effects of land use on streams (NCRWQCB, 2006).

3. *Assess whether required sediment reduction measures are undertaken.* Implementation monitoring[34] will be conducted by landowners or designated agents, per the compliance monitoring and reporting provisions of applicable waivers of Waste Discharge Requirements, Waste Discharge Requirements, and NPDES permits.

4. *Evaluate effectiveness of selected sediment reduction measures (both structural and management-related.* The Water Board will conduct upslope effectiveness monitoring to evaluate sediment delivery to channels from land use activities and natural processes. The first sediment source analysis update will occur by 2020, when sediment delivery associated with human activities may be reduced by 25 percent or more. A subsequent update may occur, assuming the water quality targets for sediment are not already achieved, by 2025, when sediment supply associated with human activities may be reduced by 40 percent or more. An additional goal for future updates of the source analysis is to reduce uncertainty associated with estimates of sediment delivery rates. We hope to develop estimates of sediment delivery rates for all sources identified in Table 2, except for urban stormwater, to a level of accuracy such that estimated sediment delivery rates are within a factor of two or less of actual values.

5. *Evaluate effectiveness of recommended habitat enhancement measures and assess progress towards goals of the Habitat Enhancement Plan.* The Water Board and local partners should monitor habitat complexity-related water quality indicators to assess progress towards achievement of a balanced sediment budget (where the amount of fine and course sediment input to a given channel reach is equal to the amount that is transported downstream).

   Monitoring should occur to determine whether there is an increasing trend in the percent of the length of mainstem of Sonoma Creek, and in the lower alluvial reaches of its tributaries, that attain the following conditions:

   a) The bankfull channel width-to depth ratio is $\geq$12:1.

   b) The average spacing between alluvial and/or forced gravel bars within the active channel is $\leq$ times the width of the bankfull channel.

[34] Implementation monitoring ensures that identified management actions (such as BMPs) are undertaken, and provides information on whether BMPs are being installed or implemented as intended.

c) Available shear stress at bankfull flow does not exceed the amount required to initiate motion of the streambed by more than approximately 20 percent.

d) Floodplain width is $\geq$ 4 times bankfull channel width.

Monitoring should also assess whether there is:

e) An increasing trend through time in the mean area and frequency of riffles and gravel bars within the mainstem channel; and

f) A decreasing trend through time in the percent of the length of the mainstem of Sonoma Creek, and in the lower alluvial reach of its tributaries, where banks or bed are hardened, and/or where constructed levees contribute to channel instability.

Rationale for these water quality indicators and conditions is found in Section 8.6 Habitat Enhancement Plan.

8.8 Adaptive Implementation

In concert with the monitoring program, described above, the Sonoma Creek Sediment Reduction and Habitat Enhancement Plan and TMDL will be regularly updated. Results of in-progress or anticipated studies that enhance understanding of the population status of steelhead trout in the Sonoma Creek watershed, and/or factors controlling those populations, may also trigger changes to the plan and TMDL. At a minimum, data in response to the following questions will be considered to guide research and monitoring efforts and focus each subsequent update of the TMDL.

Key Questions to be considered in the course of Adaptive Implementation:

- What is the population status of steelhead in the watershed? Do we see an increase in the number or percentage of steelhead that survive past the juvenile rearing life stage as sediment reduction and habitat enhancement measures are implemented?
- Are Sonoma Creek and its tributaries progressing toward TMDL targets as expected? If there has not been adequate progress, how might the implementation actions, targets or allocations be modified?
- What are expected benefits of various actions to enhance habitat for steelhead? Which actions, and in which locations, would enhancement measures have the most benefit and be the most cost-effective?
- Are the specified sediment reduction measures and recommended habitat enhancement measures resulting in an improving trend in channel stability?
- What affect will climate change have on hydrology, sediment transport, and habitat for the watershed’s aquatic species? How will climate change effect the outcome of required and recommended measures, and how should these measured be adjusted in response?

- Are there new data or information available that warrants revision of water quality targets, allocations, or implementation measures?

Chapter 9: Regulatory Analyses

9. 1. Introduction

This section of the Staff Report presents the results of an environmental impact analysis required under the California Environmental Quality Act (CEQA) and a discussion of economic considerations in compliance with Pubic Resources Code § 21159 [a]. The environmental impact analysis evaluates the reasonably foreseeable environmental impacts of the implementation measures identified in the Implementation Plan (see Section 8). The discussion of economic considerations reviews the costs associated with methods that may be used to implement the TMDL. These analyses and the rest of the Staff Report constitute a Substitute Environmental Document (SED), which provides public information about the project and review of the impacts, mitigation, and alternatives to the TMDL as proposed.

The results of the analyses of environmental impacts and economic considerations show that the TMDL is not likely to result in long-term, significant impacts and will not cause immediate, large scale expenditures by the entities required to implement the TMDL. Much of the implementation plan of the TMDL is built on existing efforts to reduce erosion and sedimentation and to improve riparian habitat. With regard to environmental impacts, many of the potential individual projects that may be developed to implement the TMDL would be required to use Best Management Practices (BMPs) and mitigation as mandatory conditions of required permits. These BMPs and other forms of mitigation, which are both feasible and already in common use, are expected to reduce most potentially significant impacts to less than significant levels. The Water Board staff further anticipates that under existing state and federal policies and permitting requirements, environmental impacts stemming from projects related to the Sonoma Creek Sediment TMDL will be avoided and minimized as much as feasible.

9.2 Peer Review

The scientific basis for the proposed TMDL has undergone external scientific peer review pursuant to §57004 of the Health and Safety Code. This regulation specifies that an external review is required for the scientific basis for any rule proposed by the Board. It defines "scientific basis" as "the foundations of a rule that are premised upon, or derived from empirical data or other scientific findings, conclusions, or assumptions establishing a regulatory level, standard or other requirement for the protection of public health or the environment." Water Board staff sent the Project Report (dated November 16, 2007) to two scientific peer reviewers with expertise in river ecology, geomorphology, and fisheries biology: Dr. Peter Goodwin and Dr. Susan Bolton. Dr. Goodwin's responses confirmed that the rule is based on sound science, commenting "The rule appears to be a good-faith effort to bring the best available knowledge to protect beneficial uses in a fair manner." Dr. Bolton commented that the scientific studies providing the background for the TMDL (i.e. Limiting Factors Analysis and Sediment Source Analysis) used standard methods and were well documented. Both reviewers commented that the problem statement needed additional clarification/justification, and Dr. Goodwin also commented that clarification is needed with regard to the locations where numeric targets are applicable. Water Board staff have revised the staff report to incorporate many of the peer reviewers' comments and suggestions. Water Board staff's specific responses to peer reviewers' comments will be contained in a document to be completed in Spring 2008.

Organization of this Section

The remainder of this section of the Staff Report is organized into three main parts: 1) the Environmental Analysis, 2) Alternatives Analysis; and 3) Economic Considerations.

The Environmental Analysis considers impacts of the proposed Basin Plan amendment and reasonably foreseeable environmental impacts of activities undertaken to implement the TMDL. An Environmental Checklist is used as the framework for the analysis which includes a discussion of the potential environmental impacts as well as probable mitigation measures that could be used to eliminate or reduce the environmental impacts. Because the Water Board cannot mandate adoption of any specific implementation methods or projects, the analysis of the potential environmental impacts of the TMDL provided here is at a general level of detail. Specific projects that may be proposed to implement the sediment TMDL may be subject to review under CEQA, as well as relevant permitting procedures by local, state and federal agencies as site-specific details of proposed actions are developed. Our analysis is a general review of likely impacts and mitigation measures based on our best knowledge of the required TMDL actions and our analysis of reasonable foreseeable compliance measures.

The second section of this regulatory analysis presents several alternatives to the proposed Basin Plan amendment. The evaluation of alternatives is required under the Water Boards Basin Planning Certified Regulatory Project under CEQA Section 15252 (a)(2)(A)to avoid or reduce any significant or potentially significant effects on the environment.

The final section provides a discussion of economic considerations or costs associated with various measures described by the TMDL's Implementation Plan. Again, it should be noted that the TMDL is not prescriptive; no specific actions to achieve the numeric target are required, rather dischargers are allowed to independently select implementation actions to meet their allocations based on their own considerations of need, budget, feasibility, or other criteria. As a result, the discussion of costs is limited to those actions that are currently technically feasible and those that dischargers are most likely to adopt.

9.3. Environmental Impact Analysis: CEQA Compliance

The Water Board is the Lead Agency responsible for evaluating the potential environmental impacts of the proposed Basin Plan amendment to establish the TMDL for sediment in Sonoma Creek. Under the provisions of Section 21080.5 of the California Public Resources Code, the California Secretary for Resources has the authority to certify the regulatory programs of state agencies as exempt from the requirements of preparing environmental impact reports (EIRs) and related documents, if the Secretary finds that the program meets the criteria specified in that section of the code. The Basin Planning process of the Water Board is certified as such a program as described and listed in Section 15251 (g) of CEQA.

Although the Water Board is not required to complete an environmental impact report, it is not given a complete exemption from the provisions of CEQA; it must still comply with the other provisions of CEQA, such as the policy of avoiding significant adverse effects on the environment where feasible. In order to demonstrate compliance with these requirements, we have produced this Substitute Environmental Documentation (SED) that, together with the Basin Planning process, fulfills the requirements of CEQA.

To satisfy CEQA's recommendation to engage the public and interested parties in early consultation about the scope of the environmental analysis, a scoping meeting was held at the Sonoma Community Center on October 3, 2007.

This section of the Staff Report contains the environmental checklist for the proposed Basin Plan amendment and includes the required analyses mentioned above. The explanation following the checklist provides details concerning the environmental impact assessment. Based on this analysis, Water Board staff concludes that adoption of the proposed Basin Plan amendment would not cause any significant adverse environmental impacts.

Project Description

As discussed in sections 7 and 8 of the Staff Report, the proposed project is a proposed Basin Plan amendment that would establish a sediment TMDL for Sonoma Creek and an implementation plan to achieve the TMDL and related habitat enhancement goals. The bases of the TMDL are numeric targets, described in Section 5 of the Staff Report for streambed permeability, pool filling and substrate composition, selected to be protective of fishery beneficial uses. The TMDL assigns wasteload and load allocations to dischargers that, over time, will ensure the target is reached. The primary objective of the project is to achieve the targets specified by the TMDL in order to restore currently impaired beneficial uses in Sonoma Creek and its tributaries.

Sediment sources and land use categories identified in the TMDL include vineyards; grazing lands; rural lands; parks, open space, and public works; and urban lands (as described in Section 6 of the staff report). The Basin Plan amendment calls for a variety of actions to reduce fine sediment inputs from these sources to Sonoma Creek and its tributaries, enhance habitat access for steelhead, and to enhance stream-riparian habitat complexity. In addition, the Basin

Plan amendment includes a Habitat Enhancement plan that includes reference to local collaboration and regional planning efforts to reduce channel incision, enhance physical habitat structure, enhance summer base flow, and reduce barriers to fish passage. These actions are described in the TMDL Implementation Plan (described in Section 8 of the Staff Report and in the Basin Plan Amendment in Tables 4.1-5.3) and are summarized below.

The proposed Basin Plan amendment contains sediment allocations for dischargers and discharge categories. As the Water Board is limited in prescribing the manner of compliance with its water quality orders, the Basin Plan amendment does not prescribe specific projects through which dischargers and discharge categories are to meet the sediment allocations.

The implementation plan would require actions to reduce sediment discharges associated with key sources: vineyards; grazing lands; rural lands; and parks and open space and/or municipal public works. Required actions by landowners include 1) submittal of reports of waste discharge (ROWDs); 2) compliance with waste discharge requirements (WDRs) or WDR waiver conditions; and 3) implementation of best management practices to reduce sediment discharges.

Reasonably Foreseeable Methods of Compliance

The proposed Basin Plan amendment will require some dischargers to submit a Report of Waste Discharge; conduct various resource and/or infrastructure inventories; and develop sediment reduction plans. These early implementation actions are not associated with direct physical changes to the environment. It is the implementation of erosion and sediment control plans, best management practices, and habitat enhancement plans that could result in adverse impacts to the environment. Only implementation measures that involve a physical change in the environment are reviewed in this analysis. Implementation actions or performance standards included in the proposed Basin Plan amendment (Tables 4.1-5.3) may be achieved though a range of reasonably foreseeable compliance measures that would be associated with physical changes to the environment. Potential compliance measures that could result from actions described in the proposed Basin Plan amendment implementation plan are identified in Table 15, below. Environmental Impacts of these reasonable foreseeable compliance measures are evaluated in the environmental checklist and analysis.

Until the parties that must comply with requirements derived from the Basin Plan amendment propose specific projects, many physical changes cannot be anticipated. That said, it is reasonably foreseeable that the following activities may take place to comply with the Basin Plan amendment: 1) minor construction, 2) earthmoving, 3) enhancement of summer baseflow; and 4) installation and maintenance of stream habitat enhancement features. Although these activities are reasonably foreseeable methods of compliance, the implementation plan does not specify the nature of these actions. Therefore, this analysis considers these actions in general terms. To illustrate the possible nature of these activities, some examples are described following the table.

- ***Minor construction***. Basin Plan amendment-related construction projects would generally be small. Examples may include: a) *detention basins* to capture sediment and/or reduce surface runoff during storms; b) *bio-swales* to deposit sediment entrained in surface runoff; c) *retrofit or replacement of road crossings* over stream channels to increase capacity to convey peak runoff and/or to provide suitable conditions for fish migration; d) *water bars, cross-drains, and/or surfacing of roads* to reduce road-surface and/or inboard ditch erosion; e) *engineered log jams* to enhance stream habitat complexity; and/or f) *minor fencing* adjacent to some stream reaches or actively eroding gullies in rangelands to accelerate re-establishment of native scrub and tree cover (as may be needed to reduce erosion rates).

- ***Earthmoving operations***. Approval of the Basin Plan amendment would result in earthmoving to reduce fine sediment supply to Sonoma Creek and its tributaries. For example, earthmoving to reduce road-related erosion may involve re-contouring the surface of some dirt roads to disperse concentrated runoff, terracing steep slopes and banks to reduce erosion rates, and/or reconstruction or relocation of road segments to avoid landslides. Earthmoving may also be employed to reduce erosion rates and enhance stream habitat complexity in the Sonoma Creek and lower reaches of its larger tributaries. Also, some actions undertaken to stabilize gullies or landslides, and/or to enhance stream channel habitat may involve earthmoving.

- ***Enhance summer baseflows.*** The Basin Plan amendment may contribute to the development of plans and policies to maintain groundwater levels in Sonoma Creek and its tributaries to support summer fisheries. Future groundwater management plans may include increased water recycling and conservation, protection of groundwater resources, and enhanced groundwater recharge.

- ***Installation and maintenance of stream habitat features.*** Adoption could lead to planting of riparian vegetation and an increase in the number of stream habitat structures installed in Sonoma Creek and its tributaries. Example habitat enhancement structures include log jams, step-pools, willow waddles, log crib walls, and rock work.

These examples are not intended to be exhaustive or exclusive. Several conceivable actions that could be taken as a result of the Basin Plan amendment require speculation, and therefore, cannot be evaluated. For example, although the implementation plan recognizes planning efforts among local, state, and federal government agencies to enhance water supply reliability and instream flows for steelhead, actual outcomes and specific actions resulting from the proposed partnerships are too speculative to determine at this time. Also, as discussed above, even in cases where some physical changes are foreseeable, the exact nature of these changes is often speculative pending specific project proposals that will be ultimately put forth by those subject to requirements derived from the Basin Plan amendment.

While the Water Board would not directly undertake any actions that could physically change the environment, adoption of the proposed Basin Plan amendment would result in future actions by landowners, municipalities and other agencies to comply with the requirements of the Basin Plan amendment and that may result in a physical change to the environment. The environmental impacts of such physical changes are evaluated below, to the extent that they are reasonably foreseeable. Changes that are speculative in nature are difficult to analyze and, as such, do not require environmental review.

Table 15: Reasonably Foreseeable Compliance Measures

TMDL Actions	Reasonably Foreseeable Compliance Measures*	Implementation Mechanism
Surface erosion control (Vineyards)	Vineyard erosion control measures such as planting cover crops; winterizing roads; installing buffer and filter strips; reducing directly connected surface drainage, and constructing detention basins to reduce peak flows.	Per Sonoma County Vineyard Erosion and Sediment control Ordinance (Sonoma County Code, Chapter 30, Article V)
Surface erosion control (Grazing land)	Erosion control measures to reduce sediment form grazing lands such as rotating livestock grazing, limit areas of grazing to stable areas, and preventing livestock from entering creeks by installing fences or other buffers.	Future Water Board Waste Discharge Requirement or waiver
Road erosion control	Reduce road erosion by treat roads and cut banks with erosion-resistant treatment such as grading, hydromulch, or gravel. Improve road drainage to prevent concentrated runoff by re-contouring or removing roads; reducing road bed and cut slope angles. Repair or replace culverts or other poorly performing road crossings.	Future Water Board Waste Discharge Requirement or waiver
Gully and landslide erosion control	Stabilize and repair gullies and landslides by re-contouring slopes to remove debris and/or stabilize slopes or gullies and by reinforce unstable areas with vegetation, crib wall, rip-rap or concrete.	Future Water Board Waste Discharge Requirement or waiver
Construction Stormwater Runoff control	Implement best management practices for construction sites to control erosion and sedimentation. Such as limiting grading to the dry season, winterizing slopes, protecting storm drain inlets, and construction site good housekeeping.	Construction General Permit (NPDES Permit No. CAS000002)
Industrial Stormwater Runoff control	Implement best management practices for industrial sites to control erosion and sedimentation such as controlling runoff volumes, covering stockpiled materials, protecting storm drain inlets, and industrial site good housekeeping.	Industrial Stormwater General Permit (NPDES Permit No. CAS000001)
Urban Stormwater Runoff control	Implement best management practices to stormwater runoff such as street sweeping, stream buffers, grassy swales and reduced impervious surfaces.	Stormwater Management Plan and applicable NPDES permit (NPDES Permit No. CAS000004)

TMDL Actions	Reasonably Foreseeable Compliance Measures*	Implementation Mechanism
State Highway Stormwater Runoff control	Implement best management practices to control erosion and sedimentation from State highways such as improved drainage, planted or protected road cuts and grassy swales.	Applicable NPDES Permit (NPDES Permit No. CAS000003)
Reduce channel incision	Channel restoration projects that include bank stabilization, channel widening, stream bank re-contouring to reduce slope, and riparian planting.	Applicable Clean Water Action Section 401 certification Reach-based stewardship programs
Enhance riparian habitat	Channel restoration projects that riparian planting, placement of large woody debris, gravel augmentation, and enhanced pool formation.	Reach-based stewardship programs
Enhance summer base flow	Groundwater management measures to increase groundwater recharge, increase water conservation, and protect groundwater quality.	Implementation of the *Sonoma Valley Groundwater Management Plan*
Increase fish passage	Increase available habitat by reduce fish passage barriers. Actions include removal or redesign of road crossings, bridges, or weirs; and construction of fish passage structures such as ladders or bypass channels.	Local public agencies and watershed groups
* These are examples of likely compliance measures and are not exhaustive. Details of sediment reduction plans will be developed during implementation of the TMDL. In addition, compliance measures will evolve based on results of monitoring and through the adaptive implementation process.		

Project Objectives

The objectives of the proposed Basin plan amendment are consistent with the mission of the Water Board and the requirements of the federal Clean Water Act and California's Water Code. The objectives are to:

- Protect Beneficial Uses of cold water fish spawning and migration, and habitat for rare and endangered species, specifically steelhead trout
- Attain numeric targets to meet water quality standards
- Comply with CWA requirement to adopt TMDL for 303(d) listed water bodies
- Avoid imposing regulatory requirements that are more stringent than necessary to meet numeric targets and attain water quality standards
- Complete implementation of the TMDL in as short a time as is feasible

ENVIRONMENTAL CHECKLIST

1. PROJECT TITLE:	*SONOMA CREEK SEDIMENT REDUCTION AND HABITAT ENHANCEMENT BASIN PLAN AMENDMENT*
2. Lead Agency Name and Address:	California Regional Water Quality Control Board, San Francisco Bay Region 1515 Clay Street, Suite 1400 Oakland, California 94612
3. Contact Person and Phone Number:	Tina Low (510) 622-5682
4. Project Location:	Sonoma Creek Watershed upstream of tidal influence, Sonoma County, California
5. Project Sponsor's Name and Address:	California Regional Water Quality Control Board, San Francisco Bay Region 1515 Clay Street, Suite 1400 Oakland, California 94612
6. General Plan Designation:	Not Applicable
7. Zoning:	Not Applicable

8. **Description of Project:** Refer to Project Description Section, above.

9. **Surrounding Land Uses and Setting:**
   The proposed Basin Plan amendment would affect the Sonoma Creek watershed upstream of tidally influenced areas, as described in Section 2 of the Staff Report. Implementation would involve specific land and water management actions throughout the watershed. Sonoma Creek watershed land uses include a mix of open space, agricultural, commercial, residential, and municipal uses.

10. **Other public agencies whose approval is required** (e.g., permits, financing approval, or participation agreement.): The California State Water Resources Control Board, the California Office of Administrative Law, and the U.S. Environmental Protection Agency must approve the proposed Basin Plan amendment.

ENVIRONMENTAL IMPACTS:

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
I. AESTHETICS -- Would the project:				
a) Have a substantial adverse effect on a scenic vista?	☐	☐	☐	☒
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☐	☐	☒
c) Substantially degrade the existing visual character or quality of the site and its surroundings?	☐	☐	☐	☒
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	☐	☐	☐	☒
II. AGRICULTURE RESOURCES -- In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation as an optional model to use in assessing impacts on agriculture and farmland. **Would the project:**				
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☒	☐
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☐	☒

c) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?	☐	☐	☒	☐
III. AIR QUALITY -- Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. **Would the project:**				
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☐	☒
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☐	☐	☒	☐
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?	☐	☐	☐	☒
d) Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☐	☒
e) Create objectionable odors affecting a substantial number of people?	☐	☐	☐	☒

IV. BIOLOGICAL RESOURCES -- Would the project:

a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☐	☒	☐
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, and regulations or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☐	☒	☐
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☐	☒	☐
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☒	☐
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☐	☐	☒
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☐	☒

V. CULTURAL RESOURCES -- Would the project:

a) Cause a substantial adverse change in the significance of a historical resource as defined in §15064.5?	☐	☐	☒	☐
b) Cause a substantial adverse change in the significance of a unique archaeological resource pursuant to §15064.5?	☐	☐	☒	☐
c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☒	☐
d) Disturb any human remains, including those interred outside of formal cemeteries?	☐	☐	☒	☐

VI. GEOLOGY AND SOILS -- Would the project:

a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☐	☒
ii) Strong seismic ground shaking?	☐	☐	☐	☒
iii) Seismic-related ground failure, including liquefaction?	☐	☐	☐	☒
iv) Landslides?	☐	☐	☐	☒
b) Result in substantial soil erosion or the loss of topsoil?	☐	☐	☒	☐
c) Be located on geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?	☐	☐	☐	☒
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	☐	☐	☐	☒

e) Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?	☐	☐	☐	☒

VII. HAZARDS AND HAZARDOUS MATERIALS -- Would the project:

a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☐	☐	☒
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☐	☒	☐
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☒
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☒	☐
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☒
f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☒

g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☒
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☐	☐	☒

VIII. HYDROLOGY AND WATER QUALITY -- Would the project:

a) Violate any water quality standards or waste discharge requirements?	☐	☐	☐	☒
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	☐	☐	☐	☒
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion of siltation on- or off-site?	☐	☐	☒	☐
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?	☐	☐	☒	☐
e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	☐	☐	☐	☒
f) Otherwise substantially degrade water quality?	☐	☐	☐	☒

g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☐	☐	☒
h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?	☐	☐	☐	☒
i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?	☐	☐	☐	☒
j) Inundation of seiche, tsunami, or mudflow?	☐	☐	☐	☒
IX. LAND USE AND PLANNING -- Would the project:				
a) Physically divide an established community?	☐	☐	☐	☒
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☐	☒
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?	☐	☐	☐	☒
X. MINERAL RESOURCES -- Would the project:				
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☐	☐	☒
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	☐	☐	☐	☒

XI. NOISE -- Would the project result in:

a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☐	☐	☒
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☒	☐
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☐	☒
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☒	☐
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒
f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒

XII. POPULATION AND HOUSING -- Would the project:

a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	☐	☐	☐	☒

b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
c) Displace substantial numbers of people necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒

XIII. PUBLIC SERVICES --

a) Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the public services:

Fire protection?	☐	☐	☐	☒
Police protection?	☐	☐	☐	☒
Schools?	☐	☐	☐	☒
Parks?	☐	☐	☐	☒
Other public facilities?	☐	☐	☐	☒

XIV. RECREATION --

a) Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☐	☒
b) Does the project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?	☐	☐	☐	☒

XV. TRANSPORTATION / TRAFFIC -- Would the project:

a) Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume-to-

capacity ratio on roads, or congestion at intersections)?	☐	☐	☐	☒
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?	☐	☐	☐	☒
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that result in substantial safety risks?	☐	☐	☐	☒
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☐	☒
e) Result in inadequate emergency access?	☐	☐	☐	☒
f) Result in inadequate parking capacity?	☐	☐	☐	☒
g) Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	☐	☐	☐	☒

XVI. UTILITIES AND SERVICE SYSTEMS -- Would the project:

a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☐	☐	☐	☒
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?	☐	☐	☐	☒

e) Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☒
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?	☐	☐	☐	☒
g) Comply with federal, state, and local statutes and regulations related to solid waste?	☐	☐	☐	☒

XVII. MANDATORY FINDINGS OF SIGNIFICANCE

a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☐	☐	☐	☒
b) Does the project have impacts that are individually limited, but cumulative considerable? ("Cumulative considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	☐	☐	☐	☒
c) Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☐	☐	☒

EXPLANATIONS

Environmental Analysis

The proposed Basin Plan amendment does not define the specific actions that responsible parties would take to comply with requirements derived from the Basin Plan amendment. As discussed above, physical changes resulting from the Basin Plan amendment are foreseeable, but the attributes of specific implementation actions (e.g., location, extent, etc.) are unknown, pending responsible parties proposing actions to comply with Basin Plan amendment requirements. Therefore, this analysis considers the above-mentioned reasonably foreseeable methods of compliance with the Basin Plan amendment in general terms and concludes that the Basin Plan amendment will not have significant environmental impacts. Specific compliance projects, when they are developed, will be subject to review and/or approval by the Water Board, which will, as part of administering its program responsibilities, either disapprove projects with significant and unacceptable environmental impacts (e.g., instream work with too many impacts) or require implementation of routine mitigation measures (e.g., best construction management practices) to ensure that environmental impacts remain at or are reduced to less-than-significant levels. Additionally, there are existing performance standards (e.g., air standards and noise ordinances) with which these compliance projects have to comply to keep impacts at less-than-significant levels. In sum, the regulatory programs, criteria, and requirements currently in place provide adequate assurances that impacts from the Basin Plan amendment will be less-than-significant. An explanation for each box checked on the environmental checklist is provided below.

I. Aesthetics

a) Any physical changes to the aesthetic environment as a result of the Basin Plan amendment would be small in scale. No actions or projects that could result from the Basin Plan amendment would result in tall or massive structures that could obstruct views from or of scenic vistas. The Basin Plan amendment would not result in adverse aesthetic impacts.

b) Actions and projects that could result from the Basin Plan amendment would occur on unpaved roads, stream channels, and private property and would not occur within a state scenic highway. The Basin Plan amendment would not result in adverse aesthetic impacts to state scenic highways.

c) Any physical changes to the aesthetic environment as a result of the Basin Plan amendment would be small in scale. The Basin Plan amendment would not substantially affect or degrade the existing visual character or quality of any site or its surroundings and no impact would occur.

d) Actions and projects that could result from the Basin Plan amendment would not include new lighting or installation of large structures that could generate reflected sunlight or glare. The Basin Plan amendment would not result in adverse light and glare impacts.

II. Agriculture Resources

a) Adoption of the Basin Plan amendment could increase the level of landowner participation in cooperative efforts to enhance channel stability and stream-riparian habitat conditions in Sonoma Creek and its tributaries, which could in turn result in a reduction in the amount of land cultivated near channels (e.g., voluntary increases in setbacks of agriculture from channels). However, these actions would not substantially reduce the fertility of soils in areas designated as Prime, Unique, or Farmland of Statewide Importance and less-than-significant impacts would result.

b) The Basin Plan amendment would not affect existing agricultural zoning or any aspects of Williamson Act contract and would not have any adverse impact in this regard.

c) Adoption of the Basin Plan amendment could increase the level of landowner participation in cooperative efforts to minimize soil disturbance in sensitive areas (on steep slopes and adjacent to stream channels), which could result in a localized, minor reductions in the amount of land cultivated, particularly adjacent to stream channels. These buffer or setback areas, that would be fallow, would comprise a small amount of land area. Therefore, less-than-significant impacts could result.

III. Air Quality

a) Because the Basin Plan amendment would not cause any significant changes in population or employment, it would not generate ongoing traffic-related emissions. It would also not involve the construction of any permanent emissions sources. For these reasons, no permanent change in air emissions would occur, and the Basin Plan amendment would not conflict with applicable air quality plans. Therefore, no air quality impact would result.

b) The Basin Plan amendment would not "violate any air quality standard or contribute substantially to an existing or project air quality standard." Nor would it involve the construction of any permanent emissions sources or generate ongoing traffic-related emissions. Construction that would occur as a result of Basin Plan amendment implementation such as earthmoving operations to reduce sediment discharges from eroding areas like roads and gullies would be of short-term duration and would likely involve discrete, small-scale projects as opposed to massive earthmoving activities.

Fine particulate matter less than 10 micrometer in diameter (PM_{10}) is the pollutant of greatest concern with respect to construction. PM_{10} emissions can result from a variety of construction activities, including excavation, grading, demolition, vehicle travel on paved and unpaved surfaces, and vehicle and equipment exhaust. Given the limited duration and scale of reasonably foreseeable construction activities to comply with the Basin Plan amendment, PM_{10} standards, however, would not be "substantially" violated, if at all. Additionally, if specific construction projects were proposed to comply with requirements derived from the proposed Basin Plan amendment, such projects would have to comply with the Bay Area Air Quality Management District's (BAAQMD) requirements with respect to the operation of portable equipment. Moreover, BAAQMD has identified readily available measures to control construction-related air quality emissions (BAAQMD 1999) that are routinely employed at most construction sites. These measures include watering active construction areas; covering trucks hauling soil; and applying water or applying soil stabilizers on unpaved areas. Therefore, in consideration of all of the foregoing, the Basin Plan amendment would not violate any air quality standard or contribute substantially to any air quality violation, and its temporary construction-related air quality impacts would be less-than-significant.

c) Because the Basin Plan amendment would not generate ongoing traffic-related emissions or involve the construction of any permanent emissions sources, it would not result in a cumulatively considerable net increase of any pollutant for which the project region is non-attainment and no air quality impact would result.

d) Because the Basin Plan amendment would not involve the construction of any permanent emissions sources but rather involves short-term and discrete construction activities, it would not expose sensitive receptors to substantial pollutant concentrations and no air quality impact would result.

d) The Basin Plan amendment would not involve the construction of any permanent sources of odor and therefore would not create objectionable odors affecting a substantial number of people. No odor impacts would result from the Basin Plan amendment.

IV. Biological Resources

a) The Basin Plan amendment is designed to benefit, enhance, restore and protect biological resources, including fish, wildlife, and rare and endangered species. Nonetheless it is possible that in order to comply with the proposed Basin Plan amendment, specific projects involving construction and earthmoving activities could be proposed that could potentially affect sensitive or special status species, either directly or through habitat modifications.

Projects proposed, that could affect sensitive species, to comply with the Basin Plan amendment implementation requirements are subject to review and/or approval by the Water Board and/or other resource agencies such as Department of Fish and Game and U.S. Fish and Wildlife Service (in consultation with the

Water Board). These agencies will either not approve compliance projects with significant adverse impacts on sensitive/special status species or require mitigation measures to reduce impacts to less-than-significant levels. For example, it is not reasonably foreseeable that the Water Board would approve earthmoving work that would disrupt or destroy habitat of a known special status species (since protection of rare and endangered species is one of the beneficial uses we are protecting in Sonoma Creek). The Water Board will work, together with California Department of Fish and Game and U.S. Fish and Wildlife Service, with the proponents of specific compliance projects to develop actions that not only meet and further the Basin Plan amendment's requirements and goals, but also have minimal impacts. Moreover, in discharging its regulatory program duties, the Water Board would require mitigation measures for work it approves that may impact special status species or other sensitive natural communities. These include but are not limited to requiring pre-construction surveys; construction buffers and setbacks; restrictions on construction during sensitive periods of time; employment of on-site biologists to oversee work; and avoidance of construction in known sensitive habitat areas or relocation and restoration of sensitive habitats, but only if avoidance is impossible.

Therefore, the Basin Plan amendment would not have a substantial adverse effect, either directly or through habitat modifications, on any sensitive or special-status species.

b) As indicated in section IV a), above, the Basin Plan amendment is designed to benefit biological resources, particularly riparian habitat and other sensitive natural communities. Nonetheless activities to improve riparian conditions, such as channel restoration and installation of woody debris, could result in minor and short term disruption to riparian habitat.

Projects proposed to comply with the Basin Plan amendment implementation plan, involving grading or construction in the riparian corridor, are subject to review and/or approval by the Water Board, which will either not approve compliance projects with significant adverse impacts on riparian habitats and sensitive natural communities, or would require mitigation measures to reduce impacts to less-than-significant levels. The Water Board will work with California Department of Fish and Game, U.S. Fish and Wildlife Service, and proponents of specific compliance projects to come up with actions that not only meet and further the Basin Plan amendment's requirements and goals, but also have minimal impacts. Moreover, in discharging its regulatory program duties, the Water Board would require mitigation measures for work it approves that may impact riparian habitats or other sensitive natural communities. These include but are not limited to requiring pre-construction surveys; construction buffers and setbacks; restrictions on construction during sensitive periods of time; employment of on-site biologists to oversee work; and avoidance of construction in known sensitive habitat areas or relocation and restoration of sensitive habitats, but only if avoidance is impossible. Therefore, the Basin Plan amendment would not have a substantial adverse effect, either directly or through habitat modifications riparian habitats and sensitive natural communities.

c) Basin Plan amendment-related implementation actions may contribute to an increase in the acreage of land where habitat enhancement and/or erosion control projects are undertaken, a fraction of which could be within wetlands. The adverse impacts on wetlands would not be substantial, however. If compliance projects are proposed that could have the potential to disturb wetlands, they would be subject to the Water Board's review and/or approval and the Water Board would require mitigation measures to minimize impacts to less-than-significant levels. The Water Board would work with other local, state, and federal agencies with permitting authorities to avoid, minimize, and mitigate impacts to wetlands consistent with the federal Clean Water Act, the Porter-Cologne Water Quality Control Act, and the Water Boards' Basin Plan's no net loss of wetlands policy. Therefore, the Basin Plan amendment would result in less-than-significant impacts on wetlands.

d) The Basin Plan amendment would not substantially interfere with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites. The main goal of the Basin Plan amendment is to improve and enhance fish passage. Thus, compliance projects would entail improving migratory fish corridors, not adversely affecting them. It is possible, however, that projects could be proposed to comply with the Basin Plan amendment that involve construction or earthmoving activities that could temporarily interfere with wildlife movement, migratory corridors, or nurseries (e.g., channel habitat enhancement projects, fish passage enhancement projects, riparian corridor planting, etc.). These channel habitat enhancement projects would be subject to the Water Board's review and/or approval, and the Water Board would either not approve projects with significant adverse impacts to wildlife movement, corridors, and nursery sites, or require mitigation measures to reduce impacts to less-than-significant levels. Mitigation measures the Water Board routinely requires in these cases include but are not limited to requiring avoiding construction in known wildlife corridors or during the breeding season, requiring buffers and setbacks, avoiding sensitive habitat areas, and minimizing disturbances. Therefore, the Basin Plan amendment would not substantially affect fish or wildlife movement, migratory corridors, or nurseries, and its impacts would be less-than-significant.

e) The Basin Plan amendment itself does not conflict with any local policies or ordinances protecting biological resources such as trees. Riparian restoration actions included in the Basin Plan Amendment call for retaining and enhancing riparian vegetation and would result in a let increase in riparian tress. Projects proposed to comply with Basin Plan amendment requirements would be consistent with the goals of the TMDL to retain riparian vegetation and would not conflict with local policies or ordinance.

f) The Basin Plan amendment does not conflict with any adopted Habitat Conservation Plan, Natural Community Plan, or other approved local, regional or state habitat conservation plan. Projects proposed to comply with Basin Plan amendment requirements would be subject to local agency review and would not conflict with local policies or ordinance.

V. Cultural Resources

a) Projects involving earthmoving or construction to comply with requirements of the proposed Basin Plan amendment are reasonably foreseeable. Construction would generally be small in scale and earthmoving would likely occur in areas already disturbed by recent human activity, not at or in areas containing historical resources as defined by section 15064.5 of the CEQA Guidelines. However, creek restoration efforts could occur in areas of California State Park lands where historic stone walls, bridges, or dams are present. Projects triggered by the Basin Plan amendment would not be permitted by the Water Board, California Department of Parks and Recreation, Sonoma County, or City of Sonoma that demolish or materially alter the physical character of historic resources. The City and County General Plans both contain policies that protect historic resources. Therefore, the Basin Plan amendment would not adversely affect any cultural resource, and its impacts would be less-than-significant.

b) Projects involving earthmoving or construction to comply with requirements of the proposed Basin Plan amendment are reasonably foreseeable. Construction would generally be small in scale, and earthmoving would likely occur in areas already disturbed by recent human activity (e.g., existing roads, vineyards, ranches)—not at or in areas containing archaeological resources as defined by section 15064.5 of the CEQA Guidelines. Projects triggered by the Basin Plan amendment would not be permitted by the Water Board or local agencies (Sonoma County or City of Sonoma) that disturb archaeological resources. The City and County General Plans both contain policies that protect archaeological resources. Therefore, the Basin Plan amendment would not adversely affect archaeological resource, and its impacts would be less-than-significant.

c) Projects involving earthmoving or construction to comply with requirements of the proposed Basin Plan amendment are reasonably foreseeable. However construction would be small in scale and would not occur in areas of known paleontological resource or areas containing unique geologic features. Therefore the Basin Plan amendment would have less-than-significant paleontological impacts.

d) Projects involving earthmoving or construction to comply with requirements of the proposed Basin Plan amendment are reasonably foreseeable. Construction would generally be small in scale, and earthmoving would likely occur in areas already disturbed by recent human activity (e.g., existing roads, vineyards, ranches)—not at or in areas human remains as defined by section 15064.5 of the CEQA Guidelines. Therefore, the Basin Plan amendment would not adversely affect human remains, and its impacts would be less-than-significant.

VI. Geology and Soils

a) The Basin Plan amendment would not involve the construction of habitable structures; therefore, it would not result in any human safety risks related to fault rupture, seismic ground-shaking, ground failure, or landslides.

b) Specific projects involving earthmoving or construction activities to comply with requirements of the Basin Plan amendment are reasonably foreseeable. Such activities would not result in substantial soil erosion or the loss of topsoil. The purpose of the Basin Plan amendment is to reduce erosion, not increase it. To meet the proposed Basin Plan amendment targets, construction would be designed to reduce overall soil erosion associated with erosion. However, temporary earthmoving operations could result in short-term, limited erosion. Compliance projects affecting an area of one acre or more would be subject to the review and/or approval of the Water Board, which would require implementation of routine and standard erosion control best management practices and proper construction site management. These projects would require a general construction National Pollutant Discharge Elimination System permit and implementation of a storm water pollution prevention plan to control pollutant runoff such as sediment. Other smaller grading projects would be subject to non-discretionary requirements of the Sonoma County grading ordinance, which would reduce potential impacts from grading. Therefore, the Basin Plan amendment would not result in substantial soil erosion, and its impacts would be less-than-significant.

c) Because the Basin Plan includes actions to stabilize existing sources of sediment, such as landslides, eroding gullies, and roads, some construction could occur in these unstable areas. The Basin Plan amendment could result in projects involving roads, creek crossings, and other projects located on steep slopes or unstable terrain. These projects would be designed to increase stability, both on-site and off-site, to reduce erosion and sedimentation. Grading for specific TMDL implementation projects would be designed to minimize any potential for landslides, lateral spreading, subsidence, liquefaction, or collapse. Therefore, the

Basin Plan amendment would not involve activities that would create or trigger landsliding, later spreading, subsidence, liquefaction or collapse, and its impacts would be less-than-significant.

d) The Basin Plan amendment would not involve construction of buildings (as defined in the Uniform Building Code) or any habitable structures. Minor grading and construction could occur in areas with expansive soils but this activity would not create a substantial risk to life or property. Therefore, the Basin Plan amendment would not result in impacts related to expansive soils.

e) The Basin Plan amendment would not require wastewater disposal systems; therefore, affected soils need not be capable of supporting the use of septic tanks or alternative wastewater disposal systems. No impacts from septic tanks or alternative wastewater disposal systems would result from the project.

VII. Hazards and Hazardous Materials

a) The Basin Plan amendment does not involve the routine transport, use, or disposal of hazardous materials. Therefore, no impacts from the use, transport or disposal of hazardous materials would result.

b) The Basin Plan amendment does not include actions that are likely to result in upset or accident conditions involving the release of hazardous materials. It is possible that hazardous materials or substances may be discovered during minor construction activities associated with erosion control and/or habitat enhancement. Required remediation actions would include the proper disposal and transport of contaminated soils, but such waste is expected to be of small volume. Proper handling in accordance with relevant laws and regulations would minimize hazards to the public or the environment, and the potential for accidents or upsets. Therefore, hazardous waste transport and disposal would not create a significant public or environmental hazard, and would be a less-than-significant impacts.

c) Basin Plan amendment actions such as minor construction to reduce erosion and habitat enhancement projects would be located along stream channels in areas used as open space and agriculture in areas that are not likely to contain schools. Furthermore, the Basin Plan amendment and TMDL implementation actions would not emit hazardous materials, substances, or waste. Therefore, no impact from hazardous materials would occur within one-quarter mile of an existing or proposed school.

d) It is unlikely that Basin Plan amendment actions would occur on sites that are included on lists of hazardous material site compiled pursuant to Government Code Section 65962.5, such as leaky underground storage tank sites or sites where hazardous materials violations have occurred. It is possible that hazardous materials or substances may be encountered during project activities on or near these sites. The Water Board regulates listed hazardous material sites and would require mitigation to ensure that the Basin Plan amendment would not create a significant hazard to the public or the environment due to hazardous materials. Therefore, impacts from hazardous materials would be a less-than-significant impact.

e) The Basin Plan amendment does not include actions that would result in a safety hazard for people residing or working near a public airport or vicinity. The Valley contains one small air field located south of the City of Sonoma that would not be affected by the Basin Plan amendment and no impact would result.

f) The Basin Plan amendment would not result in construction of buildings or others structures that could result in safety hazards for people residing or working near a private air strip and no impact would result.

g) Hazardous waste management activities resulting from the Basin Plan amendment would not interfere with any emergency response plans or emergency evacuation plans, and no impacts would result.

h) The Basin Plan amendment would not affect the potential for wildland fires. Therefore no impacts to wildfires would result.

VIII. Hydrology and Water Quality

a) The project would amend the Basin Plan, which articulates applicable water quality standards; therefore, it would not violate standards or waste discharge requirements, and no adverse impacts to water quality would result.

b) The Basin Plan amendment would not decrease groundwater supplies or interfere with groundwater recharge. Channel habitat enhancement projects to control channel incision, and/or the construction of facilities such as retention or detention basins, infiltration basins, or vegetated swales could result in minor increases in groundwater recharge. No adverse impacts to groundwater recharge would result.

c) Specific projects involving earthmoving or construction activities to comply with requirements derived from the proposed Basin Plan amendment are reasonably foreseeable. Such projects could affect existing drainage patterns. However, to meet proposed Basin Plan amendment allocations, they would be designed to reduce overall soil erosion, not increase it. Nevertheless, temporary earthmoving operations could result in short-term, limited erosion. These specific compliance projects would be subject to the review and/or approval of the Water Board, which would require implementation of routine and standard erosion control best management practices and proper construction site management. In addition, construction projects over one acre in size would require a general construction National Pollutant Discharge Elimination System permit and implementation of a storm water pollution prevention plan. Therefore, the Basin Plan amendment would not result in substantial erosion, and its impacts would be less-than-significant.

d) The Basin Plan amendment could involve earthmoving that could affect existing drainage patterns. The Basin Plan amendment could contribute to increases in the amount of riparian vegetation and/or large woody debris in stream channels to enhance habitat conditions. These actions should reduce flooding hazards. Basin Plan amendment-related activities would not substantially increase impervious surfaces, or peak flow releases from dams in any part of the watershed. The purpose of the Basin Plan amendment is to reduce sedimentation in streams, which has the effect of reducing flooding, and is environmentally beneficial. Nevertheless, placement of large woody debris in stream channels to benefit anadromous fish could potentially affect stream levels upstream; however, such compliance projects would be subject to Water Board review and/or approval and the Water Board would ensure that the projects are designed to not adversely affect upstream areas. Therefore, the Basin Plan amendment would not result in significant impacts related to increased flooding.

e) Basin Plan amendment-related activities are, by design, intended to decrease peak runoff rates from upland land uses, as needed to reduce fine sediment input to channels and channel erosion. Therefore, the Basin Plan amendment would not increase the rate or amount of runoff or exceed the capacity of storm water drainage systems and no impact adverse impacts would occur.

f) Basin Plan amendment-related activities are intended to reduce fine sediment input to channels and improve water quality. Therefore, the Basin Plan amendment would not degrade water quality and no adverse water quality impacts would occur.

g) The Basin Plan amendment will not result in construction of housing. Therefore not housing would be placed within the 100-year flood hazard zone as a result of the proposed action. No flood hazard impacts would occur.

h) The Basin Plan amendment will not result in construction of structures that could impede or redirect flood flows within a 100-year flood hazard zone and no adverse flooding impacts would occur.

i) The Basin Plan amendment will not result in construction or modification of dams or levees or activities that would expose people to significant damage from dam or levee failure and no adverse impacts would occur.

j) Basin Plan amendment-related construction would occur upstream of the tidally influenced stream channel and would not be subject to substantial risks due to inundation by seiche, tsunami, or mudflow, and no impact would occur.

IX. Land Use and Planning

a) Basin Plan amendment-related construction would be too small in scale to divide any established community, and no adverse impact would occur.

b) The Basin Plan amendment would not conflict with any land use plan, policy, or regulation. Projects proposed to comply with Basin Plan amendment requirements would be subject to local agency review and would not conflict with local land use plans or policies.

c) The Basin Plan amendment would not conflict with any habitat conservation plan or natural community conservation plan. Projects proposed to comply with Basin Plan amendment requirements would be subject to local agency review and would not conflict with habitat conservation plans or natural community conservation plans.

X. Mineral Resources

a) Basin Plan amendment-related excavation and construction would be relatively small in scale and would not result in the loss of availability of any known mineral resources that would be of value to the region or the residents of the State.

a) Basin Plan amendment-related excavation and construction would be relatively small in scale and would not be located in areas of mineral resources of local importance and no impact would occur.

XI. Noise

a) Earthmoving and construction could temporarily generate noise. Projects that local agencies propose to comply with requirements derived from the Basin Plan amendment would be required to be consistent with the local agencies' own standards.

b) To comply with requirements derived from the Basin Plan amendment, specific projects involving earthmoving or minor construction, which could result in temporary groundborne vibration or noise, are reasonably foreseeable. The Sonoma County Noise Element describes thresholds for exterior noise during the daytime and nighttime. These standards allow for a maximum exterior noise level of 70 dBA , with the average over a one hour time period not to exceed 50 dBA during the daytime. The nighttime allowable noise ranges from 45 to 65 dBA. Basin Plan amendment-related grading would be required to comply with these County standards to keep noise levels to less-than-significant levels. Therefore, the Basin Plan amendment would not result in substantial noise, and its impacts would be less-than-significant.

c) The Basin Plan amendment would not cause any permanent increase in ambient noise levels. Any noise would be short-term in nature.

d) To comply with requirements derived from the Basin Plan amendment, specific projects involving earthmoving or construction, which could result in temporary noise impacts, are reasonably foreseeable. Noise-generating operations would, however, have to comply with Sonoma County noise standards, as described in Section XI b), above. Therefore, the Basin Plan amendment would not result in substantial noise impacts, and its impacts would be less-than-significant.

e) The Sonoma Creek watershed is not within an airport land use plan area. The Sonoma Valley Airport, open to the public, is located near Shellville in the lower portion of the watershed. This small airport serves small aircraft and is not located near Sonoma Creek. The Bain Plan amendment would not result in increased population in the watershed and no impacts from airport noise exposure to residents or workers would result.

f) The Sonoma Creek watershed does not contain any private airports and no impacts would result from airport-generated excessive noise.

XII. Population and Housing

a) The Basin Plan amendment would not result in population growth in the Sonoma Creek watershed. It would not induce growth through such means as constructing new housing or businesses, or by extending roads or infrastructure, and no impacts would occur.

b) The Basin Plan amendment would not affect the population of the Sonoma Creek watershed. It would not displace any existing housing or any people that would need replacement housing, and no address housing impacts would occur.

c) The Basin Plan amendment would not affect the housing, would not displace people or create a need for the construction of replacement housing and no impacts would occur.

XIII. Public Services

a) The Basin Plan amendment would not affect populations or involve construction of substantial new government facilities. The Basin Plan amendment would not affect service ratios, response times, or other performance objectives for any public services, including fire protection, police protection, schools, or parks, and no adverse impacts to public services would result.

XIV. Recreation

a) The Basin Plan amendment could result in temporary closure of roads or trails in portions of Aladel, Jack London, Sugar Loaf Ridge State Parks or in Sonoma

County Regional park lands during road and trail restoration activities. These short term closures could result in increased visitors to other portions of these parks or, perhaps, to other park or open space destinations in the vicinity. However, the project would not result in substantial physical deterioration of park or recreation facilities. Potential changes in recreational use patterns are expected to cause less than significant impacts on the environment. No recreational facilities would need to be constructed or expanded.

b) Although the Basin Plan amendment could result in some changes in road and trail configurations or permitted uses that could alter recreational use patterns these changes would not result in the need for construction of or expansion of recreational facilities that could have an adverse affect on the environment and any short-term changes would be less-than-significant.

XV. Transportation / Traffic

a) Basin Plan amendment actions could result in minor construction that would require the use of heavy equipment and trucks to move soil, longs, or other materials needed for road, hillslope, and/or stream channel restoration. Any increase in traffic would be temporary and would be limited to local areas in the vicinity of individual restoration projects and would not create substantial traffic in relation to the existing load and capacity of existing street systems.

b) Because the Basin Plan amendment would not increase population or provide employment, it would not generate any ongoing motor vehicle trips and would not affect level of service standards established by the county congestion management agency. Therefore, the Basin Plan amendment would not result in permanent, substantially increases in traffic above existing conditions and impacts would be less than significant.

c) The Basin Plan amendment would not affect air traffic and no impacts are anticipated.

d) The Basin Plan amendment does not include provisions for the construction of new roads and no new hazards due to the design or engineering of the road network in the Sonoma Creek watershed would occur. No road design or construction hazards would occur.

e) The Basin Plan amendment would result in grading and erosion control actions on unpaved roads that are not typically used for emergency access. Therefore, the project would not result in inadequate emergency access and on impacts would occur.

f) Because the Basin Plan amendment would not increase population or provide employment, it would not affect parking demand or supply, and no impacts would occur.

g) Because the Basin Plan amendment would not generate ongoing motor vehicle trips, it would not conflict with adopted policies, plans, or programs supporting alternative transportation.

XVI. Utilities and Service Systems

a) The project would amend the Basin Plan, which is the basis for wastewater treatment requirements to improve water quality and the environment in the Bay Area; therefore, the Basin Plan amendment would be consistent with such requirements.

b) The Basin Plan amendment does not include changes to wastewater treatment facilities and no impacts would occur.

c) Basin Plan amendment-related projects would not include construction of new or expanded stormwater drainage facilities and no impacts would occur.

d) Because the Basin Plan amendment would not increase population or provide employment, it would not require an ongoing water supply. It would also not require ongoing wastewater treatment services and no impacts would occur.

e) Because the Basin Plan amendment would not increase population or provide employment, it would not require an ongoing water supply. It would also not require ongoing wastewater treatment services and no impacts would occur.

f) Basin Plan amendment implementation would not substantially affect municipal solid waste generation or landfill capacities and no impacts would occur.

g) Basin Plan amendment implementation would not substantially affect municipal solid waste generation or landfill capacities and no impacts would occur.

XVII. Mandatory Findings of Significance

a) When taken as a whole, the Basin Plan amendment would not degrade the quality of the environment. The proposed Basin Plan amendment is intended to benefit fish and wildlife species in the Sonoma Creek watershed.

b) As discussed above, the Basin Plan amendment could pose some less-than-significant adverse environmental impacts related to earthmoving and construction operations. These impacts would be individually limited, and most would be of short-term duration. As specific implementation proposals are developed and proposed, they would be subject to review and/or approval by the Water Board, which would either disapprove projects with significant and unacceptable impacts or require mitigation measures, such as the implementation of best construction management practices, to ensure that impacts remain less-than-significant. Therefore, these future projects would not lead to cumulatively considerable significant impacts.

c) The Basin Plan amendment would not cause any substantial adverse effects to human beings, either directly or indirectly. The Basin Plan amendment is intended to benefit human beings through implementation of actions to improve water quality and enhance fish populations in the Sonoma Creek watershed.

Cumulative Impact Analysis

This section provides an analysis of the significant cumulative impacts of the proposed basin plan amendment (CEQA Guidelines Section 15130). Cumulative impacts refers to "two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts."

The cumulative impact that results from several closely related projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present and reasonably foreseeable probable future projects, in this case the impacts from other municipal and private projects to reduce sediment, which would occur in the watershed during the period of implementation.

This analysis considers past, present, and reasonable foreseeable future projects that could have similar environmental impacts as the proposed basin plan amendment. These include projects that would involve road or trail restoration, hillslopes stabilization, construction of erosion control facilities; riparian habitat restoration, fish migration barrier mitigation, and physical changes to the environment to improve summer baseflow. In addition, we have included an analysis, where applicable, of adoption of other TMDLs in the watershed. This cumulative analysis considers projects that are located in the portion of Sonoma Creek watershed covered by the proposed Basin Plan amendment (e.g. upstream of tidal influence). A list of cumulative projects considered in this analysis is provided in Table 16, below.

Adoption of the Basin Plan amendment is intended to facilitate implementation of the TMDL. However the requirements identified in the TMDL implementation plan are generally implemented through waivers of waste discharge requirements, NPDES permits or other regulatory tools. The Basin Plan amendment would be cumulatively beneficial to the environment in terms of some resource areas, particularly water quality and biological resources. Conceptually the impacts associated with improving water quality through the TMDL, if occurring with other construction projects, could contribute to temporary cumulative effects to agricultural resources, air quality, cultural resources, and noise. In accordance with CEQA, this analysis does not include a discussion of impacts which do not result in part from the proposed Basin Plan amendment. Environmental impacts identified as No Impact in the environmental checklist are not evaluated in this cumulative analysis because they would have no contribution to potentially cumulative future impacts.

Table 16. Projects Consider in the Cumulative Environmental Impact Analysis

Project	Status*	Project Sponsor	Funding Source
Anedal State Park road rehabilitation	C	Southern Sonoma RCD/ CA Department of Parks and Recreation	319(h) grant
Washington Street fish passage project	C		
Jack London State Park road rehabilitation	C	CA Department of Parks and Recreation/SEC	Prop. 13 grant
Sonoma Creek spawning gravel restoration	C		Prop. 13 grant
Carriger Creek habitat enhancement	C	Southern Sonoma RCD/SEC	Prop. 13 grant
Landslide repair on Bear Creek Sugar Loaf Ridge State Park	C	CA Department of Parks and Recreation	State Parks
Nathanson Creek Restoration (downtown Sonoma)	P	Sonoma Ecology Center	
Riverside Reach Sonoma Creek Restoration (Maxwell Park)	P	Sonoma Ecology Center	
Upper Sonoma Creek Restoration (Glenn Ellen and Kenwood)	P	Sonoma Ecology Center	
Sonoma Creek Nutrient TMDL	F	Water Board	Water Board/ U.S. EPA
Sonoma Creek Pathogen TMDL	F	Water Board	Water Board/ U.S. EPA
*** C=Completed, P=Proposed and Funded, F=Reasonably foreseeable future**			

Agricultural Resources

The proposed Basin Plan amendment encourages implementation of buffers along stream banks to promote channel equilibrium and to facilitate the restoration of complex physical habitat structure. Some lands adjacent to stream banks that are currently in agricultural use could be converted to open space buffer areas. Impacts associated with agricultural resources would occur over small geographical areas and would not adversely affect soil fertility or long term agricultural value of land.

Projects listed in Table 16 are not generally associated with conversion of agricultural land to non-agricultural uses. Some of the projects have had a net beneficial impact by abating bank erosion that has reduce the amount of land adjacent to stream channel under cultivation. Overall, the activities resulting from the Sonoma Creek TMDL would not be expected to contribute considerably to a cumulative agricultural impact.

Air Quality

Implementation of the Sonoma Creek TMDL Program may cause additional emissions of PM10. Emissions of PM10 resulting from implementation of TMDL compliance measures may exceed the thresholds established by the Bay Area Air Quality Management District (BAAQMD), and therefore the TMDL, in conjunction with all other construction activity, may contribute to the region's nonattainment status. However, the BAAQMD CEQA guidelines (BAAQMD 1999) state that cumulative impacts should be determined based on an individual project's consistency with applicable local General Plans and whether it would affect conformance of the General Plan with the regional air quality plan. The majority of the implementation measures under consideration as reasonably foreseeable means of compliance with the TMDL do not result in operational activities that would increase emissions in the areas due to an increase in population or vehicular traffic that would be sustained over time.

Biological Resources

Many reasonable foreseeable compliance measure of the habitat enhancement plan would affect stream channels. Potential impacts to biological resources would be mitigated by standard requirements of the 401 water quality certifications to mitigate for the temporary impacts to sensitive wetlands, and to monitor to ensure site vegetation and habitat restoration. In addition, mitigation measures for the protection of listed or endangered species are required where applicable. For example, construction is required to operate outside of nesting seasons and during migratory fish passage windows.

Cultural Resources

Implementation of the Sonoma sediment TMDL is not expected to contribute to a cumulative loss of cultural resources in the Sonoma Creek watershed. Projects would be small to moderate in scale, spatially contained, and brief in duration. Potential impacts to cultural resources are described for the project and would not be affected by impacts from other projects identified in Table 16.

California Department of Parks and Recreation adheres to rigorous historic and archeological resource identification, protection, and mitigation procedures that would ensure protection of these resources on public land in the watershed.

Hydrology and Water Quality

Implementation of the Sonoma Sediment TMDL is expected to result in long-term improvement in water quality by reducing sediment in stream beds and enhancing riparian habitat. Other TMDLs are addressing other pollutants responsible for impairing water quality in Sonoma Creek and thus the cumulative impact of other program, as well as specific, projects constructed to meet Clean Water Act requirements, have resulted in long-term improvements in water quality and are expected to continue this improvement.

Noise

Minor construction activities and grading associated with the implementation of the Sonoma Creek Sediment TMDL in combination with other noise-generating sources may exacerbate noise conditions in some locations, however, these impacts are short term in nature. Most noise is associated with traffic. Noise levels from construction activities, once completed, would return to current levels. Other activities, such as hillslope grading with heavy equipment are expected to occur intermittently, over small geographical areas and be of short term duration. Overall, with mitigation, the activities resulting from the Sonoma Creek TMDL would not be expected to contribute considerably to a cumulative noise impact.

9.4. Alternatives Analysis

In defining and presenting reasonable alternatives to the proposed Basin Plan amendment, we discuss how each alternative could affect foreseeable environmental outcomes, and the extent to which each alternative would achieve the goals of the proposed amendment. Furthermore, considering the nature of the proposed amendment - a total maximum daily load (TMDL) for sediment and a related habitat enhancement plan - we examine effects of different choices for key elements of the TMDL and habitat enhancement plan. Our analysis includes the following alternatives: 1) No Action/No Basin Plan Amendment Alternative; 2) Implementation actions to address sediment only; and 3) Additional numeric targets for sediment. A discussion of the preferred alternative, the Proposed Basin Plan amendment is provided a the end of this section.

Alternative 1: No Action/No Basin Plan Amendment Alternative

If the Water Board does not adopt the Sonoma Creek sediment total maximum daily load (TMDL), the U.S. Environmental Protection Agency (U.S. EPA) will be required to do so, pursuant to the Clean Water Act Section 303(d) listing of the Sonoma Creek as impaired by sediment. U.S. EPA would likely rely, at least in part on analyses completed to date. Within legal constraints the agency would be free to develop a TMDL in any manner it deems appropriate. The environmental impacts of that undeveloped TMDL are unknown. Subsequently, the Water Board would be required to prepare a plan specifying actions to resolve the impairment (e.g. an implementation plan), as needed to attain and maintain the numeric targets and sediment allocations established by U.S. EPA.

Alternative 1 does not satisfy the project objective for the Water Board to fulfill its legal obligation to adopt a sediment TMDL for Sonoma Creek, a 303(d) listed water body.

Alternative 2: Implement Actions to Reduce Sediment Only

This alternative is identical to the proposed Basin Plan amendment except implementation would focus solely on actions to reduce sediment input to channels from land-use activities. Under this alternative, the Water Board would not set goals or recommend actions to enhance riparian habitat.

This alterative could be associated with fewer less-than-significant short-term impacts related to in-channel construction necessary to remove migration barrier, improve channel complexity or restore riparian habitat conditions. However, without actions to enhance riparian habitat long-term significant beneficial effects on Central California Coast steelhead populations would not occur which could result in significant, adverse impacts to a federally listed threatened species.

This alternative would satisfy legal requirements associated with the Clean Water Act and would resolve sediment-related threats to salmon and steelhead populations. However, it may not meet the project objectives to fully protect beneficial uses related to fish populations.

Alternative 3: Additional Numeric Targets for Sediment

Sediment impairment is expressed by an increase in the concentration of fine sediment in the bed of the Sonoma Creek. Under the proposed Basin Plan amendment, the Water Board will adopt three numeric targets related to the concentration of fine sediment in the streambed: spawning gravel permeability, pool filling, and substrate composition. These parameters gauge survival from spawning to emergence of salmonid eggs and larvae.

Under Alternative 3, additional monitoring parameters and target values would be proposed to evaluate relationships between sedimentation and water quality. These water quality targets may include but would not be limited to a measure of 1) the biomass of aquatic invertebrate prey species in riffles to evaluate relationship between sedimentation and food supply for juvenile salmonids; and 2) embeddedness of coarse particles. Implementation of this alternative would require development of accurate estimates of each of these parameters.

This alterative would be associated with similar physical environmental impacts as the proposed Basin Plan amendment. It would require additional costs to develop numeric targets, collect monitoring data, and to refine our understanding of spatial and temporal trends in these additional water quality targets. The water quality targets proposed in the proposed Basin Plan amendment are adequate to allow for accurate determination of the effectiveness of sediment reduction measures and habitat enhancement actions to restore fisheries in the first 15 years of TMDL monitoring.

While this alternative would satisfy legal requirements associated with the Clean Water Act and would resolve sediment-related threats to salmon and steelhead populations. However, it would be associated with additional regulatory requirements and cost that at this time are not justified.

Analysis of the Preferred Alternative

The No Action alternative is not practical because there is a legal requirement under the Clean Water Act for the Water Board to adopt a TMDL. In addition, this is not a preferred alternative because there is a higher potential for inconsistencies between the TMDL and implementation plan, when these two parts are developed by different agencies. In addition, it would delay adoption and subsequent implementation and expend additional public monies in excess of significant amount of public funds that have already gone into the development of the proposed Basin Plan amendment.

The Alternative 2 would resolve sediment-related threats to steelhead and related beneficial uses. However, actions to enhance summer baseflow, temperature, habitat complexity, and habitat access are necessary to rebuild and sustain viable populations of steelhead in the Sonoma Creek watershed, and these elements of the proposed Basin Plan amendment would not be recognized or recommended. The timeframe for rebuilding and sustaining viable populations of steelhead would be increased. Therefore, the Implementation actions to address sediment only alternative is not preferred.

The Alternative 3 would have much higher sediment monitoring costs than the proposed Basin Plan amendment, and those costs could reduce resources available for complimentary monitoring of other stressors and the population status of steelhead. In addition, scientific consensus does not exist regarding target values for biomass of vulnerable aquatic invertebrate prey species or embeddedness. For these reasons, the Additional numeric targets for sediment alternative is not preferred.

The Proposed Basin Plan amendment alternative is preferred because in addition to providing meeting most of the project objectives, it is associated with similar or fewer long-term adverse environmental impacts. Alternative 1 No Action and Alternative 2 Implementation actions to address sediment only do not meet important project objectives to protect beneficial uses in Sonoma Creek. The Proposed Basin Plan amendment is more scientifically defensible and cost-effective than the Additional numeric targets alternative.

9.5 Economic Considerations

Introduction

The California Environmental Quality Act requires that whenever one of California's nine Regional Water Quality Control Boards, such as the San Francisco Bay Regional Water Quality Control (Water Board), adopts a rule that requires the installation of pollution control equipment or establishes a performance standard or treatment requirement, it must conduct an environmental analysis for reasonably foreseeable methods of compliance (Public Resource Code 2759 [a][3][c]). This analysis must take into account a reasonable range of factors, including economics. Furthermore, if the rule includes an agriculture control plan, then the total cost of the program must be estimated and potential sources of funding must be identified (Water Code 13141).

The proposed Sonoma Creek Sediment TMDL and Habitat Enhancement Plan Basin Plan Amendment includes performance standards (i.e., targets and allocations), and therefore requires the consideration of economic factors. The Total Maximum Daily Load (TMDL) implementation plan also proposes activities for agriculture, and therefore, the total cost of the implementation effort is estimated and potential funding sources are identified.

In amending the Basin Plan, the Water Board must analysis the reasonably foreseeable methods of compliance with proposed performance standards and treatment requirements (Public Resource Code §21000 et seq.). This analysis must include economic factors, but does not require a cost-benefit analysis.

Additionally, in accordance with the Porter-Cologne Water Quality Control Act, it is the policy of the state to protect the quality of all waters of the state. Water of the state include "any surface water or groundwater, including saline waters, within the boundaries of the state" (CWC §13050). When adopting the Porter-Cologne Act, the Legislature declared that all values of the water should be considered, but then went on to provide only broad, non-specific direction for considering economics in the regulation of water quality.

> The Legislature further finds and declares that activities and factors which may affect the quality of the waters of the state shall be regulated to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible (CWC §13000).

The Porter-Cologne Act directed regulatory agencies to pursue the highest water quality that is reasonable, and *one* of the factors used to determine what is reasonable is economics. It is clear, though, that economic factors cannot be used to justify a result that would be inconsistent with the federal Clean Water Act or the Porter-Cologne Act. The Water Board is obligated to restore and protect water quality and beneficial uses.

Cost Estimates

We present cost estimates for sediment control actions by source category (e.g., channel incision, road-related erosion, etc.). These cost estimates include all costs for control of sediment discharges. We then estimate the proportion of total costs associated with agricultural sources (i.e., Agricultural Water Quality Control Program Costs).

Channel Incision and Associated Bank Erosion

Channel incision and associated rapid bank erosion is one of the largest sediment sources associated with land use activities and the primary agent for simplification of stream and riparian habitat in the Sonoma Creek watershed. As described in Chapter 8 (Implementation Plan), we will rely upon collaborative participation by landowners in reach based stewardships that will work with public agencies to implement projects that jointly reduce sediment discharges and enhance spawning and juvenile rearing habitat for salmonids and other native aquatic species. Examples of such collaborative efforts can be found in the neighboring Napa River watershed: in the 4.6-mile long Rutherford Reach of mainstem Napa River, bounded upstream by Rutherford Cross Road and downstream by Oakville Cross Road, a landowner stewardship acting in partnership with public agencies has developed a conceptual plan for bank stabilization and enhancement of stream-riparian habitat and is currently engaged in project design and permitting activities; and a similar planning effort is being considered on mainstem Napa River from Oakville Cross Road to Oak Knoll Avenue, representing an additional 10 miles of the river.

In estimating costs associated with reducing sediment discharges from channel incision and associated bank erosion, we assumed that all 18 miles of mainstem Sonoma Creek and five miles of tributaries would be treated with streambank restoration or riparian re-vegetation projects. Sediment loading from this source needs to be reduced by 35,000 tons per year, in order to achieve the allocation. This cost estimate assumes that treating all of mainstem Sonoma Creek will reduce sediment loading by 27,000 tons per year (i.e., restoration will reduce sediment loading from current loads to natural background loads), or 1,500 tons per year per mile. Treating fives of tributaries would then reduce sediment loading by approximately 8,000 (1,500 x 5) tons per year. In developing cost estimates we relied on unit costs for stream bank improvements and riparian revegetation presented in the Recovery Strategy for California Coho Salmon (CDFG, 2004). Estimated costs to reduce sediment discharges from channel incision and related bank erosion are $21.4 mil- $40 mil. Table 17 presents the costs and assumptions.

Table 17. Cost Estimates for Sediment Reduction from Channel Incision and Gullies

Actions	Implementing Parties	Item	Low Cost ($millions)	High Cost ($millions)
Develop and implement plan to enhance stream-riparian habitat and reduce sediment supply to 18-mile long mainsteam Sonoma Creek	Landowners in partnership with government agencies	• Design and environmental review	1.4	2.4
		• Construction	13.8	23.8
		• Maintenance and monitoring	1.4	2.4
Develop and implement plan to enhance stream-riparian habitat and reduce sediment supply to 5 miles of Sonoma Creek tributaries	Landowners in partnership with government agencies	• Design and environmental review	0.4	0.7
		• Construction	4.1	7.0
		• Maintenance and monitoring	0.4	0.7
Total			**21.4**	**37.0**

Key assumptions and information:

1. All of mainstem Sonoma Creek (18 miles) is treated with stream-bank improvements or riparian revegetation to reduce sediment by 27,000 tons per year.
2. Five miles of tributaries are treated with stream-bank improvements or riparian revegetation to reduce sediment by 8,000 tons per year.
3. Cost for stream-bank restoration/improvements based on $250 per lineal foot of streambank for projects located between 0.25 and 0.5 miles from a road (CDFG, 2004).
4. Cost for riparian revegetation based on cost of $35,000 per acre for projects located between 0.25 and 0.50 miles from a road. Assumes that with any stream mile that needs riparian revegetation, the width of the buffer created will be 50 ft. (CDFG, 2004) Accordingly, one stream mile equates to 6 acres.
5. Low cost assumes half of treated length will be revegetation/natural recovery, and half will be stream-bank improvements/restoration.
6. High cost assumes all treated stream miles will require stream bank improvements/restoration.
7. Design and environmental review costs, and monitoring and maintenance costs are assumed to each equal about 10 percent of construction costs.
8. Costs are presented rounded to the nearest $0.1 million; individual costs were summed prior to rounding, and the total was then rounded to the nearest $0.1 million.

Road-Related Erosion

Road-related erosion can be reduced by implementing a variety of measures, such as road decommissioning, road upgrading, relocation of roads in riparian areas, implementation of best-management practices in road construction, and limiting use of roads in the winter. In addition, sediment loads from existing roads can be reduced by stormproofing activities (e.g., removing unstable sidecast and fill materials from steep slopes, implementing surface drainage techniques that diffuse and slow down water flow, and upgrading stream crossings).

Sediment delivery from road-related erosion depends in part on the distance of the road to a watercourse. Most road-related sediment loads come from roads located within 100 ft. of a watercourse. Mapping indicates there are 268 kilometers of roads within 100 ft. of a stream. We multiply this by a factor of two to account for the incomplete stream mapping (which did not include many small headwater streams), and assume that 536 kilometers (332 miles) of roads are within 100 ft. of a stream and are thus likely candidates from road treatment.

It is important to note that up-front costs associated with prevention of road-related erosion yield significant future cost savings (benefits), as a result of much lower costs for repair and/or reconstruction following storms. Conservatively, storm-proofing roads should yield a much greater than 100 percent return on investment. These potential benefits, however, are not considered in the cost analysis. Road erosion control costs, information sources, and key assumptions are presented in Table 18. Estimated costs to reduce sediment discharges from road-related erosion are $3.6- to- 7.2 million.

Table 18. Cost Estimates for Control of Road-Related Erosion

Actions	Implementing Parties	Item	Low Cost ($millions)	High Cost ($millions)
Prepare and implement a road eroion control plan	Public and Private Landowners	• Program mgmt and administration	0.3	0.6
		• Inventory and control plan	0.3	0.6
		• Control and prevention measures	3.0	6.0
Total actions to reduce road-related erosion			**3.6**	**7.2**

Key assumptions and information:

1. Roads within 100 ft. of streams deliver most sediment to streams (SEC, 2006).
2. Length of roads within 100 ft. of a stream = 268 km (from GIS mapping) x 2 (factor to account for incomplete stream network mapping) = 536 km (or 333 miles).
3. Cost for road treatment based on costs estimated by Pacific Watershed Associates (CDFG, 2004) for road-related erosion control in San Mateo County, including planning, permitting, mobilization, and construction. Estimated cost is $18,000 per mile.
4. High cost assumes all roads within 100 ft. of stream require treatment, most likely stormproofing.
5. Low cost is equal to half of high cost value. In this scenario, we assume road-related erosion efforts are administered by local public agencies to coordinate inventories and control measures on a tributary basis, and only the most cost effective road reaches are targeted for treatment.

Vineyard Surface Erosion

The proposed Basin Plan Amendment anticipates that the Water Board will develop conditional waivers of Waste Discharge Requirements (WDRs) for vineyards. At this point, the site-specific actions or general waiver conditions are not known. However, the approach is that vineyard owners/operators will need to perform an inventory and assessment of sediment and erosion control practices, and develop a plan and schedule to implement best management practices needed (if any).

According to available land use data, there are approximately 14,700 acres of vineyards in the Sonoma Creek watershed. Vineyards undergoing new plantings or replantings are regulated by the Sonoma County Vineyard Erosion and Sediment Control Ordinance (VESCO), administered by the County Agricultural Commissioner—existing vineyards that are not undergoing replanting are not regulated. New costs associated with the Basin Plan Amendment would be those costs associated with actions not required by the VESCO, or not already implemented. Based on field observations, and the findings of the Interview Report on Best Management Practices in Sonoma Valley (Sonoma Valley Vintners & Growers Alliance, 2005), a large portion of vineyards in the Sonoma Creek watershed already implement best management practices. Therefore, we assume that 20 percent of the vineyard acreage would require best management practices to minimize erosion and sedimentation (i.e., 80 percent of needed actions are already implemented or required by VESCO). Our cost estimate is based on unit costs reported by the Central Coast Vineyard Team Demonstration Project (Stimson and O'Connor, 2005), which evaluated the effectiveness and cost of several vineyard erosion control best management practices. Vineyard surface erosion control costs, information sources, and key assumptions are presented in Table 19. We estimate costs to reduce sediment discharge from vineyard surface erosion necessary to achieve the allocation to be $2-to-4.2 million.

Table 19: Cost Estimate to Reduce Sediment from Vineyard Surface Erosion

Actions	Implementing Parties	Item	Low Cost ($millions)	High Cost ($millions)
Implement management measures to reduce sediment from vineyard lands	Vineyard owners and/or operators	Assessment and inventory, Implementation of erosion and sediment control measures, and monitoring	2.0	4.2
Total			**2.0**	**4.2**

Key Assumptions and Information:

1. There are approximately 14,700 acres of vineyards in the watershed, according to land use data from Sonoma Ecology Center
2. Twenty percent of vineyard acreage will require BMPs (i.e., 80 percent are regulated by County's VESCO, or already have BMPs in place).
3. Costs for vineyard erosion control range from $170 per acre to $238 per acre (Stimson and O'Conner, 2005), including assessment, BMP implementation, and monitoring.
4. Cover crops, which are a common BMP, need to be replaced every 3-5 years.
5. Implementation period is 20 years.
6. Low cost assumes erosion control costs $170 per acre, and BMPs must be replaced every 5 years.
7. High cost assumes erosion control costs $238 per acre, and BMPs must be replaced every 3 years.

Rangeland Surface Erosion/Livestock Grazing

The proposed Basin Plan amendment anticipates that the Water Board will develop conditional waivers of Waste Discharge Requirements (WDRs) for grazing land operators. At this point, the site-specific actions or general wavier conditions have not been determined. However, we expect that grazing land operators will need to develop ranch water quality plans, meet minimum standards related to minimizing sediment loads to surface waters, develop a implementation plan and schedule to meet the minimum stands, and conduct compliance monitoring and reporting.

From available land cover data, we estimate that there are 8,700 acres of potentially grazed lands in the watershed and that of this acreage only one-third is actually being grazed. Available information regarding costs indicates a wide range of unit costs, depending on the type of BMP implemented. For example, livestock exclusion is more costly than cover crops. The exact combination of BMPs depends on site-specific conditions, and would be selected by the grazing land operator/owner. To develop a range of costs, we assumed costs of combinations of similar practices [i.e., streambank stabilization practices (high-end cost) and permanent vegetative cover on critical areas (low-end cost), as defined by the Agricultural Stabilization and Conservation Service]. Total costs of actions to reduce sediment from rangeland surface erosion/livestock grazing, information sources, and key assumptions are presented in Table 20. Estimated costs are from $0.1-to 0.3 million.

Table 20. Cost Estimates for Implementation Measures to Reduce Sediment from Rangelands

Actions	Implementing Parties	Item	Low Cost ($)	High Cost ($)
Implement management measures to reduce sediment from grazing lands	Ranch owners and/or operators	Assessment and inventory	26,000	26,000
		Implementation of erosion and sediment control measures	34,000	261,000
		Monitoring	26,000	26,000
Total			86,000	313,000

Key Assumption and Information:

1. Acres of potential grazing land (i.e. , acreage of land cover in pasture and grassland) = 8,700 acres, per land cover data from Sonoma Ecology Center.
2. Approximately 1/3 of potential grazing land is actually grazed.
3. All grazing lands will need to complete an assessment, and perform BMP monitoring and reporting.
4. High Cost assumes grazed lands needing treatment will have Streambank Stabilization (ASCS practice code SP10) practices such as critical area planting, livestock exclusion, mulching, streambank protection, and treeplanting. Average cost per acre for Pacific Region is $100 per acre (U.S. EPA, 1993)
5. Low Cost assumes grazed lands needing treatment will have Permanent vegetative cover on critical areas (ASCS practice code SL11) practices such as cover and green manure crop, critical area planting, fencing, field borders, filter strips, forest land erosion control system, mulching, streambank protection and tree planting). Average cost per acre for Pacific Region is $13 per acre (U.S. EPA, 1993)
6. Assessment and monitoring will each cost $10 per acre, which is 10 percent of high cost of BMP implementation.
7. Costs are rounded to the nearest thousand.

Landslides

Future sediment delivery from shallow landslides and unstable areas need to be reduced by 700 tons per year, in order to meet the allocation. We estimate the cost to reduce this sediment source to be from $69,000 to $277,000. Table 21 presents the costs, information sources, and key assumptions.

Table 21. Cost Estimates for Sediment Reduction and Prevention in Landslide Areas

Actions	Implementing Parties	Item	Low Cost $	High Cost $
Accelerate natural recovery and avoid future human-caused increase in sediment delivery from unstable areas	Vineyard owners, ranchers, other rural private property owners, and public agencies	Erosion control assessment	6,000	25,000
		Control measures	63,000	252,000
Total			**69,000**	**277,000**

Key assumptions and information:

1. Future sediment delivery from shallow landslides and unstable areas need to be reduced by 700 tons per year (900 tons that is human caused- 200 allocation).
2. Assumes 20-year implementation period
3. High value for cost per ton of sediment prevented from entering a channel (from gully and/or landslide erosion), assuming biotechnical and/or traditional engineering approaches is $20 per metric ton ($18 per ton) (S. Chatham, personal communication, 2005).
4. Low cost for per ton of erosion prevented from entering a channel is estimated to equal 25 percent of high value, assuming an approach that would emphasize addressing present-day management influences on gully or landslide erosion at half or more of all sites (e.g., dispersion and/or diverting concentrated runoff to stable areas, planting of native wood, etc.).
5. Costs are rounded to the nearest thousand.

Stormwater Runoff

This category includes sediment discharges regulated by NPDES permits including the Sonoma County municipal stormwater program, California Department of Transportation's permit for stormwater discharges, and Industrial and Construction General permits. We rely on compliance with these existing NPDES permits to achieve sediment allocations for stormwater runoff.

However, the implementation plan calls for measures to prevent additional sediment loading due to channel incision. Specifically, the implementation plan calls for Phase II Municipal stormwater permittees to implement hydromodification management measures to attenuate peak flows and durations (see Section 8.5). The Phase II stormwater permittees would need to amend their stormwater management plans to incorporate requirements to control peak flows and durations, and implement such plans. Development and implementation of stormwater management plans is already a requirement of the Phase II municipal stormwater permit. Actions associated with controlling peak flows and durations would be extensions of existing programs (e.g., outreach and education, staff training, plan review). Costs for stormwater management plan implementation are difficult to calculate because activities often overlap with other city or county activities (e.g., street sweeping could be funding as part of street maintenance or stormwater management). To calculate a cost estimate, we assume the increased cost of incorporation of hydromodification management measures is 10-20 percent of the current budget for stormwater management. Based on information from Marin's Phase II stormwater program, we assume an annual budget of $100,000. Therefore, estimated costs to prevent further sediment loads due to channel incision, from municipal runoff is $200,000-$400,000 (equivalent to $10,000-$20,000 over the 20-year implementation plan. Hydromodification management costs, information sources, and key assumptions are also presented in Table 22.

Table 22. Cost Estimates for Preventing Further Channel Incision from Municipal Stormwater

Actions	Implementing Parties	Item	Low Cost $	High Cost $
Accelerate natural recovery and avoid future human-caused increase in sediment delivery from unstable areas	Phase II municipal stormwater permittees	Amend and implement stormwater management plans to control peak flow rates and durations	200,000	400,000
Total			**200,000**	**400,000**

Key assumptions and information:

1. Annual budget for stomwater management is $100,000, per information from Marin County's Phase II program (Lewis, 2004b). Dollar amounts are in 2004 dollars and have not been adjusted for inflation.
2. Assumes 20-year implementation period
3. Low cost estimate assumes an increase of 10 percent above the current budget for stomwater management.
4. High cost estimate assumes an increase of 20 percent above the current budget for stormwater management.

9.6 Agricultural Water Quality Program Costs

Implementation measures for grazing lands and vineyards constitute an agricultural water quality control program and therefore, consistent with California Water Code requirements (Section 13141), the cost of this program is estimated herein. This cost estimate includes the cost of implementing all sediment control and stream channel restoration measures specified in the implementation plan, and is based on costs associated with technical assistance and evaluation, project design, and implementation of actions needed to achieve the TMDL. In estimating costs, the Water Board has assumed that owners of agricultural businesses (e.g., grape growers and ranchers own 75 percent of total land area on hillside parcels, and 95 percent of the land along the length of Sonoma Creek and its tributaries. Based on these assumptions, we estimate that total cost for program implementation for agricultural sources could be $1.3-to-2.3 million per year throughout the 20-year implementation period. Considering potential benefits to the public in terms of ecosystem functions, aesthetics, recreation, and water quality, we conclude that at least 75 percent of the cost of these actions will be paid for with public funds, and therefore, we estimate that total cost to agricultural businesses associated with efforts to reduce sediment supply and enhance habitat in Napa River is $300,000-to-$600,000 per year. A summary of cost estimates for agricultural sources is presented in Table 22.

Table 23. Agricultural Water Quality Control Program Costs

Item(s)	Responsible Parties	Agricultural Sources (percent cost)	Low Cost to Agriculture ($millions)	High Cost to Agriculture ($millions)
Sonoma Creek watershed sediment reduction and channel restoration	Riverside landowners	95	20.3	35.1
Reduce road-related erosion by 50 percent	Owners of roads on hillside parcels	75	2.7	5.4
Accelerate natural recovery and avoid future human caused increases in sediment delivery from unstable areas	Ranchers, rural landowners, grape growers, public agencies	75	0.05	0.2
Control vineyard surface erosion	Grape growers	100	2.0	4.2
Control pasture surface erosion	Ranchers	100	0.09	0.3
NPDES stormwater treatment measures	Public agencies, developers, contractors	0	0.0	0.0
All measures to reduce sediment discharge to Sonoma Creek[35]	As above	…	25.2	45.2
As above with 75% cost of Sonoma Creek sediment reduction and habitat enhancement publicly funded			**6.3**	**11.3**
Average annual cost over 20-year implementation period			**0.3**	**0.6**

9.7 Sources of Funding

Potential sources of funding include monies from private and public sources. Public financing includes, but is not limited to grants, as described below, single-purpose appropriations from federal, state, and/or local legislative bodies, and bond indebtedness and loans from government institutions. There are several potential sources of public financing through grant and funding programs administered, at least

[35] Sonoma Creek habitat enhancement costs are included because the only feasible approach for reducing sediment discharges from channel incision and associated erosion of streambanks in Sonoma Creek is to undertake a channel enhancement approach.

in part, by the Regional Water Board and the State Water Board. These programs vary over time depending upon federal and state budgets and ballot propositions approved by voters. Regional and State Water Board grant and funding programs that are pertinent to the proposed Sonoma Creek Watershed Sediment TMDL and Habitat Enhancement Plan Basin Plan Amendment, and are currently available at the time of this writing or will be available in the near future are summarized and described below.

- **Consolidated Watershed Nonpoint Source Grant Program (Proposition 40).** The Consolidated Watershed Nonpoint Source (NPS) grant program is funded by Proposition 40, the California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2002. This program has not yet solicited grant proposals, but will fund nonpoint source, coast non-point source, urban storm water, and watershed management projects.

- **Nonpoint Source Pollution Control Program (Proposition 40).** The Non-point Source Pollution Control Program provides funding for projects that protect the beneficial uses of water throughout the state through the control of nonpoint source pollution. Up to $19 million is available to local public agencies and non-profit organizations.

- **Integrated Regional Watershed Management Grant Program (Proposition 40).** The Integrated Regional Watershed Management grant program funds projects for development of local watershed management plans and for implementation of watershed protection and water management projects. This grant program will provide $47.5 million statewide for competitive grants to non-profit organizations and public agencies.

- **Integrated Regional Water Management (IRWM) Grant Program (Proposition 50).** The IRWM Grant Program is a joint program between the Department of Water Resources (DWR) and the State Water Board which provides funding for projects to protect communities from drought, protect and improve water quality, and reduce dependence on imported water. Funding is available for both IRWM Planning and Implementation Grants.

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