LAGUNITAS CREEK

MARIN COUNTY, CALIFORNIA

Final

SEDIMENT AND RIPARIAN MANAGEMENT PLAN

June 1997

prepared for

MARIN MUNICIPAL WATER DISTRICT

in compliance with

California State Water Resources Control Board Order WR 95-17

prepared by

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For Balance Hydrologies, Inc.
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ACRONYMS

COE — U.S. Army Corps of Engineers

CDF&G — California Department of Fish and Game

CEQA — California Environmental Quality Act

DPR — California Department of Parks and Recreation

DPW — Marin County Department of Public Works

EPA — U.S. Environmental Protection Agency

GGNRA — Golden Gate National Recreation Area

MCCDA — Marin County Community Development Agency

MCDPW — Marin County Department of Public Works

MCFD — Marin County Fire Department

MCOSD — Marin County Open Space District

MCRCD — Marin County Resource Conservation District

MCSTOPPP — Marin County Stormwater Pollution Prevention Program

MMWD — Marin Municipal Water District

NMFS — National Marine Fisheries Service

NPS — National Park Service

NRCS — Natural Resource Conservation Service

PRNS — Point Reyes National Seashore

RWQCB — San Francisco Bay Regional Water Quality Control Board

SGVPG — San Geronimo Valley Planning Group

SPT — Samuel P. Taylor State Park

SWRCB — State Water Resources Control Board

TAC — Technical Advisory Committee

TBAC — Tomales Bay Advisory Committee

TU — Trout Unlimited

USFWS — U.S. Fish and Wildlife Service

1.0 Executive Summary

Diversion and use of surface water from streams and rivers is regulated by the California State Water Resources Control Board (SWRCB). Because Marin Municipal Water District (MMWD) diverts water from Lagunitas Creek, SWRCB Order WR 95-17 directs MMWD to prepare and implement a sediment management plan and a riparian management plan as one of several mitigation measures for enlarging Kent Lake in 1982. The order requires that the:

> "Permittee shall prepare a Sediment Management Plan that describes measures that should be taken to reduce sedimentation and to provide an appreciable improvement in the fishery habitat within the Lagunitas Creek watershed." (SWRCB, 1995)
>
> "Permittee shall prepare a Riparian Management Plan that describes measures to be taken to improve the riparian vegetation and woody debris within the Lagunitas Creek watershed in order to improve habitat for fishery resources." (SWRCB, 1995)

1.1 Goals and Objectives

The plan, prepared in compliance with Order WR 95-17, has two goals:

- Provide an appreciable, long-term improvement to streambed conditions in Lagunitas Creek for the benefit of coho salmon and steelhead; and
- Enhance instream fish habitat in Lagunitas Creek between Kent Lake and Tocaloma through riparian vegetation management and by placement of woody debris.

The sediment management objectives of the plan are to:

- Control fine sediment at its source;
- Trap fine sediment before it enters anadromous fishery habitat areas;
- Increase the supply of beneficial size gravel and cobble to the reach of Lagunitas Creek between Peters Dam and Shafter Bridge; and
- Coordinate and cooperate with other agencies and organizations performing sediment management programs in the Lagunitas Creek watershed.

The riparian management objectives of the plan are to:

- Place stable, large woody debris across the channel to retard the downstream migration of gravel and cobble at existing riffles where the substrate is too coarse for spawning and to retard the downstream migration of spawning gravel at incipient riffles. This will expand and maintain pool volume at the base of these riffles and contribute to high flow refuge habitat, adult holding habitat, and summer rearing habitat in the vicinity of these riffles;
- In pools below riffles, place stable, large woody debris across the channel to increase pool volume, to promote debris piles for summer rearing habitat, and to increase high flow refuge habitat;
- Tether large woody debris and tree tops in pools that are located at the downstream end of riffles to increase cover for summer rearing habitat;
- Develop and implement policies by the California Department of Parks and Recreation (DPR) and the MMWD that promote stable, large woody debris in the stream channel;
- Establish riparian trees in locations along Lagunitas Creek where canopy cover should be increased and where additional riparian trees for woody debris recruitment could be grown;
- Establish low growing, overhanging streamside vegetation adjacent to pools in areas of open canopy; and
- Manage foot traffic to increase the natural recruitment of low growing, overhanging vegetation adjacent to the stream.

1.2 Sediment Management

Field investigations for the preparation of this plan identified over 300 sources of sediment in the Lagunitas Creek watershed. Although a substantial proportion of the sediment sources are associated with human land use, many of these sources of sediment occur in areas that are not intensively used. Much of the sediment yield from these latter sources is episodic, highly localized, and cannot feasibly be reduced. In some cases where erosion produces beneficial size gravel to the stream, it is not desirable to eliminate a source of sediment.

This plan specifies erosion reduction measures to be installed at the 34 sediment source sites that hold the largest potential for long-term yield of

undesirable sediment sizes and that are feasible and cost-effective to repair. The plan also specifies operation of four small sediment traps that are located off the main channel of Lagunitas Creek and its primary tributaries. Sediment removed from these traps could be sorted by size. Material larger than 1" diameter could be used to replenish the reach of Lagunitas Creek between Peters Dam and Shafter Bridge where beneficial substrate is in short supply.

1.3 Riparian Management

Riparian management measures specified in this plan include installation of woody debris at 42 locations along Lagunitas Creek, planting of riparian vegetation at six locations, and repair of a streambank failure below Tocaloma Bridge.

1.4 Coordination with Other Agencies

Several agencies have their own programs dedicated to sediment reduction or enhancement of fisheries resources in the Lagunitas Creek watershed. This plan takes these companion programs into consideration and identifies actions that will complement their efforts. MMWD will cooperate and seek to enter into Memoranda of Understanding (MOUs) with these other agencies, which include DPR, the National Park Service (NPS), Marin County Open. Space District (MCOSD), Marin County Fire Department (MCFD), and the MCRCD.

One of the ongoing sediment reduction programs is the San Geronimo Bedload Sediment Reduction Program (San Geronimo Program), which is a cooperative effort of MMWD and the Marin County Resource Conservation District (MCRCD). This program has included erosion control projects in the San Geronimo Creek watershed along with a 10-year maintenance and monitoring effort. The San Geronimo Program will continue and encompasses many of the same objectives as the Lagunitas Creek Sediment and Riparian Management Plan.

1.5 Monitoring and Maintenance

This plan includes an annual monitoring program that will assess the streambed conditions in Lagunitas Creek and monitor of the function and condition of the sediment and riparian management measures that are

implemented. Maintenance be performed as needed to sustain the function of the installed measures. MMWD will form a Technical Advisory Committee (TAC) to review implementation of specific plans and projects and to provide continuing consultation and advice on the management plan.

1.6 Cost

The estimated cost to implement the identified measures for sediment and riparian management is over $1.16 million in 1997 dollars. In addition, there will be recurring costs for maintenance of the installed measures, operation of the sediment traps, placement of gravel and cobble below Peters Dam, monitoring, and reporting. The estimated annual cost for these recurring activities varies from year to year with an annual average of approximately $220,000 in 1997 dollars. In addition to these costs, substantial MMWD staff time will be required on an ongoing basis. The costs for MMWD staff time are not included in the cost estimates contained in this plan.

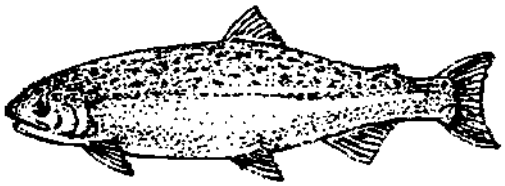
1.7 Public Participation Process

The preparation of this plan has included two meetings with the public agencies who own land or have land management responsibilities in the watershed, are regulatory agencies with jurisdiction over measures specified in this plan, or are agencies with an interest in the fisheries resources in Lagunitas Creek. In addition to the agency meetings, two tours of Lagunitas Creek and workshops were held for members of the public and community groups prior to development of the plan and after release of the draft plan.

At each of these events, the participants were invited to provide their comments either during the meeting or in writing after the meeting. All comments provided to MMWD during the meetings were recorded and, along with written comments submitted separately, were considered in the preparation of the draft and final plan.

As required by SWRCB Order WR 95-17, a draft of this plan was submitted to SWRCB, California Department of Fish and Game (CDF&G), United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and the San Francisco Bay Regional Water Quality Control Board (RWQCB). In addition, copies of the draft plan were offered to all parties and

agencies that participated in the public input process or who have otherwise expressed an interest in the plan. Over 100 copies of the draft plan were distributed for review to 37 agency representatives, 64 community groups, and members of the public. Comments from all of these parties were considered in the preparation of the final plan. Approval of the final plan rests with the Chief of the Division of Water Rights, SWRCB.



2.0 Introduction and Project Overview

2.1 Project Background

Following the drought of the late 1970s, the Marin Municipal Water District (MMWD) recognized a need to increase the storage capacity of the Kent Lake Reservoir by raising Peters Dam. In October 1979, MMWD and the California Department of Fish and Game (CDF&G) entered into an agreement for interim operation of an enlarged Kent Lake. This agreement specified that biological, hydrologic, and geomorphic studies be undertaken. In Decision 1582, issued on April 7, 1982, the State Water Resources Control Board (SWRCB) approved a Water Right Application from MMWD for the enlargement of Kent Lake. The SWRCB also established interim flows for fish and wildlife protection and directed MMWD to conduct additional studies. By 1988, MMWD had substantially completed the required fisheries, hydrologic, and geomorphic studies. In 1995, the SWRCB issued Order WR 95-17 (Appendix A), which details MMWD's mitigation requirements for raising Peters Dam (SWRCB, 1995). This order modifies MMWD's Water Rights Permits. Two of the requirements of the order are to:

> "Prepare a Sediment Management Plan that describes measures that should be taken to reduce sedimentation and to provide an appreciable improvement in the fishery habitat within the Lagunitas Creek watershed." (SWRCB, 1995)

> "Prepare a Riparian Management Plan that describes measures to be taken to improve the riparian vegetation and woody debris within the Lagunitas Creek watershed in order to improve habitat for fishery resources." (SWRCB, 1995)

The plan is to describe specific sediment and riparian management programs and projects, including agency responsibility, estimated costs, time schedule for implementation, public participation process, monitoring program, and reporting procedures.

SWRCB Order WR 95-17 states:

> "The riparian management plan and the sediment management plan can be prepared as separate components of a single plan."

During development of the sediment and riparian management plan, the SWRCB directs MMWD to:

> "Coordinate with appropriate public agencies, and provide an opportunity for input by local environmental groups, property owners in the area, and the general public." (SWRCB, 1995)

2.2 Organization of Sediment and Riparian Management Plan

The sediment and riparian management plan is organized as follows:

Section 1 is an executive summary of the sediment and riparian management plan. Section 2 contains the project overview and study area, a brief discussion of each section in the plan, and a description of the watershed, landownership, and aquatic resources found in the Lagunitas Creek.

Section 3 is the sediment management plan. It contains a summary of the SWRCB Order WR 95-17 discussion of sediment issues in the Lagunitas Creek watershed. This is followed by a detailed overview of sediment concerns in the watershed, sediment reduction strategies, source control findings, road related erosion issues, cobble and gravel retention in the reach between Peters Dam and Shafter Bridge, and previous erosion control efforts. The sediment management plan contains goals and objectives to meet the goal of SWRCB Order WR 95-17. It identifies specific management programs, projects, and public outreach. The plan identifies site specific projects for MMWD to control erosion, trap fine sediment, and enhance the spawning area between Peters Dam and Shafter Bridge. The plan focuses on MMWD's sediment management actions but also identifies efforts of many other public agencies and local groups.

The riparian management plan in Section 4 follows a similar outline as the sediment management plan. This includes a summary of the riparian management issues discussed in SWRCB Order WR 95-17 and a detailed overview describing the functions of riparian vegetation and woody debris in

the Lagunitas Creek watershed. The riparian management plan contains goals and objectives to meet SWRCB Order WR 95-17 and identifies specific management programs, projects, and public outreach. The plan focuses on MMWD's efforts and identifies site specific projects to revegetate the riparian corridor, place woody debris in the stream channel, and control non-native vegetation along the streambanks.

Section 5 describes the monitoring program, including formation of a Technical Advisory Committee, and reporting requirements. Section 6 outlines implementation responsibilities, a timeline, and costs. References are listed in Section 7. Section 8 is a glossary of technical terms used in this plan.

The plan contains 11 appendices. Appendix A is SWRCB Order WR 95-17. A summary of the public participation process, including comments from the public meetings and letters received during the planning process and on the draft plan, are contained in Appendix B. Responses to public comments received during the planning process and on the draft plan are in Appendix C. Appendix D describes the methods used by field investigators to identify and catalog erosion sites. Appendix E contains standard specifications that could be used for erosion control projects. Appendix F contains the inventory data sheets and site location maps for the priority sediment source control sites. Data sheets for the riparian revegetation projects are in Appendix G, and sketches of woody debris sites are in Appendix H. The streambed monitoring protocol is described in Appendix I, and the Aquatic Resources Monitoring Workplan is in Appendix J. Cost estimates for the Lagunitas Creek Sediment and Riparian Management Plan are in Appendix K.

2.3 Project Overview

Before preparing the sediment and riparian management plan, MMWD conducted outreach efforts with the general public and public agencies to inform them about the plan and planning process and to solicit ideas about where enhancement work was necessary and the appropriate type of work to be done. Table 1 lists public agency interests and responsibilities in the Lagunitas Creek watershed. A summary of the public participation process,

including summaries from public meetings and copies of comment letters, are in Appendix B.

Members of the public and public agency representatives suggested many ideas for the sediment and riparian management plan. Appendix C identifies the major issues that were identified during the planning process and from review of the draft plan. Wherever possible, suggestions have been incorporated into the plan.

SWRCB Order WR 95-17 required MMWD to submit a draft Sediment and Riparian Management Plan to the SWRCB for review by the Chief of the Division of Water Rights. The order specifically states that the San Francisco Bay Regional Water Quality Control Board (RWQCB), California Department of Fish and Game (CDF&G), U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS) have an opportunity to review and comment on the draft plan. MMWD also provided an opportunity for other agencies and the general public to comment on the draft plan. This process included a public workshop to discuss the draft plan.

SWRCB Order 95-17 also states:

> "Following consideration of any comments provided by the Regional Board, CDF&G, USFWS, NMFS, and the Chief of the Division of Water Rights, Permittee shall prepare and submit a final Sedimentation [and Riparian] Management Plan to the State Water Resources Control Board for approval by the Chief of the Division of Water Rights."

The RWQCB, CDF&G, USFWS, and NMFS will have an opportunity to review and comment on the final plan prior to approval by the Chief of the Division of Water Rights.

The order stipulates that following approval of the plan:

> "Permittee shall provide the appropriate level of funding and resources to ensure effective implementation of the measures described in the plan." (SWRCB, 1995)

TABLE 1

Public Agency Interest and Responsibility

LOCAL GOVERNMENT AGENCIES

Marin Municipal Water District	MMWD provides domestic and commercial water services for eastern Marin County. The State Water Resources Control Board's Order WR 95-17 requires MMWD to take various actions to mitigate for the raising of Peters Dam. MMWD owns approximately 22,000 acres of watershed lands for Lagunitas Creek, including the reach of Lagunitas Creek between Peters Dam and Shafter Bridge.
Marin County Community Development Agency	The MCCDA oversees development activities on private land.
Marin County Fire Department	The MCFD maintains an extensive network of fire access roads in the Lagunitas Creek watershed, including the San Geronimo Valley.
Marin County Open Space District	MCOSD owns and manages land in the San Geronimo watershed, including portions of Roy's Redwoods and the San Geronimo Ridge Preserve.
Marin County Department of Public Works	The MCDPW maintains county roads and operates the Flood Control District. MCDPW issues grading permits for work in Marin County. Local agencies are exempt from obtaining these permits but still must notify the Department. The Flood Control District has no jurisdiction for flood control and stream maintenance in the San Geronimo and Lagunitas Creeks watersheds.
Marin County Resource Conservation District	Since the early 1980s, MCRCD has undertaken erosion control projects in the Lagunitas and San Geronimo Creek watersheds. MCRCD oversees the San Geronimo Bedload Sediment Reduction Program.
Marin County Stormwater Pollution Prevention Program	MCSTOPPP is a joint program of Marin County and the City of San Rafael to coordinate and oversee non-point source pollution control activities for the cities in eastern Marin County.
Tomales Bay Advisory Committee	TBAC is a consortium of landowning and regulatory agencies, and interested public agencies and organizations. TBAC is a forum to discuss the issues and activities that affect the natural resources of Tomales Bay and to identify cooperative solutions.

TABLE 1

Public Agency Interest and Responsibility

CALIFORNIA STATE AGENCIES

California Department of Fish and Game	CDF&G administers the California Endangered Species Act and issues 1601 and 1603 Streambed Alteration Agreements for work occurring within the bed and bank of a stream.
California Department of Parks and Recreation	DPR owns and manages Samuel P. Taylor State Park. The park is entirely within the Lagunitas Creek watershed and contains some of the most significant salmonid habitat.
California State Water Resources Control Board	The SWRCB oversees water quantity and quality plans within California. The Division of Water Rights issued and is overseeing the implementation of the WR 95-17 order.
San Francisco Bay Regional Water Quality Control Board	The RWQCB regulates both surface and ground water quality and has the authority to protect beneficial uses of water (agriculture, recreation, aesthetic preservation, and enhancement of fish, wildlife, and other aquatic resources or preserves). Under Section 401 of the Clean Water Act, Water Quality Certifications are issued by the RWQCB for all permits issued by the U.S. Army Corps of Engineers. The RWQCB issues discharge permits for discharges to surface waters and to land. Permitted facilities in the Lagunitas Creek watershed include waste treatment plants, septic systems, water treatment facilities, and certain industries and construction projects.

TABLE 1

Public Agency Interest and Responsibility

FEDERAL AGENCIES

Army Corps of Engineers	Under Section 404 of the Clean Water Act, the COE issues permits for discharges of dredged or fill material into waters of the United States. In non-tidal areas, their jurisdiction extends up to the ordinary high water line or the upper limit of wetlands.
Environmental Protection Agency	For projects requiring a COE permit, the EPA has oversight and veto authority.
U.S. Fish and Wildlife Service	Under the federal Endangered Species Act (ESA), the USFWS is responsible for federally-listed animal species (with the exception of coho salmon and steelhead). Listed species in the Lagunitas Creek watershed are the California freshwater shrimp and red-legged frog.
National Marine Fisheries Service	NMFS administers the ESA for federally-listed marine and anadromous species. Actions impacting coho salmon and steelhead will require consultation and take permits from NMFS.
National Park Service	Both Golden Gate National Recreation Area (GGNRA) and Point Reyes National Seashore (PRNS) own land in the Lagunitas Creek watershed. PRNS manages all lands within the seashore's boundaries and land of the GGNRA in the Lagunitas Creek area.
Natural Resources Conservation Service	NRCS (formerly the Soil Conservation Service (SCS)) works with private and public landowners to conserve natural resources. They also provide technical assistance to the MCRCD.

The order also states:

> "As recommended by the District's consultant, the plan should have the flexibility to respond to changing conditions within the watershed and should have approximately a 10 year time frame." (SWRCB, 1995)

MMWD recognizes its public trust responsibilities in the Lagunitas Creek watershed. The projects identified in the sediment and riparian management plan are expected to meet the goals and requirements of the order. However, the plan does not relieve MMWD of its long-term responsibilities. After the 10-year period in which MMWD has met the requirements of the SWRCB order, MMWD will continue its efforts to maintain the Lagunitas Creek fishery and will set forth new programs and policies at that time.

2.3.1 Project Area

The earlier studies conducted by MMWD for the SWRCB indicated that the reach of Lagunitas Creek through Samuel P. Taylor State Park is important for spawning, incubation, and rearing of salmonids (Kelley and Dettman, 1980) and is important habitat for the California freshwater shrimp. Reaches of Lagunitas Creek downstream of Tocaloma were found to have more limited habitat for salmonids and to be less affected by bed sedimentation. The sediment and riparian management plan focuses on the reach of Lagunitas Creek from Peters Dam to Tocaloma. Other areas in the Lagunitas Creek watershed and plans for these areas, including San Geronimo Creek, Olema Creek, and the reaches downstream of Tocaloma Bridge, are discussed below and in the plan.

Area Downstream of Tocaloma Bridge.
In this management plan, MMWD focuses on the area above Tocaloma Bridge for sediment control projects. SWRCB Order WR 95-17 is based on a public record that indicates that sediment reduction is important for habitat areas upstream of Tocaloma Bridge. Sediment control projects that are installed above Tocaloma Bridge will benefit the reaches upstream and downstream of Tocaloma. Sediment projects in the downstream area would not benefit fishery habitat above Tocaloma.

For riparian management projects, MMWD performed a reconnaissance survey downstream of Tocaloma Bridge. While there are openings in the riparian forest, only one of these sites was considered important for habitat enhancement. There is adequate woody debris in the system in these reaches. The benefits of working to improve the riparian habitat below Tocaloma do not approach the benefits of working above. Because the background for SWRCB Order WR 95-17 focuses on the need to enhance the amount of woody debris in the system, the plan also focuses on this need.

Subsequent to MMWD's decision to concentrate its work upstream of Tocaloma Bridge, NPS has decided to undertake a habitat assessment that will include areas both above and below Tocaloma Bridge (including sediment analysis) as part of their Coho Habitat Assessment and Enhancement Program. NPS has stated their project will include areas below Tocaloma (D. Fong, 1997, and R. Smith, 1997). The NPS will also conduct monitoring in Lagunitas Creek. Station locations have not yet been determined but could include sites below Tocaloma Bridge. MMWD will coordinate with NPS rather duplicate this effort.

San Geronimo Creek.

MMWD has in the past, and plans in the future, to conduct sediment management projects in the San Geronimo Valley. San Geronimo Creek and its watershed have previously been addressed in the San Geronimo Bedload Sediment Reduction Program (see Section 3). The SWRCB acknowledged the San Geronimo Program, characterizing it as an excellent sediment control program, but requested that the work be extended to other parts of the Lagunitas Creek watershed. MMWD's intent is to continue the San Geronimo Program. Important sediment source sites that were identified in MMWD's 1990 *San Geronimo Creek Bedload Reduction Opportunities* have been addressed through the San Geronimo Program. Some additional work will be conducted under the Lagunitas Creek Sediment and Riparian Management Plan. Several sites in the San Geronimo Valley that have worsened or were not previously identified have been targeted as priority repairs in the management plan.

In addition, MMWD will attempt to develop a cooperative agreement with MCOSD and MCFD for repair, maintenance, and possible closure of fire roads in the San Geronimo Valley. The plan also identifies continued public outreach with residents in the San Geronimo Valley to promote appropriate land use practices and non-structural measures to reduce erosion on private lands. Areas of overlap between the San Geronimo Program and Lagunitas Creek management plan include maintenance of the two sediment traps in San Geronimo Valley (Spirit Rock and Dickson Weir) and an annual streambed monitoring effort. If, in the future, new projects are identified for the San Geronimo Valley, they will be conducted under the San Geronimo Program.

MMWD's public outreach efforts for riparian management will continue to encourage landowners along San Geronimo Creek, and its tributaries, to leave woody debris in the creek as a beneficial feature for fish habitat. This will include the section of San Geronimo Creek through MMWD's water treatment plant where there are opportunities to add woody debris into the creek channel by pulling down trees that fell across the streambanks during the 1996-97 winter storms.

Tributaries.

Some of the tributary streams are important salmonid habitat areas. Coho salmon and steelhead occur in Devil's Gulch, Cheda Creek, and McIsaac Creek. Some the tributaries to San Geronimo Creek also support coho and steelhead, such as Larson Creek at the Lagunitas School in San Geronimo and the unnamed creek along Arroyo Road in Forest Knolls. It is unlikely that these fish are found in Irving Creek, Barnabe Creek, Deadman's Gulch, or the smaller feeder tributaries in the watershed for several reasons. Flows in these smaller tributaries may be too intermittent to sustain incubating eggs or juvenile salmonids. A few tributaries drain directly into the main stem of Lagunitas Creek but pass through culverts that are too high above the main stem channel to allow fish passage. Habitat conditions in some tributaries may have insufficient gravel to provide spawning habitat for salmonids. It is possible that some tributaries are used in the wettest years and not in average or dry years.

The tributaries from Peters Dam to Tocaloma Bridge are addressed in the management plan. All of the tributaries below Tocaloma Bridge, except Nicasio and Olema Creeks, are discussed above. In 1990, MMWD examined all the tributaries in San Geronimo. From a sediment management perspective, these tributaries have been addressed. If tributary canyons have not been historically adequate for fish habitat, flow or passage issues are the likely reasons. It is not practical to address riparian habitat and woody debris issues if flow or passage are problems. Neither flow nor passage are part of the SWRCB Order for the sediment and riparian management plan.

Olema Creek.

As explained above, NPS will be undertaking a study over the next five years of the fishery resources in Olema Creek and will likely be implementing its own projects.

Nicasio Creek.

MMWD does not include Nicasio Creek in this management plan for several reasons. The record on which SWRCB Order WR 95-17 is based does not identity Nicasio Creek as a tributary with potential coho and steelhead habitat. There is only about a mile long stretch of Nicasio Creek between Seeger Dam and the confluence with Lagunitas Creek. This stretch does support coho and steelhead, but the rest of the creek, upstream of Seeger Dam, does not. Therefore, efforts to improve stream habitats upstream of Seeger Dam would not benefit coho or steelhead. According to CDF&G, providing passage over Seeger Dam would be "just about impossible" due to the height of the dam and lack of constant flows over the dam (Cox, 1997). Order WR 95-17 specifically prohibits MMWD from releasing Nicasio Reservoir water directly into Lagunitas Creek or its tributaries.

The geology of the Nicasio Creek watershed upstream of Seeger Dam is more unstable than other parts of Lagunitas Creek, and sedimentation is an inherent problem. Erosion control efforts in the watershed are not likely to be cost-effective and may not result in a net benefit to the coho and steelhead habitat downstream of Seeger Dam. Also, the Nicasio Creek watershed is largely privately-owned land, and MMWD has little authority to implement erosion control projects in the watershed. MMWD is willing to participate in a cooperative agency and public effort to address land use, sedimentation, and stream habitat conditions in the Nicasio Creek watershed, but this is beyond

the scope of SWRCB Order WR 95-17 and is not part of this management plan.

2.3.2 Goals of the Sediment and Riparian Management Plan

Order WR 95-17 directs MMWD to prepare a sediment management plan that describes measures to be taken to reduce sedimentation and to provide an appreciable improvement in the fishery habitat within the Lagunitas Creek watershed. It further orders MMWD to prepare a riparian management plan that describes measures to be taken to improve the riparian vegetation and woody debris within the Lagunitas Creek watershed in order to improve habitat for fishery resources.

Under Order WR 95-17, the SWRCB did not establish what constitutes an "appreciable" improvement in the fishery habitat. To date, the SWRCB has not clarified this terminology. Black's Law dictionary defines appreciable as "capable of being estimated, weighed, judged of, or recognized by the mind. Capable of being perceived or recognized by the senses. Perceptible but not a synonym of substantial."

MMWD will quantitatively evaluate changes to the physical habitat that may result from sediment and riparian management projects. Data collected under the streambed monitoring program will help determine if there has been an accumulation or depletion of sediment in the streambed over time, how deeply cobbles are embedded in the streambed, how abundant cobble is, and how much of the streambed is covered by fine sediment or cobble.

In addition, Order WR 95-17 requires MMWD to prepare and implement a workplan for monitoring coho salmon, steelhead, and freshwater shrimp populations in Lagunitas Creek. MMWD's Aquatic Resources Monitoring Workplan was approved by the SWRCB after review by NMFS, USFWS, and CDF&G. The workplan is included in the plan as Appendix J. The habitat typing that is conducted under the Aquatic Resources Monitoring Workplan in conjunction with the annual monitoring of sites specified in this management plan can be used by MMWD to evaluate how well the riparian vegetation and woody debris in Lagunitas Creek are functioning in terms of fish habitat.

Implementation of the identified measures should result in a measurable and possibly significant improvement in habitat. Studies conducted by MMWD for the SWRCB under Decision 1582 indicated that the types of measures described in the sediment and riparian management plan would benefit the fishery habitat in Lagunitas Creek. At the completion of the implementation of this plan, a decision regarding whether or not MMWD is to do more fisheries habitat mitigation and enhancement work will be in the domain of the SWRCB.

2.4 Watershed Description

Lagunitas Creek drains much of west central Marin County, California (see Figure 1: Lagunitas Creek Watershed Location Map) and is the largest watershed in the county, encompassing 103 square miles. It originates on Mt. Tamalpais and flows eight miles through three small reservoirs before entering a fourth reservoir, Kent Lake. From Kent Lake, it flows northwest about 14 miles before emptying into the southern end of Tomales Bay. The four dams constructed on Lagunitas Creek are Lagunitas Dam (1872), Alpine Dam (1918), Bon Tempe Dam (1948), and Peters Dam (1954). Peters Dam, which forms Kent Lake, is the most downstream dam on the main stem of Lagunitas Creek. When Peters Dam was raised in 1982, Kent Lake became the largest of the municipal supply reservoirs operated by MMWD, with a storage capacity of 32,700 acre-feet. A fifth dam constructed by MMWD in the Lagunitas Creek basin is Seeger Dam (1961), which forms Nicasio Reservoir on Nicasio Creek about one mile upstream from its confluence with Lagunitas Creek.

Downstream of Peters Dam several major, unregulated tributaries join Lagunitas Creek, including San Geronimo Creek, Devil's Gulch, and Olema Creek. San Geronimo Creek flows through the San Geronimo Valley, collecting runoff from several small towns, pasture land, and a golf course before it joins Lagunitas Creek at Shafter Bridge near the Inkwells, about one- . quarter mile downstream of Peters Dam. The San Geronimo Valley contributes a major portion of the sediment load to Lagunitas Creek. Devil's Gulch is a smaller tributary that flows through a narrow, steep, well-shaded canyon in Samuel P. Taylor State Park. Olema Creek flows parallel to

Highway 1 and the San Andreas Fault and joins Lagunitas Creek downstream of Point Reyes Station.

Landownership.
Most of the land along the main stem of Lagunitas Creek is publicly owned. Landowners include MMWD, DPR, which owns Samuel P. Taylor State Park, and NPS, which owns Golden Gate National Recreation Area (GGNRA) and Point Reyes National Seashore (PRNS). There are a few private landowners between the NPS boundary and the mouth of Lagunitas Creek. Figure 2: Public Lands in the Lagunitas Creek Watershed Map shows public landownership boundaries in the Lagunitas Creek watershed. Land use in the watershed is primarily open space, with livestock grazing on some NPS lands.

Most of the land in the San Geronimo Creek watershed is privately owned, rural residential development. The Marin County Open Space District (MCOSD) owns and manages 1,170 acres, including Roy's Redwoods, the Gary Giacomini Open Space Preserve, and the Maurice Thorner Memorial Open Space Preserve. MMWD owns the water treatment plant and surrounding land. There is a 158-acre golf course, one livestock ranch, and one horse boarding and training facility near Woodacre. San Geronimo Creek joins Lagunitas Creek just past the Inkwells, *a* bedrock feature near Shafter Bridge.

In the Nicasio Creek watershed, MMWD owns Nicasio Reservoir and a surrounding perimeter of land. The remainder of the watershed is privately owned, and much of it is in agricultural production. Most of the Olema Creek watershed is owned by the NPS.

2.5 Aquatic Resources

Two salmonids utilize the Lagunitas Creek watershed: coho salmon *(Oncorhynchus kisutch)* and steelhead trout *(O. mykiss).* Priority for managing these two species has always been high; however, recent actions to list them under the Endangered Species Act (ESA) have elevated the level of interest. Another species of concern is the California freshwater shrimp *(Syncaris pacifica).* The life histories and status of these species and a list of other aquatic species found in Lagunitas Creek follows.

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Coho salmon.

Coho salmon are anadromous fish—they spend their adult life in the ocean, migrate up freshwater streams to spawn, rear at least partially in freshwater, and migrate to the ocean as juveniles. Unlike other Pacific salmon in California, this three-year cycle is fairly rigid. Spawning years with relatively poor reproductive success can result in poor spawning runs three years later. Adult coho start to arrive in Tomales Bay and near the mouth of Lagunitas Creek in late summer and fall to begin acclimation to freshwater before they migrate upstream. Upstream migration is usually triggered by an increase in flow from a winter storm event (Kelley & Associates and Entrix, 1992). The spawning period in the creek occurs between late October and early February.

Coho salmon usually spawn at the heads of riffles with appropriate gravel substrate. For spawning and for incubation, coho require substrate ranging in size from 0.8 to 4.5 cm (Bratovich and Kelley, 1988). Others have suggested larger spawning substrates for coho salmon, such as 1.3 to 10.2 cm (Bell, 1986, cited in Kelley & Associates and Entrix, 1992) or 0.8 to 6.8 cm (Bovee, 1982). Female coho dig pits in the gravel substrate where they deposit their eggs. Often more than one male will fertilize the eggs before the female covers the eggs with gravel, creating a redd. Following spawning, adult coho die. Juvenile coho emerge from the gravel the following spring and usually rear in the stream for one year before migrating to the ocean.

While in the stream, juvenile coho often occupy sheltered habitat at the heads of pools, which generally provide an optimum mix of high food availability and good cover with low swimming cost. Juveniles depend on cool water and abundant invertebrate food to rear successfully. Juvenile coho require substrate ranging in size from 7.6 to 60 cm (Kelley & Associates and Entrix, 1992). Water temperatures between 12° and 14° C (53.6° and 57.2° F) are considered optimal for coho (Brett, 1952; Moyle, 1976). The critical thermal maximum (CTM), the temperature at which a fish loses equilibrium and dies, for coho varies among streams but has been shown to be as high as 29.2° C (84.6° F) (Konechi, et al., 1995). Warmer water requires more abundant food resources for fish survival because of the resultant increase in their metabolic rate.

Wild stocks of coho have declined or disappeared from all streams for which there are data, and Lagunitas Creek is no exception. Reasons for the decline of coho salmon in California include loss of habitat above dams, habitat degradation from livestock grazing and other land uses, breakdown of genetic integrity of wild stocks, introduced diseases, overharvesting, and climatic change. In Lagunitas and Nicasio Creeks, Peters and Seeger Dams blocked fish access to the upper reaches of the system, caused flows to deviate from the natural hydrograph (Brown, et al., 1995), and reduced sediment supply (Hecht, 1992).

The present coho salmon population in Lagunitas Creek has been significantly reduced from historic levels. However, recent surveys appear to indicate an upward trend in the coho salmon population below Peters Dam. Spawner surveys from the mid 1980s indicated that approximately 100 coho spawned annually in Lagunitas Creek and its tributaries (Kelley & Associates and Entrix, 1992), while a coho spawner survey in 1995-96 indicated at least 300 coho spawned in the main stem of Lagunitas Creek alone (Trihey & Associates, Inc., 1996). Recent juvenile abundance estimates indicate that in Lagunitas Creek, Devil's Gulch, and the downstream reach of San Geronimo Creek, coho salmon were substantially more abundant in 1994 than in 1993, 1995, or 1996. However, the juvenile coho population estimates from these years are all above population estimates for the period 1980 to 1990. (Trihey & Associates, Inc., 1996).

As of this writing, coho salmon are listed by NMFS under the federal ESA. Populations in the Central California Coast Ecologically Significant Unit (ESU), which includes Lagunitas Creek, have been listed as "threatened." Under the state ESA, coho runs south of San Francisco Bay have been declared "endangered," but coho runs north of the bay have no state designation.

Steelhead trout.

Steelhead trout, an anadromous form of rainbow trout, usually spend one to two years in the ocean before returning to spawn for the first time. Unlike other anadromous Pacific salmonids, steelhead may survive spawning, return to the ocean, and spawn again in a later year. Steelhead typically migrate upstream in Lagunitas Creek between January and

March. For spawning and incubation, steelhead require the same gravel sizes as coho salmon—0.8 to 4.5 cm. Juvenile steelhead require substrate ranging from 6.4 to 25 cm (Kelley & Associates and Entrix, 1992).

In California, juvenile steelhead generally spend one to three years in freshwater before migrating to the ocean, usually between March and June. Larger steelhead, usually yearlings or older, have been observed using heads of pools for feeding. Young-of-the-year steelhead often utilize riffle and run habitat during the growing season and move to deeper, slower water habitat during the high flow months. In these ways, steelhead are more habitat generalists than coho. In addition, juvenile steelhead can typically tolerate warmer water temperatures than coho (Moyle, 1976). Preferred temperatures range between 12.8° and 15.6° C (55.0° and 60.1° F), with a CTM up to 29.4° C (84.9° F) (Lee and Rinne, 1980).

Steelhead trout populations have declined throughout their range in California, especially south of Monterey Bay. In Lagunitas Creek, as in other small, central California coastal streams, they have not been as affected as coho salmon. Their variable life history, ability to utilize both pool and fast water habitat types for rearing, ability to spawn multiple times, and tolerance of warmer water temperatures enable steelhead to be more resilient than coho to adverse environmental conditions (Kelley & Associates and Entrix, 1992). Juvenile steelhead sampling in Lagunitas Creek indicates no long-term trend in steelhead densities below Peters Dam since the 1970s, although there may be a slight upward trend in the past couple of years. The 1996 juvenile abundance survey indicated that young-of-the-year steelhead populations were generally lower in 1996 than in 1993, 1994, and 1995. Yearling steelhead populations were estimated to be more abundant than in 1993 and 1995 and similar to 1994 (Trihey & Associates, Inc., 1996).

As of this writing, steelhead have been proposed for federal listing as "endangered" by NMFS in all ESUs south of and including the Russian River watershed. The final rule on this proposed listing is expected to occur in late July, 1997. Steelhead are not protected under the state ESA.

California freshwater shrimp.

California freshwater shrimp are endemic to perennial lowland streams in Marin, Napa, and Sonoma counties and are currently known to occur in only seventeen streams within their native range. They inhabit the edges of pools where the water velocity is slow, and where there are stable undercut banks, exposed root systems, or submerged vegetation (Serpa, 1992).

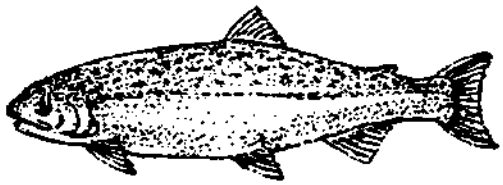
Breeding takes place in the fall prior to winter storms, and females carry the fertilized eggs for up to eight months until they are released in May and June. Juveniles become sexually mature about fifteen months after their release, and adults live for approximately two to three years. The California freshwater shrimp is a detritus feeder, scraping small particles from the substrate or from the submerged vegetation that filters out materials from the flowing water (Serpa, 1992).

California freshwater shrimp are listed as "endangered" under the state and federal ESAs. Human-related impacts, including channelization, introduced fish predators, pollution, and water withdrawal have eliminated them from most of the habitat within their native range (Serpa, 1992). Sampling conducted in Lagunitas Creek in 1981 and in the early 1990s is difficult to compare because of the differences in study design and the long time frame between the sampling periods given the shrimp's relatively short life span. Recent sampling indicates that the freshwater shrimp population in Lagunitas Creek has increased since both the 1991 and 1994 surveys and is doing quite well (Serpa, 1996).

Other aquatic species.

Many other species comprise the aquatic community in and around Lagunitas Creek. The fish community includes native species like California roach *(Lavina symmetricus),* Sacramento sucker *(Catostomus occidentalis),* Pacific lamprey *(Lampetra tridentata),* three-spine stickleback *(Gasterosteus aculeatus),* prickly sculpin *(Cottus asper),* riffle sculpin *(C. gulosus),* and coast range sculpin (C. *aleuticus).* Non-native bluegill *(Lepomis macrochirus),* largemouth bass *(Micropterus salmoides),* green sunfish *(Lepomis cyanellus),* and carp *(Cyprinus carpio)* have also been observed in Lagunitas Creek in small numbers.

Amphibians, aquatic reptiles, and a crustacean also use Lagunitas Creek. It is within the range and contains some appropriate habitat for red-legged frog *(Rana aurora),* although they have not been observed in the creek. The California red-legged frog *(R. aurora ssp. draytonii)* is listed as "threatened" under the federal ESA. Other amphibians that may inhabit the Lagunitas Creek watershed and use the stream or riparian zone include foothill yellow-legged frog *(R. boylii),* western toad *(Bufo boreas),* Pacific treefrog *(Hyla regilla),* Pacific giant salamander *(Dicamptodon ensatus),* Pacific slender salamander *(Batrachoseps pacificus),* other salamanders *(Ensatina spp.),* rough-skinned newt *(Taricha granulosa),* California newt *(T. torosa),* and non-native bull frog *(R. catesbeiana).* Lagunitas Creek is also in the range of the northwestern pond turtle *(Clemmys marmorata),* and the non-native crayfish *(Pacifastacus leniusculus)* is present. River otters *(Lutra canadensis)* have also been observed in Lagunitas Creek between Kent Lake and Tocaloma.



3.0 Sediment Management Plan

State Water Resources Control Board Order WR 95-17 states:

> "Permittee shall prepare a Sediment Management Plan that describes measures that should be taken to reduce sedimentation and to provide an appreciable improvement in the fishery habitat within the Lagunitas Creek watershed." (SWRCB, 1995)

The discussion accompanying Order WR 95-17 describes the problem:

> "Erosion and sedimentation have resulted in large quantities of sand and fine gravel filling pools and glide habitat areas, and filling the spaces around cobbles, boulders and undercut banks. The result is to reduce habitat available for juvenile fish, freshwater shrimp and other aquatic organisms." (SWRCB, 1995)

The discussion presents the following conclusions regarding sediment control measures:

> "The District has begun development of an excellent sediment control program, but there are three areas where the program should be improved." (SWRCB, 1995)

> "The District's sediment control project should be designed to help provide the habitat needed to maintain fish in good condition, rather than to simply mitigate for the impacts caused by the most recent project." (SWRCB, 1995)

> "A second deficiency in the present program is that it focuses on the San Geronimo Basin and does not include a management program for the entire Lagunitas Creek watershed. Evidence submitted by the district indicates that there may be other areas such as county roads, District land, and land in the Devil's Gulch area, where sediment control projects would be cost effective and feasible." (SWRCB, 1995)

> "Finally, the District's present sediment control program focuses primarily on structural programs although the evidence indicates that greater use of

non-structural sediment control measures would also be beneficial".
(SWRCB, 1995)

3.1 Overview

Erosion is the source of detrimental sediment in Lagunitas Creek. It is the source of the large quantities of sand and fine gravel that fill pools and glide habitats, as well as the spaces around cobbles, boulders, undercut banks, and spawning redds. Erosion is also the source of beneficial gravel and cobble that are utilized by salmonids for spawning and can create undercut banks. (See Figure 3: Examples of Stream Sediments.)

When large amounts of fine material are deposited in the spaces between beneficial gravel and cobble, these fines reduce circulation of water, oxygen, nutrients, and the removal of waste products through the coarser material in the streambed. This can stress and kill fish eggs. It reduces the spaces between large cobbles and boulders that are available to young fish for refuge and for aquatic insects. Fines can destabilize the gravel in which redds are made, making them more susceptible to damage by scour. Fine sediment fills in pools that are important resting and rearing areas for fish. As the volume of pools decreases, fish become crowded, and competition increases for food and shelter from predators.

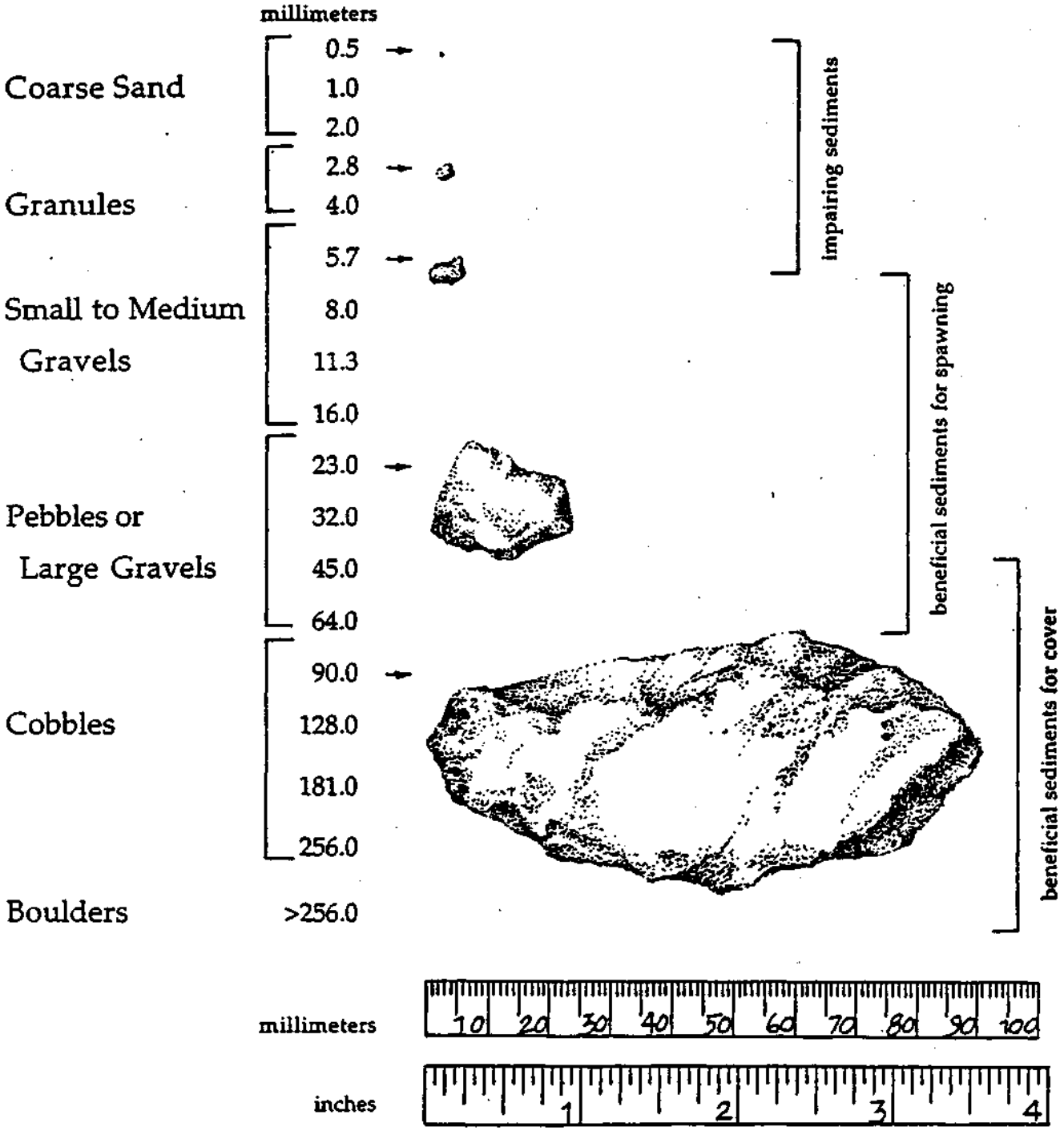
The construction and operation of dams on rivers alters the transportation of sediment through the stream system. Sediment above the dam is prevented from moving downstream, and sediment transport below the dam is changed. Channel characteristics, including the configuration and character of pools, riffles, and glides, are altered. Below dams, streambeds can become depleted of desirable sediment. The dams reduce the highest flows that would occur without them, thus inhibiting the ability of the stream to flush out the system and move sediment through the stream channel.

In the reach between Shafter Bridge and Tocaloma, deposition of sand and fine gravel has reduced the volume of pools, as well as the spaces between cobbles, diminishing both summer rearing and winter refuge habitat for salmonids (Kelley & Associates and Entrix, 1992).

Figure 3. Examples of Stream Sediments

Smallest Particles (Fines):			
Clay	<0.0039 mm	Fine to Medium Sand	0.0625-0.250mm
Silt	0.0039-0.0625		

Coarse Particles:



On Lagunitas Creek between Peters Dam and Shafter Bridge, the streambed has been depleted of beneficial sediment. One measure that would help the fish habitat between Peters Dam and Shafter Bridge would be to increase the amount of beneficial gravel and cobble. In recent years, many coho spawners have been observed in the reach above Shafter Bridge (Davis, 1996; White, 1997). In 1995 significant numbers of young salmon were observed in this reach (Cox and Chatham, 1995).

The first 2,000 feet downstream of Shafter Bridge is particularly unique. In drier years, sediment (including spawning gravel) from San Geronimo Creek is deposited in this reach. For example, careful measurements in 1981 showed that virtually all of the coarse sand and gravel transported by San Geronimo Creek during that year was deposited in the first three pools downstream of Shafter Bridge. When Kent Lake spills, this gravel can be scoured and transported downstream. During years of moderate and high spills, some of the highest quality habitat in Lagunitas Creek can occur in this reach just below Shafter Bridge (Hecht, 1991).

Farther below Shafter Bridge, a different problem develops from the presence of Peters Dam and other reservoirs. San Geronimo Creek, which carries a high bedload, enters Lagunitas Creek below Shafter Bridge near the Inkwells. The bedload is largely composed of undesirable sand and fine gravel. Changes in the hydrology of Lagunitas Creek due to the upstream dams cause more of the undesirable sediment from San Geronimo Creek to settle out in the Lagunitas Creek bed.

To provide the habitat necessary to maintain the fishery in good condition, sediment control project design should consider both the transport of undesirable sediment sizes, such as sand and fine gravel, as well as the transport of beneficial sizes, such as gravel, cobble, and boulders. This plan identifies measures that should reduce the delivery of undesirable sand and fine gravel to Lagunitas Creek. It also identifies measures that will increase beneficial gravel and cobble in the reach between Peters Dam and Shafter Bridge.

3.1.1 Overview of Sediment Reduction

In Lagunitas Creek, the reduction of sedimentation can be accomplished in either of two ways. The amount of sediment yielded from its source can be reduced. This is known as "source control." The sediment can also be trapped or detained between its source and the point of entry into Lagunitas Creek or the point of entry into the tributaries that provide fish habitat. This is known as "sediment trapping." A third alternative would be to use flushing flows to reduce sedimentation. This is not considered a viable alternative for Lagunitas Creek (SWRCB, 1995; Hecht, 1983).

Source control is typically the more favored strategy for sources such as roads, streambank failures, and gullies. This approach has low maintenance costs and, in the long term, is generally more effective and a better value. Source control frequently has higher initial capital costs per unit of sediment reduction, but it holds strong potential for yielding benefit long after the completion of the project.

Sediment trapping is functional in limited circumstances. It captures background sediment yielded from the watershed. Background sediment is not easily controlled at the source. It also allows for the capture of sediment sizes that are not cost-effective to control at their source. This strategy is limited because trapped sediment must be removed from the trap and disposed of, and the trap ceases to function after the program ends. It does hold one important benefit that is not available with source control— sediment traps provide a local and readily accessible source of beneficial substrate sizes.

MMWD has an existing program for reducing sediment delivery from the San Geronimo Creek watershed to Lagunitas Creek (see Section 3.1.3). It includes the use of both source control and sediment traps.

Discussion included with Order WR 95-17 indicates that, while MMWD has begun development of an "excellent sediment control program" in the San Geronimo watershed, that program is deficient because it does not include the entire Lagunitas Creek watershed. The order requires MMWD to identify other specific sediment control measures because evidence indicates that

there may be areas, such as county roads, MMWD land, and land in the Devil's Gulch area, where sediment control projects would be cost-effective and feasible (SWRCB, 1995).

To prepare this plan, an investigation of the Lagunitas Creek watershed area between Peters Dam and Tocaloma Bridge was performed. The goal of this investigation was to identify sources of sediment and locations where sediment could be trapped. The methods used are described in Appendix D: Sediment Source Investigation Methods.

3.1.1.1 Overview of Findings of the Sediment Source Investigation.

The investigation for sources of sediment found the following:

- Over 300 locations were identified as specific sources of sediment. Some of these sources, such as roads, are directly associated with human land use, while many others are not. Of these 300+ sites, this plan specifies erosion reduction measures be installed at the 34 highest priority sites, which are the sources that hold large potential for substantial yields of undesirable sediment. They are also feasible and cost-effective to repair.

- Because soil erosion is a natural process, it is not desirable to control all sources of sediment. The objective of the erosion control program is to achieve an appreciable improvement in the fishery habitat. By controlling the selected sites, MMWD believes that an appreciable improvement will be achieved.

- One single, large source of fine sediment delivery to Lagunitas Creek stands out from all the others. It is a gully along the boundary of the spoils pile from the raising of Peters Dam. It is near the base of Peters Dam entering from the left side of the stream.

- Much of the sediment is from natural, background erosion in areas that are not intensively used or exploited. (Such erosion is episodic and highly localized.) This material is predominately colluvium from landslides that works down through tributaries into Lagunitas Creek. The material from these sites often has a large component of beneficial particle sizes (see Figure 3: Examples of Stream Sediments). An example

is the influx of sediment from an unnamed south bank tributary at Big Bend.

An additional important source of background sediment is from "windthrow," or trees that fall during wind and storm events. Windthrow often contributes sediment directly from uprooted trees and indirectly by creating debris jams. Many debris jams in the upper drainages have caused water diversions that lead to streambank toe scour and bank slumping.

Steep sloped, forested areas dominated by bay trees contribute background sediment due to a lack of understory cover. The Barnabe Peak tributaries are an example of this.

- There is relatively little streambank erosion along Lagunitas Creek. More streambank erosion occurs on San Geronimo Creek. Streambank erosion along these two creeks, however, is not a significant source of undesirable sediment. Streambanks frequently contain a significant component of gravel and cobble that has been washed and rounded. This beneficial gravel and cobble are preferred by spawning salmonids.

- Sediment from several of the sites is not transported into the stream channel. For example, at some landslides and roads, sediment moves from its source but is naturally trapped before it reaches the creek or swale. Such a natural trap might be a terrace below a landslide, or it might be a flat area adjacent to a road where sheet and rill erosion from the road surface are captured by the gentle slope and filtering action of grass. Several sites identified during the sediment source investigation were determined to be in this category. Although such sites are not stable, these sources of erosion are the lowest priority as they have little or no impact on fishery resources.

- Some current erosion problems are related to watershed logging that occurred in the late 19th century. After forests were cut, an increased amount of colluvium likely moved into the steep ephemeral tributaries high in the watershed, increasing the rate at which this material will

reach Lagunitas Creek. Investigations for sediment sources identified a few abandoned skid trails that are still yielding sediment in small amounts. Although some current downcutting occurs in the colluvium, contributing to the sediment supply, these skid trails are not economical to repair due to lack of access.

- The field survey only identified one area that was deforested—the reach of Lagunitas Creek below Peters Dam. The site is slated for revegetation (See Section 4). Previously logged areas are already reforested.

- Existing or abandoned unpaved roads are a chronic source of fine sediment. However, much of the sediment yielded from these roads is trapped before entering the watercourse. In the sediment control literature and in public opinion, roads hold a place of notoriety as a significant source of detrimental sediment. Discussion of roads in the Lagunitas Creek watershed follows.

3.1.1.2 Overview of Roads in the Lagunitas Creek Watershed

Poorly designed roads, or roads placed and constructed without consideration of the amount of sediment they might yield, have proven to be a chronic source of undesirable sediment in most of California's watersheds including the Lagunitas Creek watershed.

Nearly all of the sediment yielded from roads is undesirable fine sediment. Most sediment yield from roads is the function of road drainage. Road drainage problems can be placed in two groups: drainage problems that induce erosion to occur downslope but not necessarily in the road "envelope" itself, and drainage problems that cause sediment yield from the road itself or from within the road "envelope."

The primary mechanism of road drainage that causes erosion downstream of the road is the tendency of roads to collect and concentrate water. Where roads run across slope, a portion of the slope is uphill of the road. The rain that falls on this uphill slope runs downslope until it meets the road. On most roads, this runoff collects on the uphill edge of the road, frequently in a road ditch. It then moves along the ditch to a culvert that conveys the water

under the road to the downhill side of the road. The slope downhill of the culvert outfall is at an increased risk of erosion because the runoff is focused there. Energy dissipators at culverts help reduce this erosion risk, but they do not eliminate it. Other techniques include outsloping the road (so that sheet runoff passes over the road without being channeled into a ditch), more frequent placement of culverts or other cross road drainage, waterbars, rock or concrete inlet protection (headwalls), and gravelling or paving the road.

There are several mechanisms that cause erosion from the road surface or road envelope. These include plugged culverts at creek crossings, rusted and broken culverts, ruts in the road surface (rilling) and lack of cross slope on the road surface, headcutting and downcutting along road drainage ditches, sheet erosion on the road surface, and rilling on cut slopes above the road. Culverts in forested areas tend to plug frequently from woody debris. In these situations, trash racks can be a solution.

Culverts at creek crossings are a predictable problem. It is axiomatic that culverts plug. Culvert sizing is typically based on the amount of water that needs to be conveyed. On first order stream crossings, this is invariably smaller than the size needed to pass the debris that is entrained in the water. Culverts plug when it is raining the hardest and when there is the greatest amount of runoff occurring. When culverts plug, the water surface rises until it overtops the road. If there is a sustained flow of water across the road, it will wash out the road embankment and deposit many tons of fine sediment in the stream.

In the Lagunitas Creek watershed, culverts are a significant, chronic source of fine sediment. The most effective solution for this is to replace the culvert with a wet crossing (see Appendix E: Standard Specifications). There are several wet crossings in Devil's Gulch in Samuel P. Taylor (SPT) State Park. This plan specifies the installation of several additional wet crossings throughout the watershed.

Ruts in the road surface and lack of cross slope on the road surface can create chronic sources of fine sediment. Ruts are of greater concern than lack of cross slope. Vehicle tracks (including from bicycles) run along the length of the

road. They most commonly occur when there is traffic on a dirt road during the wet season. Rain flows along the road surface in the ruts and forms gullies along the alignment of the road if uncorrected, especially on roads that are not outsloped. An example of this is on upper Rockridge Road above Woodacre in San Geronimo (see Site SG 6 on Figure 5: Sediment Control Sites Map). Many unpaved roads have been recently outsloped, but berms are often left on the downhill side of the road. This causes rilling and water concentration on the outboard side of the road.

Generally, several solutions are available: install and maintain waterbars along the road (see Appendix E: Standard Specifications); limit use of dirt roads to the dry season only; grade the road when ruts develop; and/or pave the road with gravel or road base. Point Reyes National Seashore (PRNS) has expressed an interest in using the sand and fine gravel from the sediment traps in the San Geronimo Valley to surface ranch roads.

Headcutting and downcutting along road drainage ditches with a slope greater than five percent is common. Solutions for this include more frequent cross drainage, waterbars or culverts, and lining the road ditch with rock.

Rilling, slumping, and small slides occur along cut slopes. This is a source of fine sediment that is difficult to effectively control. Cut slopes above a road are often unvegetated and steep. In these circumstances, small quantities of sediment are chronically yielded during wet weather. This material is deposited frequently in a road ditch at the base of the cut slope. During runoff events, water flowing in the ditch picks up this sediment and quickly moves it into the stream system. An example of this is along the access road on the right side of Peters Dam. Revegetation of cut slopes is costly, and regrading is frequently not feasible. Small sediment traps require ongoing maintenance but are frequently the most cost-effective solution. At some locations, the sediment can be directed into and trapped in a flat, grassy area.

In the Lagunitas Creek watershed, there are several public agencies with road maintenance responsibilities. These agencies include MMWD, DPR, MCOSD, MCFD, and NPS. Several citizens in the San Geronimo Valley have expressed

concern about road-related erosion issues. Some residents have volunteered their time to maintain waterbars as well as other erosion projects.

The most cost-effective sediment source controls are those that treat sources that contribute sediment directly to a watercourse. This plan specifies repairs at several road sites that yield sediment directly into a watercourse. It also calls for a cooperative working relationship to be fostered between MMWD and other agencies with road management responsibilities in the Lagunitas Creek watershed. Programs being implemented by agencies other than MMWD are described in Section 3.1.3.

3.1.2 Overview of Gravel and Cobble between Peters Dam and Shafter Bridge

The reach between Peters Dam and Shafter Bridge is often devoid of spawning gravel because of the lack of sediment transported from above Peters Dam. Spills from Kent Lake tend to remove any gravel from this reach.

The reach below Peters Dam and above Shafter Bridge provides marginal and unstable fish habitat. It is, however, a reach that has potential to support salmonids and could contribute to maintaining fish in good condition. Spawning adult coho were observed in this reach in 1996 and 1997 (Davis, 1997; Andrew, 1997; White, 1997). In years when there are no flows over the spillway at Peters Dam, this reach could provide moderate flows that would be favorable to salmonid egg survival providing there is sufficient gravel present in which to spawn. Under some circumstances, flows can be high in Lagunitas Creek below Shafter Bridge and moderate above Shafter Bridge. Even in years when there are spills, the short channel used for Kent Lake water releases could have stable flows.

The primary sediment management measure that should be made to improve conditions in this reach of Lagunitas Creek is placement of beneficial gravel and cobble in years after Kent Lake has spilled. Adding spawning gravel to a stream system requires careful planning, knowledge of the hydrologic and geologic limitations of the system, access to the channel, an appropriate source of material, maintenance, and monitoring. In other river systems, considerable effort has been made to introduce spawning gravel into streams below dams (Kondolf, 1996; Dettman, 1996). Current research on the

merits of placing spawning gravel below dams on the Merced River indicates that spawning gravel will not be maintained in channels with a gradient of more than five percent regardless of the structure used (Kondolf, 1996). Below Peters Dam, the gradient of Lagunitas Creek is typically less than one percent.

In years when Kent Lake does not spill, gravel and cobble placed at the heads of riffles or behind weirs or equivalent structures should be stable. In years when Kent Lake spills heavily, beneficial gravel placed in the reach below Peters Dam will be moved to down-stream habitat areas. This plan specifies measures for placement of beneficial gravel and cobble and related habitat structures in Lagunitas Creek between Peters Dam and Shafter Bridge.

3.1.3 Overview of Current and Past Sediment Management Programs

Several organizations have ongoing sediment management programs and efforts, and others have plans to begin specific programs in the near future. Since the early 1980s, there have been efforts to control erosion in the Lagunitas Creek and San Geronimo Creek watersheds. In 1983, the MCRCD, State Coastal Conservancy, CDF&G, NRCS (formerly the Soil Conservation Service), DPR, NPS, MMWD, Trout Unlimited (TU), Marin Conservation Corps, Marin County Fire Department (MCFD), and volunteers undertook an effort to reduce erosion and restore salmonid habitat. MMWD helped identify project locations and contributed technical expertise, equipment, and equipment operators. Projects in the watershed included repairing 35 gullies ranging from 2 to 20 feet deep and approximately 20 miles of unsurfaced roads, as well as stabilizing eight streambank erosion sites. Low cost, biotechnical methods were used wherever possible.

MMWD Watershed Lands Maintenance

MMWD maintains roads within its watershed boundaries with assistance from MCFD. MMWD has an active program to train equipment operators in road maintenance techniques to reduce erosion. The program includes regular clearing of culverts and regrading road surfaces.

MMWD watershed protection agreements with private landowners.

To help augment protection afforded by the county's land use controls, MMWD establishes written, watershed protection agreements with private

landowners to control non-point source agricultural impacts. The agreements call for buffer setbacks (300' from the reservoir, 100' from tributary streams), non-point source controls, seasonal limits on construction activities, on site inspections by water utility personnel, and review and approval by MMWD for recommended improvements.

Most of the existing 61 watershed protection agreements are in the Nicasio Creek watershed. These agreements are established at the time of a property's sale or when property owners apply for a building permit with the county. Marin County requires landowners in the Nicasio Creek watershed to sign watershed protection agreements with MMWD before it will approve building permits for new construction or improvements to existing facilities.

National Park Service Sediment Management Program

National Park Service (NPS) lands within the Lagunitas Creek watershed are leased ranch land. PRNS oversees the leases within Golden Gate National Recreation Area (GGNRA). Since 1987, NPS has monitored the use of grazed range lands using residual dry matter (RDM) to evaluate the distribution of protective vegetative cover left after the grazing season. The RDM standards used by NPS are higher than those recommended by the University of California or the NRCS. Poor livestock distribution rather than grazing itself is usually a cause of low RDM rates. NPS has very few instances of low RDM rates in either PRNS or GGNRA (Gustafson, 1996). NPS works with ranchers to maintain NPS's RDM standards. NPS supports ranch leaseholders' applications for cost-share funding to repair gully and other erosion sites.

Using RDM standards has been adequate for evaluating range land use. NPS is considering additional management strategies to minimize impacts on fisheries (Shook, 1996).

NPS recently received a five-year, $800,000 grant from the federal government. The grant project, *Preservation and Restoration of Coho Salmon and Steelhead at Point Reyes National Seashore, Muir Woods National Monument, and Golden Gate National Recreation Area,* will develop and implement a habitat restoration plan for coho salmon and steelhead trout in these three NPS jurisdictions. Project objectives include

analysis of historic salmon and steelhead presence and abundance; surveys to evaluate fish abundance; analysis of habitat components including stream channel morphology, water quality, and vegetation; developing and implementing a restoration and monitoring plan; and public education. Within the Lagunitas Creek watershed, Lagunitas Creek below Peters Dam, as well as Olema Creek, Devil's Gulch, and Cheda Creek, will be included in the plan.

MMWD and NPS plan to coordinate their implementation and monitoring efforts. This could include sharing data and resources.

In 1990, the *Olema Creek Sedimentation and Erosion Study* (Questa Engineering Corporation) was completed. Commissioned by NPS, the study was undertaken to identify and evaluate the main sources of sediment in Olema Creek and to develop recommendations to alleviate any accelerated erosion in the watershed or along the creek. Study conclusions indicated that channel stabilization would reduce the most sediment but would also be the most costly and would alter the natural character of the creek. Repairing gullies and other surface erosion problems would be more cost-effective but would not significantly reduce the sediment yield from Olema Creek.

Samuel P. Taylor State Park Program

DPR does not have a formal erosion control program, although they respond to areas that need attention. DPR tries to minimize road maintenance efforts; for example, roads that are not a significant source of erosion are not maintained. MCFD grades DPR's roads as needed. DPR administration is interested in closing roads that are not necessary (Boyd, 1997). MMWD will contribute to this effort by coordinating other resources to assist with road closures. MMWD will seek to coordinate use of its own equipment and operators, MCFD equipment and operators, and community volunteers to assist with these road closures.

Marin County Open Space District Program

MCOSD owns 1,170 acres in the San Geronimo Creek watershed, including Roy's Redwoods, the Gary Giacomini Open Space Preserve, and the Maurice Thorner Memorial Open Space Preserve. MCOSD grades some of their fire

access roads, especially those that are sensitive problem sites; others are graded by the MCFD or by independent contractors working for MCOSD (Paolini, 1996). MCOSD is conducting a survey of erosion sites on the Gary Giacomini Open Space Preserve property. They anticipate completing the survey and implementing erosion control projects in the spring of 1997. Implementation will occur over several years.

Marin County Resource Conservation District Program

MCRCD has been involved in erosion control efforts in the Lagunitas Creek watershed since the early 1980s. Their most current effort is the San Geronimo Program, which is funded by MMWD.

Marin County Fire Department Program

In 1982, the MCFD conducted an inventory of roads that it maintains. By the mid 1980s, the fire department was a very active participant in erosion control efforts. Many watershed roads were outsloped, culverts were replaced, and waterbars were constructed to reduce sediment from unsurfaced roads. The fire department has now scaled back their former grading practices (grading for smoothness and fire breaks) in favor of not disturbing the surface whenever possible and utilizing equipment and time to enhance long-term erosion control instead. MCFD only does blade down grading for fire breaks on strategic ridge tops and as necessary to make critical accesses passable to fire apparatus (Selfridge, 1997). MCFD has indicated an interest in cooperating with other agencies in their road maintenance and closure efforts.

Marin County Stormwater Pollution Prevention Program

MCSTOPPP is a program sponsored by the City of San Rafael and Marin County to reduce non-point source pollution in eastern Marin County. MCSTOPPP has produced educational materials for homeowners, including a creek care guide and streambank repair brochure.

Trout Unlimited Program

In both 1994 and 1995, TU volunteers placed 10 cubic yards of gravel in the reach between Peters Dam and Shafter Bridge. High flows in 1995 and 1996 washed this material downstream. In the early 1980s, TU constructed a V-shaped log weir in this reach. In periods of high flows, the logs were lifted up

by the water. Gabion weirs to hold sediment from construction of Peters Dam were also constructed in the reach between Peters Dam and Shafter Bridge. The log weir has been washed out. Portions of one of the gabions remains and is a part of one of the specific measures identified in this plan.

TU currently assists the Bodega Marine Lab in monitoring the status of fish populations in Lagunitas Creek. They have periodically sponsored work weekends in the Lagunitas Creek watershed to install sediment and riparian management projects with help from TU members and community volunteers.

Tomales Bay Association Program

The Tomales Bay Association's volunteer program has included constructing fences and replanting along Olema Creek, streambank stabilization projects, log jam removal, and other small-scale projects.

3.1.3.1 MMWD's San Geronimo Bedload Sediment Reduction Program

In 1990, MMWD sponsored a study to inventory and prioritize erosion sites in the San Geronimo Creek watershed—*San Geronimo Creek Watershed Bedload Reduction Opportunities* (Prunuske Chatham, Inc., 1990). Based on the study findings, MMWD created the San Geronimo Bedload Sediment Reduction Program (San Geronimo Program) in 1993. MMWD selected MCRCD as an independent, neutral agency to implement the program. MMWD has committed $874,000 for implementation of this 10-year program. This includes $324,000 for construction of erosion control projects and $550,000 for a 10-year maintenance and monitoring program.

The San Geronimo Program included a three-year construction program in the San Geronimo Creek watershed and has an ongoing, ten-year maintenance and monitoring program in Lagunitas and San Geronimo Creeks. The objective of the program is to reduce sediment input to San Geronimo Creek by an average of 600 tons of sediment per year through source control and off site sediment traps. The recommendations made by Balance Hydrologies, Inc. (BHI), DW Kelley & Associates and Entrix, Inc., about streambed conditions needed for good fisheries habitat and sediment transport in the watershed form the program's scientific basis.

The three-year construction program (begun in 1993 and completed in 1996) addressed the major sources of erosion identified in the 1990 study, *San Geronimo Creek Bedload Reduction Opportunities.* This included installation of grade control structures at the Spirit Rock property; a headcut repair at the Dickson Horse Ranch; a gully repair off of Edgewood Drive; several repairs at the MCOSD property (waterbars, headwall repair, loose rock checkdams, wet crossing, and streambank stabilization); and a gully stabilization near Meadow Way. Preliminary design and permit applications were also completed for site SG 6 listed below. Three small sediment traps were constructed on the Spirit Rock property and are designed to be cleaned out periodically. MMWD has contributed $324,000 to this program.

The 10-year maintenance and monitoring program includes sediment trap clean out and streambed monitoring. In addition to the traps at Spirit Rock, an existing concrete weir at the Dickson Ranch (possibly constructed in the 1930s or earlier) functions as a sediment trap near the headwaters of San Geronimo Creek. By the summer of 1996, the Spirit Rock traps were not yet full, and the MCRCD chose not to clean them. Spirit Rock landowners and a neighbor are interested in a small amount of the sediment (about 20-50 cubic yards). NPS is also interested in this material. In 1996, approximately 200 cubic yards of sediment were removed from behind the Dickson Weir and stockpiled on the ranch. The majority of the material was sand and fine gravel. The monitoring program, a quantitative analysis of the streambed and bed core condition, is described in Section 5.

MMWD's intent is to continue the San Geronimo Program. Several sites in the San Geronimo Valley that have worsened or were not previously identified have been targeted as priority repairs in this management plan. In addition, MMWD will attempt to develop a cooperative agreement with MCOSD and MCFD for repair, maintenance, and possible closure of fire roads in the San Geronimo Valley. The plan also specifies continued public outreach with residents in the San Geronimo Valley to promote appropriate land use practices and non-structural measures to reduce erosion on private lands. Areas of overlap between the San Geronimo Program and Lagunitas Creek management plan include maintenance of the two sediment traps in

San Geronimo Valley (Spirit Rock and Dickson Weir) and the annual streambed monitoring effort. If, in the future, new projects are identified for the San Geronimo Valley, they will be conducted under the San Geronimo Program.

3.2 MMWD's Sediment Management Plan Goal and Objectives

The goal of this sediment management plan is to provide a significant, long-term improvement in streambed conditions in Lagunitas Creek for the benefit of coho salmon and steelhead. This plan's objectives to achieve this goal are to:

- Control fine sediment at its source;
- Trap fine sediment before it enters Lagunitas Creek or San Geronimo Creek channels;
- Increase the supply of beneficial size gravel and cobble to the reach between Peters Dam and Shafter Bridge; and
- Coordinate and cooperate with other agencies and organizations performing sediment management projects and programs to reduce sedimentation in the Lagunitas Creek watershed.

3.3 Sediment Management Plan Actions

Four types of sediment management measures will be implemented: source control, sediment traps, placement of large gravel and cobble, and public outreach. The actions are intended to be complementary to existing and future programs of other agencies.

3.3.1 Source Control Projects

Investigators examined aerial photographs of the watershed to identify potential locations for source control of sediment. They hiked each tributary of Lagunitas Creek from Peters Dam to Tocaloma and walked Lagunitas Creek to identify sources of erosion.

In addition, individual problem sites in San Geronimo Creek and below Tocaloma that were identified by other agency representatives or members of the public were investigated.

At each site, field investigators took photographs and recorded the site number, location, landowner, basic description, site dimensions, erosion type, percent impairing sediment, erosion potential, activity, access, estimated repair cost, repair priority, and repair type. A description of each of these parameters is presented in Appendix D: Sediment Source Investigation Methods. This investigation of erosion sites identified over 300 specific sources of sediment (see Figure 4: Sediment Source Sites Map), 34 of which have been identified as the highest priority for erosion control treatment.

This plan describes sediment reduction measures be taken at the 34 sites shown in Figure 5: Sediment Control Sites Map. The erosion survey data sheets for these sites are in Appendix F: Sediment Source Inventory Data Sheets. The 34 sites specified for sediment source control are sorted by priority. The first site listed is the most important site to repair. The priority for each of the sites is based on the following considerations.

- Potential to contribute large quantities of detrimental fine sediment to Lagunitas Creek;
- Proportion of beneficial coarse sediment to detrimental fine sediment;
- Cost of repair relative to the quantity of detrimental sediment controlled;
- Additional benefit for repairing erosion sites that will enhance on site wildlife and fisheries habitat;
- Additional benefit for repairing erosion associated with roads that provide access for fire suppression and public safety; and
- A combination of a high component of fines and a position farther upstream in the watershed.

1. **Site 1.2.** This is the single largest source of fine sediment being delivered to Lagunitas Creek. Located on MMWD property, this large, active gully is along the toe of a spoils pile that was graded into a natural drainage channel during dam construction. Over time, the concentrated runoff has forced its way around the dense, rocky spoils pile and is eroding the softer adjacent soil and hillside. The gully has a 14' headcut with 20' and 30' vertical sides. It is comprised of 90% orange-colored silts and sands. The headcut has a high potential to erode at a chronic rate of over 100 tons per year. The repair could consist of a loose rock headcut repair, loose rock-lined channel, and/or loose rock grade stabilization structures with fill soils and a revegetation effort. Sediment from this site was noted along the entire reach from Peters Dam to Shafter Bridge on December 10, 1996 Jensen, 1996).

2. **Site SG 6.** There is an historic landslide and a gully with toe scour and bank failure on the Giacomini property. This site is located 200' down stream of Meadow Way Bridge on the left bank of San Geronimo Creek. Under the San Geronimo Program, a headcut and gully at the site were repaired with rock riprap in 1996. The streambank at the toe of the slide is being scoured by high streamflows causing annual sloughing. The repair concept is to stabilize the toe at the stream bench with sack-crete and rock riprap with additional rock upstream and downstream to prevent undermining. A biotechnical approach can be used for the bank above the toe stabilization. A large bay root wad may lead to additional erosion, but since it contributes to good fish habitat it should be incorporated into the design.

3. **Site 15.23.** An active headcut 6' wide x 8' high with 90% impairing sediment has slumped due to subsurface water and surface flow. The site is located on the Cheda Ranch and is accessible from the ridge road between Devil's Gulch and Cheda Creek. A loose rock headcut repair, reforestation, and possible subsurface drains to reduce subsurface flows are recommended.

4. **Site 17.2.** A gully system on GGNRA (McIsaac Ranch) is actively headcutting and downcutting. The system is yielding a high proportion of impairing sediment sizes. In the last two years, the headcut at the top of the gully has yielded approximately 130 tons of sediment. Possible repairs include loose rock headcut repairs, loose rock checkdams, fencing, willow establishment, and regrading.

5. **Site 15.50.** A series of five, highly active headcuts is downcutting through a Cheda Ranch drainage basin to a culvert at milepost (MP) marker 18.91 on Sir Francis Drake Blvd. Repairs should include loose rock head cut repairs, biotechnical grade control techniques, and livestock fencing.

6. **Site 11.3.** Located in SPT State Park, a grassy drainage basin in Deadman's Gulch is threatened by two large, active headcuts. The largest headcut is 9' high x 10' wide, and the uppermost headcut is 3' high x 6' wide. Both will require loose rock headcut repairs.

7. **Site 13.87.** An actively downcutting drainage approximately 100' long has bank slumping, eroding cattle trails, headcuts, and a downstream bank slump (40' x 30' x 5'). The site has approximately 90% impairing material that drains to Devil's Gulch. In addition, the road has chronic rolling due to its steep slope. The site is located on GGNRA leased ranch land and has potential to erode the ridgetop fire/ranch road. The recommended repair consists of a loose rock headcut repair, loose rock toe protection, waterbars, willow plantings, and livestock control fencing.

8. **Site SG 1.** A landslide 152' long x 20' wide is located on the back side of Barnabe Peak to the east. According to the MCFD, it is three to four years old. Chronic rills on the unvegetated slide run for an additional 110', dumping fine sediment into a tributary that drains to San Geronimo Creek. A biotechnical and revegetation effort should be undertaken to control the chronic erosion source.

9. **Site SG 7.** Sylvestris Road is yielding substantial quantities of sediment from downcutting inboard ditches and chronic surface erosion. An

adjacent landslide is contributing fine sediment. The road should be repaired by regrading, revegetation, and rock work.

10. **Site 11.4.** A trail in Deadman's Gulch in SPT State Park has severe, chronic trail rilling. The largest rills are 12" deep and have the potential to develop into a small gully system in the near future. To minimize cost and prevent additional erosion, the trail should be repaired as soon as possible by outsloping the trail or installing waterbars.

11. **Site 14.1.** This is a 15' wide x 8' high headcut that is active and moving parallel to the Bolinas Ridge bike road on GGNRA leased ranch land. There is a series of five smaller headcuts (2' high x 10' wide) above the main headcut that need repair also, but they are not as large. A loose rock headcut repair is recommended.

12. **Site 13.27.** This site is a right streambank failure and road blowout on the main stem of Devil's Gulch. Three existing root wads can be incorporated into the bank repair for cover habitat and bank protection. Repairs could include a rock/boulder streambank toe protection, streambank revegetation, and anchoring of the root wads. This will help prevent the root wads from washing downstream during high flows.

13. **Site 15.21.** Portions of Cheda Ranch Road behind the barns are actively eroding in six locations. Three of the locations are 3'-4' headcuts, which will require loose rock headcut repairs, wet crossings, and rock-lined channels. The others are road rilling, which will require grading, waterbars, and rock.

14. **Site 15.27.** A landslide is moving downhill accelerated by headcutting and downcutting of the channel passing through the slide area. Repair methods include willow sprigging, livestock control fencing, loose rock headcut repairs, and subsurface drains.

15. **Site 17.10.** A 200' x 75' landslide with 80% impairing sediment has active slumping and a downcutting gully with headcuts. The landslide/gully drains to McIsaac Creek below the farm pond on the McIsaac home ranch. The landslide may be spring-induced. A biotechnical repair could be used. Subsurface drains, loose rock headcut repairs, and livestock fencing should be incorporated.

16. **Site 15.10.** This site is in a tributary to Cheda Creek. There are several headcuts in close proximity, which could be arrested with rock headcut repairs. Access is along the left bank of the tributary. The erosion potential of this site is high.

17. **Site SG 4.** This fire road is a chronic source of fine sediment. The road is insloped and eroding. Some areas are outsloped, but there is a berm on the outside of the road causing water to erode along it. Repair types include road grading, waterbars, and wet crossings.

18. **Site 13.40.** This chronic, highly active headcut/slump (50' long x 40' wide x 8' deep) has 80% impairing sediment that enters the drainage. The site is located on GGNRA leased land and drains to Devil's Gulch. The site has low access and will require a biotechnical slope stabilization repair, revegetation, and livestock fencing.

19. **Site 15.13.** An active headcut 8' wide x 7' high has downcut in a forested drainage, creating a 60' long incised gully that will lead to future bank sloughing. The site is located on the Cheda Ranch and is accessible by the ridge road between Cheda Creek and Devil's Gulch. A loose rock headcut repair is recommended. There is also a less active 5' headcut approximately 80' downstream that should be repaired.

20. **Site 15.18.** Chronic bank sloughing is occurring upstream of the MCRCD stream channel repair. Bank protection with riparian revegetation is recommended.

21. **Site 13.115.** A downcutting road ditch on the access road to the upper vineyard on GGNRA leased land will become a chronic source of fine sediment entering Devil's Gulch. There are small headcuts with bank slumping. Without repair, the headcuts will downcut the ditch for the entire length of the road. The recommended repair is a rock- or grass-lined channel with rock grade control and revegetation.

22. **Site 11.5.** A plugged 18" culvert is diverting water across the road and eroding it. The culvert should be replaced by a wet crossing and a loose rock energy dissipator or toe below the crossing. The upstream end of the wet crossing requires armoring to control a 4' headcut. This site is approximately 200' upstream of a pump house.

23. **Site 5.7.** The dirt road leading from Irving Campground to Barnabe Peak has a drainage crossing running down the road for 25' and causing a headcut/slump. This drainage has potential to completely blow out the road. A wet crossing is recommended with a rock mortar energy dissipator installed downstream. Steep slopes will make this a difficult repair.

24. **Site 13.7.** A deeply incised channel 2' wide x 6' high has downcut for a distance of approximately 50'. A 2' wide x 6' high headcut is on the upstream end and has medium potential to continue to move upstream. The site is located in Devil's Gulch on SPT State Park property. A loose rock headcut repair is recommended with reforestation on the incised channel banks.

25. **Site 9.2.** A plugged and bent 18" culvert is piping and threatens to blow out the fire road between the water tank and Manzanita Campground in SPT State Park. Twenty feet upstream is a headcut or filled debris trap that will eventually erode and downcut. The old culvert should be removed, and a rock and gravel or concrete wet crossing installed with a loose rock headcut repair incorporated into the repair upstream.

26. **Site 13.108.** Drainage along the road is eroding the toe of the right bank and causing bank and road failure. Waterbars and loose rock toe protection are recommended.

27. **Site 13.104.** Streambank erosion is threatening the road. Use loose rock toe protection and native plant reforestation.

28. **Site 13.26.** A bank failure 20' long x 4' wide x 7' high in Devil's Gulch (SPT State Park) is sloughing downstream with 90% impairing sediment. The repair can be a biotechnical approach using willow revetment with minor grading to reslope the bank.

29. **Site 4.1.** Several headcuts near MP A104 (15.45 mi.) on Sir Francis Drake Blvd. should be repaired. An effective, low cost solution would include native plant reforestation and brush checkdams.

30. **Site 5.3.** A 4' headcut in a deeply incised 6' deep channel has high erosion potential. A loose rock headcut repair is recommended.

31. **Site 7.6.** A 6' headcut is very active. Native plant reforestation and brush packing slope stabilization are the recommended repairs.

32. **Site 13.17.** An active headcut and bank erosion area is located in the woods. A loose rock headcut repair is recommended.

33. **Site 12.13.** A failed 24" culvert has broken in half at the collar causing a slump 40' long x 8' wide with an average depth of 3.5' at the downstream end. The culvert now threatens the paved access road/bike path. DPR is planning to replace the culvert. A wet crossing would be the preferred solution.

34. **Site 1.11.** This is the Bolinas Ridge-Shafter Bridge Fire Road above site 1.2. It is approximately two miles in length and continues to Bolinas Ridge and has chronic erosion problems. Its location at the top of the habitable Lagunitas Creek reach gives this site priority. The road has six headcuts 2' to 8' in size and rilling in various places. Much of the

problem can be corrected by grading and/or the proper placement of waterbars, but at least three rock headcut repairs will be necessary. At the top of the road, there is approximately 500' of a 2' wide gully running parallel to the road that needs brush checkdams. This gully drains to a 24" culvert that needs inlet control (minor grading). It would be possible to remove the culvert and redirect water to its original drainage pattern. Some clearing and grading would be required as well.

Source control projects will be inspected annually or as specified by the design. Projects will be maintained as needed to sustain the sediment control function of the projects. Structural repairs should occur between June 1 and October 1. Biotechnical repairs may need to occur as late as January.

3.3.2 Sediment Trap Projects

Four small sediment traps will be operated on tributaries to Lagunitas and San Geronimo Creeks. These structures will be used to trap materials with a high component of fines that are not cost-effective or feasible to control at the source. All of the traps are or will be designed to capture sediment load from the surrounding watershed. Sediment delivery to the traps will be episodic. In some years, the traps may fill to capacity; in other years, the traps may not fill.

Material excavated from the traps should be sorted with a 1" screen. Material smaller than 1" and smaller than approximately 6" to 8" could be used for road surfaces or clean fill. Material larger than 1" should be stockpiled for placement in the reach of Lagunitas Creek between Peters Dam and Shafter Bridge (see Section 3.3.3: Gravel and Cobble Placement Projects). Material will be stockpiled or disposed of in such a way that it doesn't enter the creek.

See Figure 5 for the location of the four sediment traps. The four sediment trap sites are:

Trap 1. The Spirit Rock traps were constructed in 1994 and are maintained and operated by MCRCD as part of the San Geronimo Program. These structures capture an estimated 200 cubic yards per year.

Trap 2. The Dickson Weir is an existing structure that functions as a sediment trap and can capture an estimated 200 cubic yards per year. It is operated by MCRCD as part of the San Geronimo Program.

Trap 3. This will be a new trap and is listed in the erosion inventory as Site 13.66. It is in a tributary to Devil's Gulch on GGNRA leased land upstream of the road culvert. A large number of upstream landslides and bank failures with a high percentage of impairing sediment makes this an ideal location for off site sediment control. An additional upstream sediment bar 300' long x 20'-50' wide is beginning to move downstream with an estimated 60-70% impairing sediment. A large landslide that occurred in the 1982 storm caused a stock pond upstream of the proposed sediment basin to blow out and, according to a local rancher, fill the channel with sediment and woody debris. The sediment basin could be constructed by modifying the existing road culvert and using loose rock checkdams. Approximately 400 cubic yards can be held in these basins.

Trap 4. This is another new trap that is located in SPT State Park across from the picnic area and is listed as Site 8.1 in the erosion inventory. Minor structural work is needed to make a site behind the bicycle path functional as a trap. This location could be operated to capture approximately 40 cubic yards of sediment per year.

Each trap will be monitored and maintained annually. Traps should be inspected in April of each year. Sediment from the traps should be removed if the trap is more than 60% full. If sediment is removed from these traps, it should be removed before September 1. The structural and operational integrity of the traps will be maintained as needed. MMWD is specifying maintenance of the sediment traps for 10 years—the life span of this plan.

After 10 years, MMWD and the Technical Advisory Committee (TAC) will assess the traps to see if they have functioned as intended. The District will consider continuing to empty and maintain those traps that work as designed. If MMWD and the TAC agree to discontinue use of any traps, MMWD will ensure that the traps themselves are stable.

3.3.3 Gravel and Cobble Placement Projects

Four sites are identified for placement of gravel and cobble (see Figure 6: Riparian Management Site Locations Map) in Section 4. Three of the sites are also listed as potential sites for woody debris placement in Section 4. The primary source of gravel and cobble will be the sediment traps that are operated for sediment reduction under this program (See Section 3.3.2 above). The material that is removed from these traps will be sorted with a 1" screen. Material larger than 1" will be used for beneficial gravel and cobble placement at four sites between Peters Dam and Shafter Bridge. The gravel that is placed at these locations will come from within the Lagunitas Creek watershed when available, but at times it may be necessary to use gravel from existing, permitted commercial sources.

GP-1. This is the small channel on the right bank at the base of Peters Dam. Summer water is released from Kent Lake into the head of this channel, which is a possible location to place beneficial gravel and cobble for habitat improvement. The risk that gravel will be moved downstream is low. Place gravel for spawning habitat and replace as needed.

WD-1. This site is also listed as a woody debris placement site in the riparian management plan. It is located just above an existing, broken concrete weir below Peters Dam. Place cobble and gravel approximately 100' above the weir. Spread up to 40 tons of gravel along the oblique bar that forms the riffle. Replace material in years after Kent Lake has spilled at Peters Dam and as material is available. Access for placement is from an existing road on the left bank.

WD-2. This site is also listed as a woody debris placement site in the riparian management plan. It is located at the road fork across from the rock riprap culvert energy dissipator on the right bank. Place up to 25 tons on the left bank behind the weir that is specified for this location in the riparian management plan (see Section 4). Access for beneficial gravel and cobble placement is from the existing road along the left bank.

WD-4. This site is also listed as a woody debris placement site in the riparian management plan. Place beneficial gravel and cobble at the head of the first riffle downstream of the rock riprap pool in the vicinity of the tributary entering from the left bank via a 36" culvert. Place up to 15 tons in years after Kent Lake has spilled and as material is available.

Replace beneficial gravel at these four sites as necessary during the low flow periods.

3.3.4 Public Outreach Projects

Eight public outreach projects are specified.

- **Brochure preparation and distribution to visitors at Samuel P. Taylor State Park and local citizens.**
  Visitors to the state park often play in the creek and on the creek banks. Information about the role of sediment in the channel will assist MMWD and other agencies by fostering cooperation from the public. MMWD will develop a one page, three-fold brochure that summarizes the goals and activities of the sediment and riparian management plan. This brochure can be disseminated to park visitors and other members of the public.

- **Public displays.**
  The existing display board at the Leo Cronin Memorial fish viewing area near Shafter Bridge will be enhanced to chronicle sediment and riparian management plan efforts.

- **Press coverage.**
  MMWD will make annual press releases to the *Marin Independent Journal, Point Reyes Light, Ross Valley Reporter, Coastal Post, Pacific Sun* and *Stone Soup* (the San Geronimo Valley Cultural Center newsletter). These press releases will cover MMWD's sediment and riparian management projects conducted in that year.

- **Annual outreach to local community groups.**
  MMWD will annually offer to attend at least one meeting each of the San Geronimo Valley Planning Group, the San Geronimo Valley Property Owners Association, Tomales Bay Association, Trout Unlimited, the Tomales Bay Advisory Committee, Marin Audubon Society, Marin Horse Council, and the MCRCD. MMWD is willing to speak to other groups if requested. MMWD will describe the status of sediment control efforts, fishery habitat, and the importance of the ongoing cooperation of the local community in meeting the goals and objectives of improving fisheries resources in the Lagunitas Creek watershed.

- **Public Forum.**
  MMWD will provide a forum for regular input on the management plan by members of the public, environmental groups, and other agencies. The purpose of the forum will be for MMWD to provide information to the public about the status of the plan, for MMWD to hear comments and recommendations from the public, and to organize volunteer efforts and coordinate them with other activities. The structure of the public forum will be developed by MMWD and may consist of the formation of a citizens advisory council (or ad hoc committee as was done for the San Geronimo Program), public representation on the Technical Advisory Committee (see Section 5.4), or special meetings of MMWD's Watershed Committee. The public forum will meet at least once a year subsequent to MMWD's year-end compliance report, and perhaps more frequently. Meetings will be announced in advanced.

- **Integrate descriptions of the plan into information disseminated by MMWD, including an annual flyer to MMWD customers.**
  MMWD will integrate descriptions of the goals and actions of the sediment and riparian management plan with other appropriate public information that is disseminated, both internally to MMWD staff and to the public.

- **Support community-based watershed restoration efforts.**
  TU has periodically sponsored work weekends to install sediment control and riparian habitat projects. MMWD has co-sponsored these events and provided substantial financial and material support. MMWD will cooperate with TU to provide equipment, design expertise, and supervision for those events that benefit the Lagunitas Creek fishery.

- **Make copies of reports available to the public.**
  MMWD will provide copies of all future MMWD reports related to fishery enhancement activities to the public libraries in San Geronimo Valley, Point Reyes Station, and Civic Center in San Rafael.

3.3.5 Specific Policy Development Projects

- **Support other agencies implementing sediment management activities.**
  Public agencies including MCOSD, DPR, NPS, and MCFD have indicated support for erosion control on roads and each operate their own programs targeted at sediment reduction on their lands. The MCFD owns and operates heavy equipment for the maintenance of roads and has indicated an interest in cooperating with the closure of some roads. MMWD will meet annually or more frequently with these agencies to identify areas of common interest such as roads for closure, techniques to close them, and culvert maintenance. MMWD will assist other agencies to the extent possible in their efforts to reduce sedimentation from lands in the Lagunitas Creek watershed.

  MMWD will also coordinate with the Marin County Stormwater Pollution Prevention Program (MCSTOPPP) to make sure that educational materials about non-point source pollution are available to homeowners in the San Geronimo Valley.

- **Develop MOUs with local agencies.**
  MMWD will seek to enter into Memoranda of Understanding with DPR, MCOSD, NPS, and MCFD to foster the working relationship between these agencies in terms of road maintenance and sediment control.

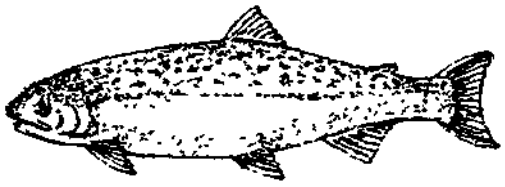
3.4 Sediment Management Plan Flexibility

Watershed conditions are not fixed. If conditions in the watershed should change in such a way as to make implementation of any of the measures specified in this plan unfeasible, MMWD will identify alternative measures and implement them as a substitute.

Periodically, existing sources of erosion will become more active, and more sediment will be yielded from these sites. If an existing site identified for repair in this plan becomes more active, it will be moved up the repair priority list to an appropriate position that reflects its increased rate of sediment yield.

Periodically, new sources of erosion will develop after large storm events. If one or more new sites develop that are clearly cost-effective and feasible to repair, and that achieve an appreciable reduction of detrimental sediment in Lagunitas Creek and its tributaries, MMWD will include such new sites in this plan for repair.

If an individual landowner does not wish to cooperate with MMWD for an erosion control project, MMWD will seek to implement an equivalent project on a different site.



4.0 Riparian Management Plan

State Water Resources Control Board Order WR 95-17 requires MMWD to:

> "Prepare a Riparian Management Plan that describes measures to be taken to improve the riparian vegetation and woody debris within the Lagunitas Creek watershed in order to improve habitat for fishery resources." (SWRCB, 1995)

The findings for SWRCB Order WR 95-17 state that woody debris is important for juvenile coho salmon, yearling steelhead, and California freshwater shrimp. Specifically the order mentions that woody debris creates and maintains pools, provides cover, provides foraging sites, creates habitat diversity by varying water velocity and depth, and provides habitat for the freshwater shrimp. Woody debris is particularly important to the Samuel P. Taylor State Park reach of Lagunitas Creek. SWRCB Order WR 95-17 concludes that additional woody debris would improve fishery habitat in Lagunitas Creek.

4.1 Overview

This overview details the functions of riparian vegetation and woody debris in the Lagunitas Creek watershed and provides the rationale for the specific riparian management measures described in the plan.

4.1.1 Major Functions of Riparian Vegetation

The riparian zone of a stream is that area bordering the stream that contains distinctive soils and vegetation influenced by streamside hydrologic characteristics. It is the transition area between the upland terrestrial and aquatic ecosystems. There is an interaction between the riparian zone, the fluvial process of the channel, and fish habitat (Baltz and Moyle, 1984a; Murphy and Meehan, 1991; Flosi and Reynolds, 1994). The four major functions of riparian vegetation with regard to instream habitat are stream temperature control, streambank stability, food production, and habitat complexity. All of these functions are important in Lagunitas Creek.

Stream Temperature Control

In California coastal streams, the main function of riparian vegetation in temperature control is shading, which moderates the rise of stream temperatures in summer. In many western streams, increased summer temperatures caused by the removal of shading cover have changed historical salmonid streams into warm water streams that support only non-native, non-salmonid species (Platts, 1991).

In Lagunitas Creek, stream temperatures measured at the State Park stream gauge typically meet the SWRCB Order 95-17 requirement of 58° F or less between May 1 and October 31 and 56° F or less between November 1 and April 30. Cool water is released from Kent Lake throughout the summer in all but the driest of water years. These cool water releases contribute to maintenance of the desirable water temperatures. Throughout the study area, the riparian forest is almost completely mature and intact. There are, however, a few locations where there are substantial openings in the riparian canopy. Enhancement of the riparian canopy for stream temperature control at seven locations is called for in this plan.

Streambank Stability

Streambank stability is influenced by several elements of the stream environment. Riparian vegetation is one of these elements. Its importance to streambank stability is greater in reaches where the stream channel is contained in alluvium. Where the stream channel is contained entirely in bedrock, riparian vegetation does not substantially influence streambank stability.

Natural surface erosion and mass wasting of streambanks occurs over long periods. Streambank erosion is frequently in equilibrium with bank building processes (Platts, 1991). During floods, water transports large amounts of sediment within streams. Riparian vegetation reduces water velocity along the stream's edge, causing sediments to settle out and become part of the bank. This deposition of sediments contributes nutrients to the bank soils and increases vegetative production. In alluvial channels, thickets of streamside vegetation can add substantially to the accumulation of sediments that are needed to build and maintain productive streambanks.

In Lagunitas Creek, the function of riparian zone vegetation in streambank stability is distinctly different in the reaches above and below Big Bend. Upstream of Big Bend, the contribution of riparian vegetation to streambank stability is less critical. Much of the channel is controlled by bedrock outcrops. The channel is geologically confined in many sections. High flows do not have much opportunity to spread out and flow more slowly over flood terraces. Velocities are high, and only minimal deposition of bank building materials occurs. However, where it does occur, and when it is stabilized by colonization of streamside vegetation, overhanging banks do develop. Such overhanging banks are highly important components of fish and freshwater shrimp habitat. In the upper portion of the reach between Kent Lake and Shafter Bridge, there are several locations that need riparian revegetation to enhance streambank stability. Specific sites for riparian revegetation are listed in Section 4.3.1.

In the reaches between Big Bend and Tocaloma, the stream channel becomes more alluvial and is not controlled by bedrock. The channel is also more dynamic. Bank building and erosion processes are more active. In these downstream reaches, riparian vegetation becomes important for streambank stability and is functioning naturally in this regard. While the riparian forest is mature and intact, it is impacted by the presence of significant colonies of exotic ground covers. These ground covers reduce the ability of native plants to become established in areas that are actively building or eroding. The presence of these exotics is not significantly affecting the riparian function with respect to streambank stability. This plan identifies one riparian revegetation project for streambank stability in the reaches below Big Bend.

Food Production

Riparian vegetation provides habitat for terrestrial insects that are an important food for salmonids and other aquatic species. It also provides organic material, which comprises about 50% of a stream's nutrient energy supply (Cummins, 1974). Detritus from terrestrial plants is a principal food source for the California freshwater shrimp and other aquatic invertebrates that in turn are prey for salmonids and other fish.

The riparian corridor appears to be functioning efficiently with regard to detritus input and subsequent insect and fish food production. Juvenile salmonids in the stream consistently appear to be well nourished and growing during the fall surveys (Davis, 1996). California freshwater shrimp populations have increased in recent years (Serpa, 1996). The riparian management measures do not include specific food production projects.

Throughout Lagunitas Creek, there is a substantial population of periwinkle *(Vinca sp.)* and ivy *(Hedera sp.).* Both of these exotic species are ground covers and frequently occupy the lower bank adjacent to the stream. It is not known if these species have a detrimental impact on food production, but it is felt that they have a detrimental effect on the native vegetation. That is, at locations where these exotics are present, they are preventing the establishment of native species. However, the studies on which SWRCB Order WR 95-17 is based do not identify exotic species as a limiting factor for aquatic species.

Habitat Complexity

Aquatic habitat in streams is closely linked to the channel forming processes. Habitat is created and maintained by the physical interaction of the hydraulic forces in the stream against the bed and bank of the channel (Murphy and Meehan, 1991). Channel gradient, amount and dominant sediment size, streamflow volume, extent and type of riparian vegetation, amount and type of instream woody debris, and geologic setting are important factors in channel form and aquatic habitat complexity (Montgomery, et al., 1995). The interaction of these elements combines to form pool, run, glide, and riffle habitats and to provide structural and hydraulic complexity within the individual habitat types. This plan focuses on two aspects to improve habitat complexity: riparian vegetation management and woody debris.

Riparian Vegetation.

Several important elements of habitat complexity are provided by, or originate from, riparian vegetation. Roots adjacent to the channel and those hanging in the water contribute to the development and stability of overhanging banks and underwater structural complexity. Vegetation that is low growing, overhanging, and near the water's surface provides summer cover refuge for juvenile fish. Stems and branches that

hang into the water contribute to structural complexity for summer rearing habitat and California freshwater shrimp habitat. Vegetation that becomes inundated during high flows provides high flow refuge habitat. The riparian forest is also the source of woody debris in the system.

Foot and horse traffic below the campground bridge and some creek access trails have inhibited natural regeneration of low growing, overhanging, understory vegetation along Lagunitas Creek. This plan calls for specific riparian vegetation management actions to be taken at a few sites for habitat complexity purposes. The site specific projects for riparian vegetation management are in Section 4.3.1.

Woody Debris.

The habitat complexity provided by woody debris is fundamental and critical to good fisheries habitat. Debris piles or log jams constrict the channel and can aid in the development of pools. Pools with complexity from woody debris provide feeding sites, low flow escape cover, and high flow refuge for salmonids. Woody debris is important in sediment retention and, therefore, can be important in maintaining spawning and aquatic insect production sites (Lisle, 1986; Montgomery, et al., 1995). When woody debris has been removed from streams, salmonid populations have been reduced (Dolloff, 1986).

In Lagunitas Creek, the input of woody debris to the system has been substantially modified. Lagunitas Creek was first settled in the mid 1800s, and nearly the entire watershed was logged, interrupting the natural processes that provided woody debris for the stream. The first dams were built shortly thereafter in the upper watershed, blocking woody debris transport from the area above the dams. In the 1970s and early 1980s, woody debris was regularly removed from the stream channel. These changes have reduced the amount of woody debris in Lagunitas Creek below Kent Lake. This reduction of woody debris input has impacted the reach of Lagunitas Creek between Kent Lake and Devil's Gulch more severely than the reaches below Devil's Gulch.

The practice of removing woody debris has slowed in most locations in recent years. DPR managers and MMWD staff recognize the importance of woody debris in the system and support efforts to enhance fish habitat with woody

debris. There are, however, resource management conflicts that result in the removal or destabilizing of naturally occurring instream woody debris. Two common conflicts are trees fallen across streamside trails and roads and trees that have fallen in the channel, which create an "attractive nuisance" and safety hazard. Trees in these situations are frequently cut to clear the trail or road or to eliminate the "attractive nuisance." This reduces the size of the log or top and separates the root mass. Such actions destabilize the material, and small logs tend to wash downstream.

The quality of fish habitat in the reach of Lagunitas Creek between Kent Lake and Devil's Gulch would be improved by the addition of substantial quantities of large woody debris. In the reach between Devil's Gulch and Tocaloma, there are many large woody debris jams and many pools with woody debris cover. Below Devil's Gulch, there are few opportunities for woody debris enhancement. The unmanaged riparian processes are functioning appropriately for ongoing maintenance of good fish and freshwater shrimp habitat.

4.1.2 Overview of Current and Past Riparian Management Programs

MMWD Riparian Management Program

In 1994 and 1995, MMWD and TU volunteers installed woody debris along the main stem of Lagunitas Creek between Peters Dam and Irving Bridge at thirteen locations. At some locations, tree tops were installed. At other locations, logs were installed. All of the locations were selected to provide cover in existing pools for rearing habitat. Volunteers also planted alders in the reach between Peters Dam and Shafter Bridge in 1995.

National Park Service Program

NPS recently received a five-year, $800,000 grant from the federal government. The grant project—*Preservation and Restoration of Coho Salmon and Steelhead at Point Reyes National Seashore, Muir Woods National Monument, and Golden Gate National Recreation Area*—will develop and implement a habitat restoration plan for coho salmon and steelhead trout in these three NPS jurisdictions. Project objectives include analysis of historic salmon and steelhead presence and abundance; surveys to

evaluate fish abundance; analysis of habitat components including stream channel morphology, water quality, and vegetation; developing and implementing a restoration and monitoring plan; and public education. Within the Lagunitas Creek watershed, portions of Lagunitas Creek, as well as Olema Creek, Devil's Gulch, and Cheda Creek, will be included.

MMWD and NPS plan to coordinate their implementation and monitoring efforts. This could include sharing data and resources.

Samuel P. Taylor State Park Program

DPR cooperated with MMWD and TU for the 1994 and 1995 woody debris projects. DPR has a program to eradicate eucalyptus that grows in the Devil's Gulch riparian zone.

San Geronimo Valley Planning Group (SGVPG)

SGVPG has recently formed a Creek Committee and plans to address woody debris issues facing homeowners who live along San Geronimo Creek (i.e., when to leave or remove woody debris in the creek).

4.2 MMWD's Riparian Management Plan Goals and Objectives

The goal of the riparian management plan is to enhance instream fish habitat in Lagunitas Creek between Kent Lake and Tocaloma by riparian vegetation management and by placement of woody debris structures in the stream channel.

The objectives for the riparian management plan include:

- In the reach between Peters Dam and Devil's Gulch, establishing riparian trees in locations along Lagunitas Creek where openings in canopy cover could be reduced by establishment of riparian forest and where additional riparian trees for woody debris recruitment could be established.
- In the reach between Peters Dam and Devil's Gulch, establishing low growing, overhanging streamside vegetation adjacent to pools in areas of open canopy.
- In the reach between Irving Bridge and the downstream end of the campground at Camp Taylor, management of foot traffic to increase the

natural recruitment of low growing, overhanging vegetation adjacent to the stream.

- Placement of stable, large woody debris across the channel to retard the downstream migration of beneficial substrate sizes at existing riffles where the substrate is too coarse for spawning, to retard the downstream migration of spawning gravel at incipient riffles, to expand and maintain pool volume at the base of these riffles, and to contribute to high flow refuge habitat, adult holding habitat, and summer rearing habitat in the vicinity of these riffles and pools.
- Placement of stable, large woody debris at an oblique angle to the flow, protruding 25% to 40% across the channel in pools below riffles to increase pool volume, to promote debris piles for summer rearing habitat, and to increase high flow refuge habitat.
- Tethering of large woody debris and tree tops in pools that are located at the downstream end of riffles to increase cover for summer rearing habitat.
- Implementation of public outreach projects to increase awareness of the importance of woody debris in the stream channel.
- Development and implementation of policies by DPR and MMWD that promote stable, large woody debris in the stream channel.

4.3 Riparian Management Plan Actions

The identified measures focus on riparian vegetation management and instream woody debris. They include site specific work along Lagunitas Creek, public outreach, and policy development.

4.3.1 Riparian Revegetation Projects

Field investigators walked the riparian corridor between Kent Lake and Tocaloma Bridge to identify sites where vegetation management could enhance the four functions of riparian vegetation described in Section 4.1.1 above. A reconnaissance survey was conducted below Tocaloma Bridge.

The following six sites were selected for their ability to influence stream temperature, streambank stability, and habitat complexity. A seventh site was identified by other field researchers and is located downstream of Tocaloma along Platform Bridge Road. The sites are located on Figure 6. Data sheets for

these seven sites are in Appendix G. Specific implementation details are in Section 6.

Site R-l. Immediately below Peters Dam is an infestation of broom on the left bank. The area is approximately 10' wide x 500' long. The broom should be removed and replaced with 160 trees and shrubs. Care must be taken to avoid removal of coyote brush, which is mixed in with the broom and can look similar to younger broom plants. Bare areas should receive seed and mulch. Primary benefit will be to provide future replacement and recruitment trees for habitat complexity.

Site R-2. An area approximately 10' wide x 330' long on the left bank is infested with periwinkle below Peters Dam. Recommendations include removing the exotics, seeding and mulching bare steep banks, and installing 188 plants, including ground cover, shrubs, and trees. The primary benefits will be stream temperature control, streambank stability, and increased habitat complexity.

Site R-3. In the Peters Dam reach, areas on both the left and right banks lack understory and overstory vegetation. This is part of the area that was planted by TU in 1995 and is in the vicinity of the cross channel sediment traps placed below Peters Dam during construction when the dam was raised. The total area needing revegetation is approximately 1000 square feet. The left bank needs approximately 125 plants, the right bank approximately 135 plants. Scattered patches of periwinkle and broom should be removed.

Several of the alders planted by TU volunteers in 1995 have withstood high flows and are growing. Most of the irrigation pipe is in place and can be reused. The primary benefits will be stream temperature control, streambank stability, and habitat complexity.

Site R-4. At the Shafter Bridge parking lot, a 10' to 30' wide x 150' long zone of periwinkle and ivy occupies the understory. Recommendations are to remove the exotics, seed and mulch, and plant with 124 ground cover and shrub plants and 18 trees. Primary benefit will be replacement trees and roots in the stream zone for habitat complexity.

Site R-5. Immediately below Shafter Bridge on the left bank is infested with ivy, Himalaya berry, and periwinkle. The area is approximately 25' wide x 150' long. Remove the ivy and berries in the riprap. Remove the periwinkle downstream and replace with 200 California blackberries and 10 big leaf maples. Primary benefits will be tree cover and roots within the stream zone.

Site R-6. In the vicinity of milepost marker 15.6, there is a large opening in the canopy upstream and downstream of a large, fallen redwood tree on the left bank. The area is approximately 200' long. Install 20 coast redwood and 20 white alders. The primary benefit will be stream temperature control.

Site R-7. On the right bank downstream of Tocaloma Bridge is a streambank failure. Stabilize the streambank failure and establish willow and alder along the failed area. The primary benefit will be stream temperature control, streambank stability, and habitat complexity.

During a three-year establishment period, reforested sites will be maintained. Maintenance will include weeding, summer watering, repair and replacement of browse protectors, replanting, and continued removal of exotic plants.

4.3.2 Site Specific Woody Debris Placement Projects.

This plan's site specific projects for woody debris placement are targeted at four woody debris functions:

- Retard downstream migration of medium to large gravel and cobble (see Figure 3: Examples of Stream Sediments) at incipient riffles and at existing riffles that are too coarse or are lacking sufficient quantities of desirable gravel;
- Increase pool volume via local scour from flow obstruction;
- Increase high flow refuge habitat by creating eddies and slower moving water behind obstructions; and

- Increase summer escape cover habitat by increasing the complexity of the underwater environment and increasing the percentage of the pool that is shaded by cover on or just above the surface of the water.

Each of these functions and methods to help achieve them are explained below.

Retard downstream migration of medium to large gravel and cobble at existing riffles. The first woody debris function is to retard downstream migration of medium to large gravel and cobble at existing riffles, which will enhance habitat at several locations in Lagunitas Creek above Devil's Gulch.

- One set of locations includes existing riffles where the riffle substrate is too coarse for spawning or is largely bedrock. In Lagunitas Creek, these occur primarily in the reach between Peters Dam and Shafter Bridge and in the upper half of the reach between Shafter Bridge and Irving Bridge.

- The second set of locations where retarding the downstream movement of cobble is desirable is in runs where incipient riffles are becoming visible. The incipient riffle locations occur in the reaches between Shafter Bridge and Devil's Gulch.

The prototype woody debris structure for this function is shown in Figures 7 and 8: Cross Channel Double Log Structure. The concept for this structure is taken from a naturally occurring tree fall in Lagunitas Creek at milepost 15.61. The amount of this type of woody debris included in this plan for Lagunitas Creek is governed by the number of riffles where the substrate is too coarse, plus the number of incipient riffles between Shafter Bridge and Devil's Gulch. The candidate sites for woody debris placement include 13 locations for this type of structure.

Pool volume enlargement via local scour. The second woody debris function is to enlarge pool volume via local scour induced by the turbulence associated with an obstruction. Pools at the downstream ends of riffles provide good summer rearing habitat and spawning adult holding habitat. Three types of woody debris structures will be used for this function: the cross channel

double log structure (Figures 7 and 8), the single oblique obstruction log (Figures 9 and 10), and the double oblique obstruction log (Figure 11).

The single oblique obstruction log is frequently described as a digger log, an appropriate description when it is used for pool enlargement. Using the oblique log for pool creation or enlargement is specified only where the fluvial process is tending towards scour. Placement in locations where the fluvial process tends toward deposition will not create pool habitat. During the high flows of a storm event, local scour occurs around the log. As the flows drop after a high flow event, the scoured area will fill if the log is placed in a depositional zone. Because pool creation or enlargement cannot occur in bedrock areas of the stream channel, woody debris structures will not be placed at these locations.

The amount of this type of woody debris needed in the system is determined by the number of locations where the fluvial process tends towards scour and where a pool needs to be created or enlarged to improve habitat for fisheries resources.

High flow refuge habitat. The third woody debris function is the increase of high flow refuge habitat, the calm water or eddies accessible to fish during high flow events. Young salmon rear for one winter in the stream, young steelhead for one to three winters, before migrating to the ocean. Current understanding of young salmonid behavior is that fish do not migrate up and downstream during the summer. They tend to take up residence within a short section of the stream. However, they may be forced to move in winter without desirable high flow refuge habitat, the area within that reach of residence that the fish can "hold" with a minimal expenditure of energy during periods of high velocity flows.

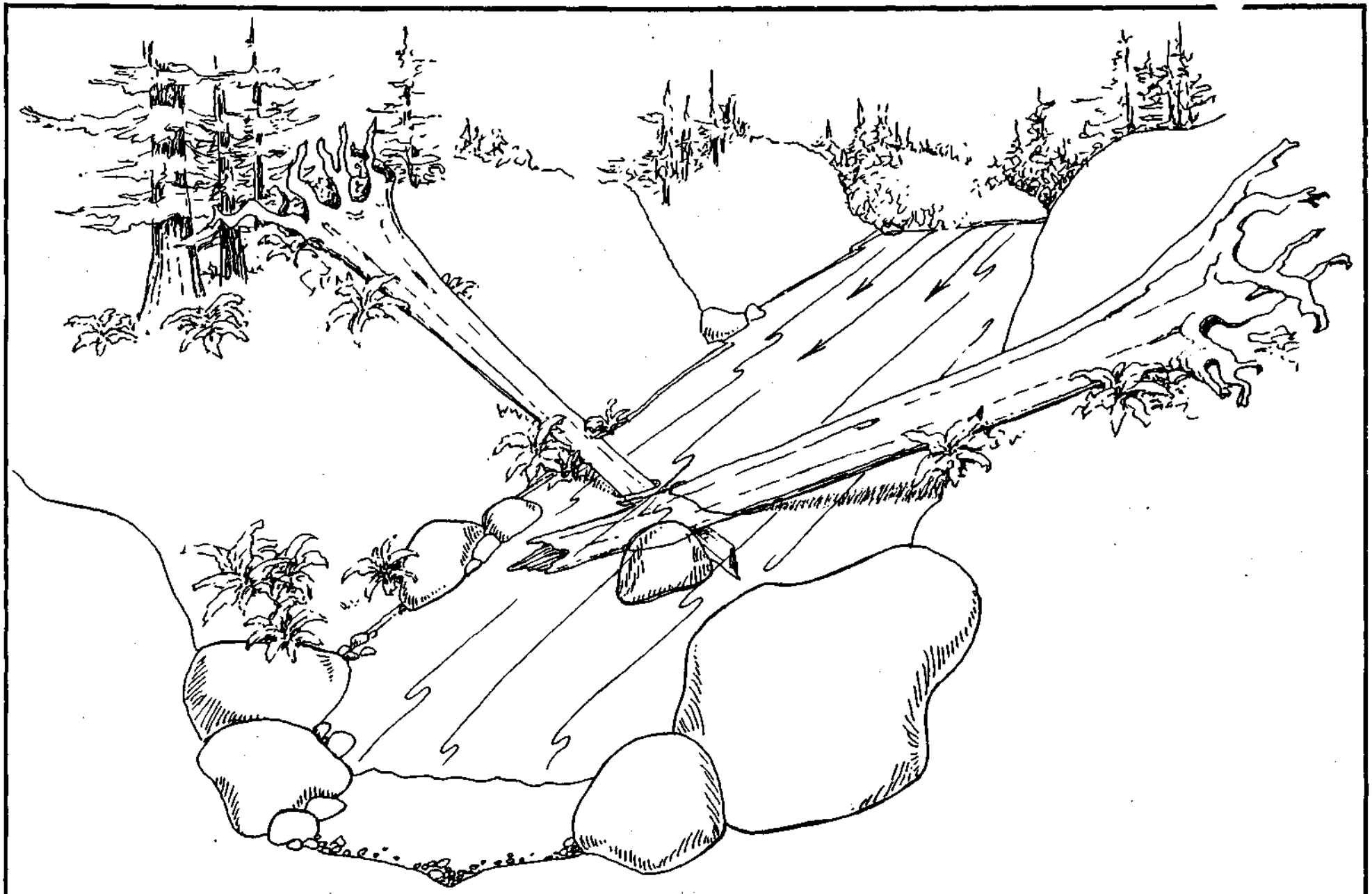
The cross channel double log structure (Figures 7 and 8); the single oblique obstruction log (Figures 9 and 10), and the double oblique obstruction log (Figure 11) contribute to this habitat. These structures tend to trap loose woody debris that is carried by flows and cause debris piles to accumulate. Stable debris piles along the edges of the stream below the high water surface elevation are important high flow refuge habitat.

The amount of high flow refuge habitat needed in the Lagunitas Creek system is not known. The placement of cross channel double log structures for gravel accumulation and pool enlargement and the placement of single oblique obstruction logs for pool enlargement will increase winter refuge habitat in the vicinity of pools used for summer rearing. Beyond those locations, the next best opportunities for placement of woody debris for high flow refuge habitat would be in the glides.

Substantially increasing the amount of woody debris present in the glides in Lagunitas Creek between Shafter Bridge and Devil's Gulch could be done without much risk of negative impact. However, the gain would likely be marginal.

Historically, the high flow refuge habitat has come from stable woody debris. In the reach of Lagunitas Creek between Peters Dam and Devil's Gulch, stable woody debris comes primarily from whole trees that fall into the stream, with tree tops in the channel and the lower part of the stem and root mass on the bank above high water. Large woody debris entrained in the stream does not generally lodge in the reach between Peters Dam and Devil's Gulch and, therefore, does not provide high flow refuge habitat. The entrained material passes through this reach and lodges below Devil's Gulch. Because the woody debris that falls into the channel along the banks between Peters Dam and Devil's Gulch has historically provided the high flow refuge habitat, the only action identified for winter refuge habitat is development and implementation of a policy to leave all trees that fall into the channel.

Summer rearing escape cover habitat. The fourth woody debris function, summer rearing escape cover habitat, is most important in pools that are downstream of riffles. In addition to the presence of woody debris, this type of habitat can be provided by overhanging banks, by riparian vegetation, by very deep water (over 4 feet), and by boulders in the stream channel. In Lagunitas Creek, overhanging banks, low growing overhanging riparian vegetation, and woody debris are the primary sources of this habitat. The type of woody debris included in this plan for providing such habitat includes the cross



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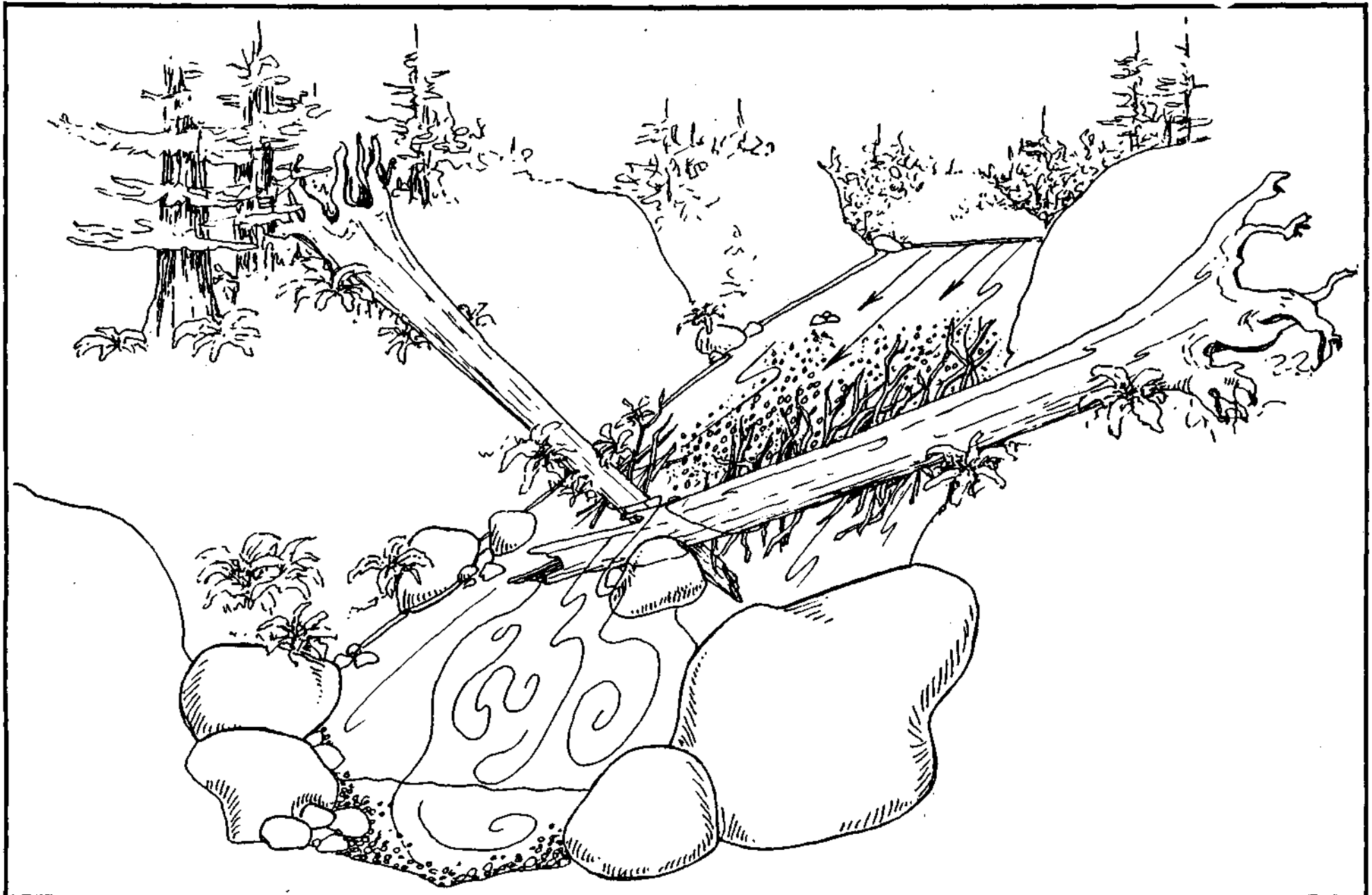
Cross Channel Double Log Structure

At Installation

Figure 7



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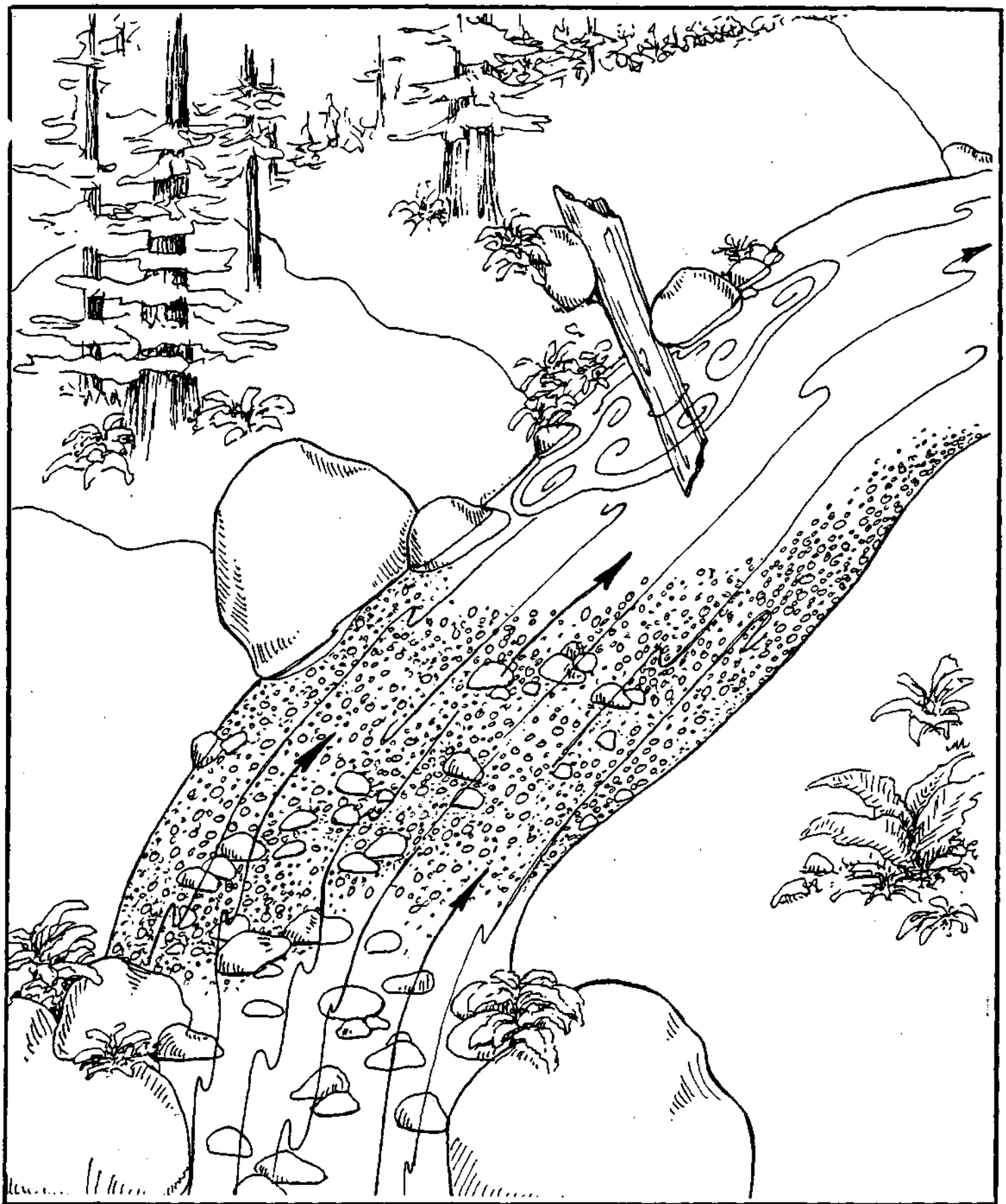
Cross Channel Double Log Structure

After Storms

Figure 8



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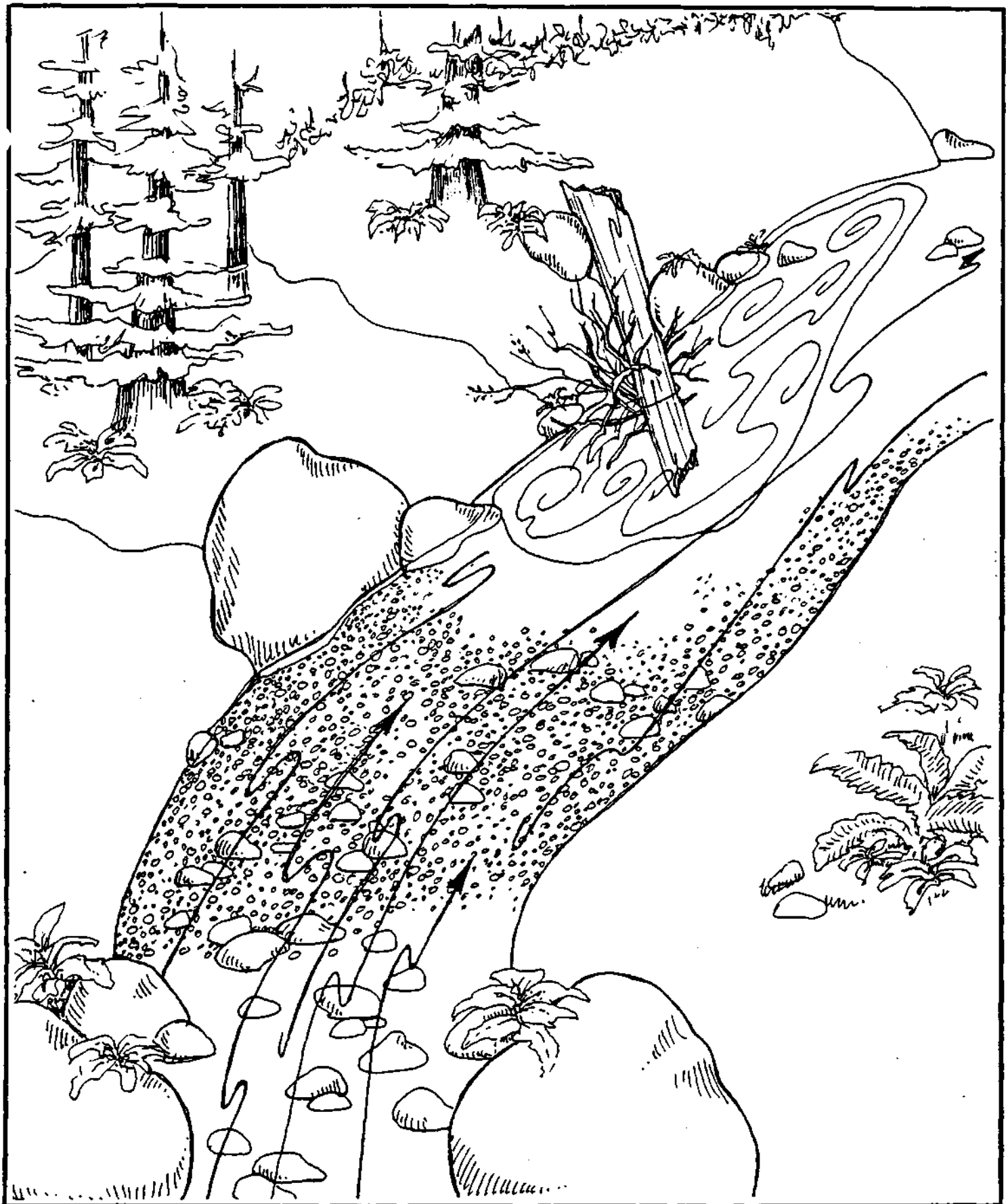
Single Oblique Obstruction Log

At Installation

Figure 9



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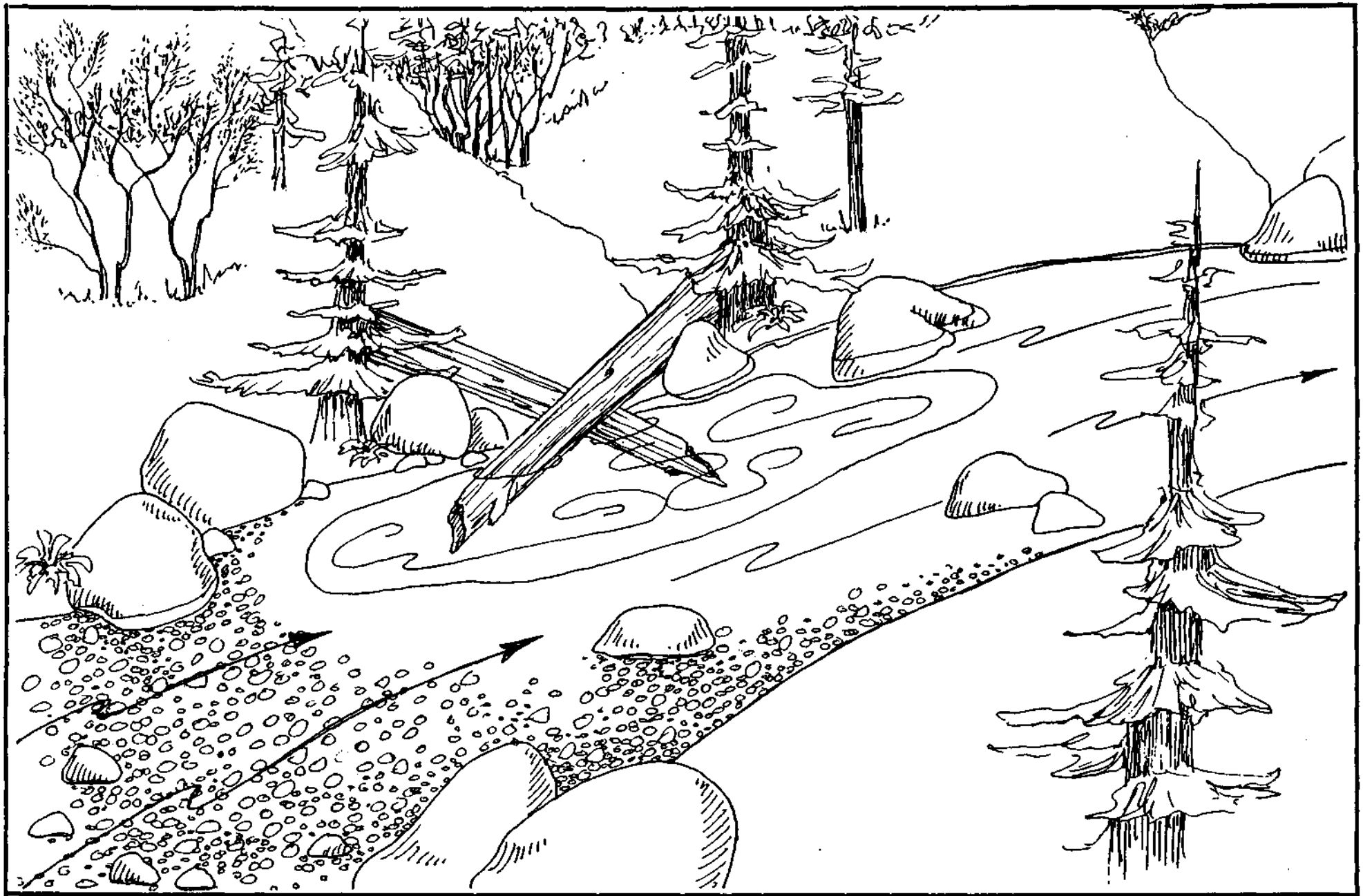
Single Oblique Obstruction Log

After Storms

Figure 10



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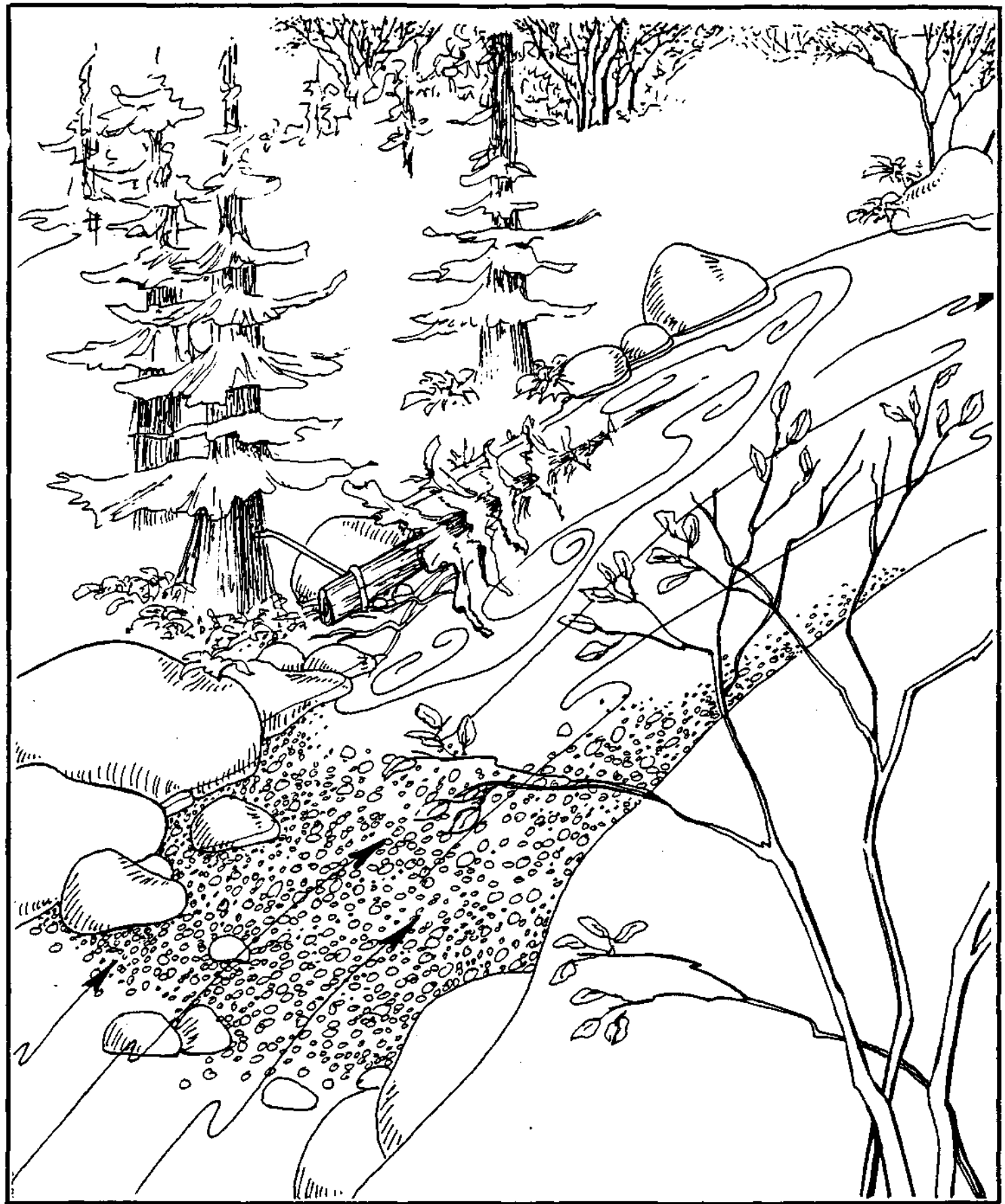
Double Oblique Obstruction Logs

At Installation

Figure 11



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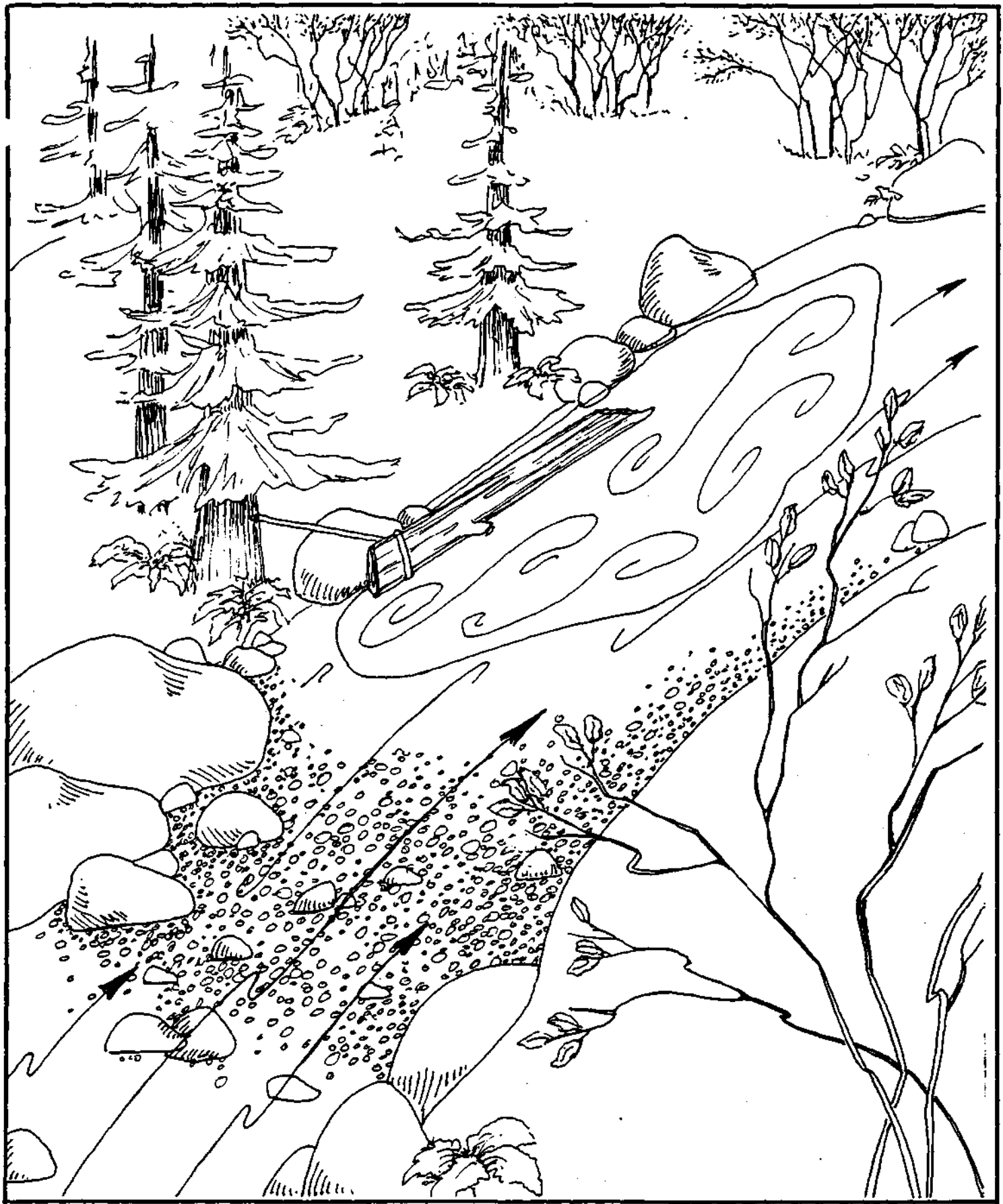
Tethered Treetop for Summer Escape Cover

At Installation

Figure 12



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DATE: _____
SCALE: NTS
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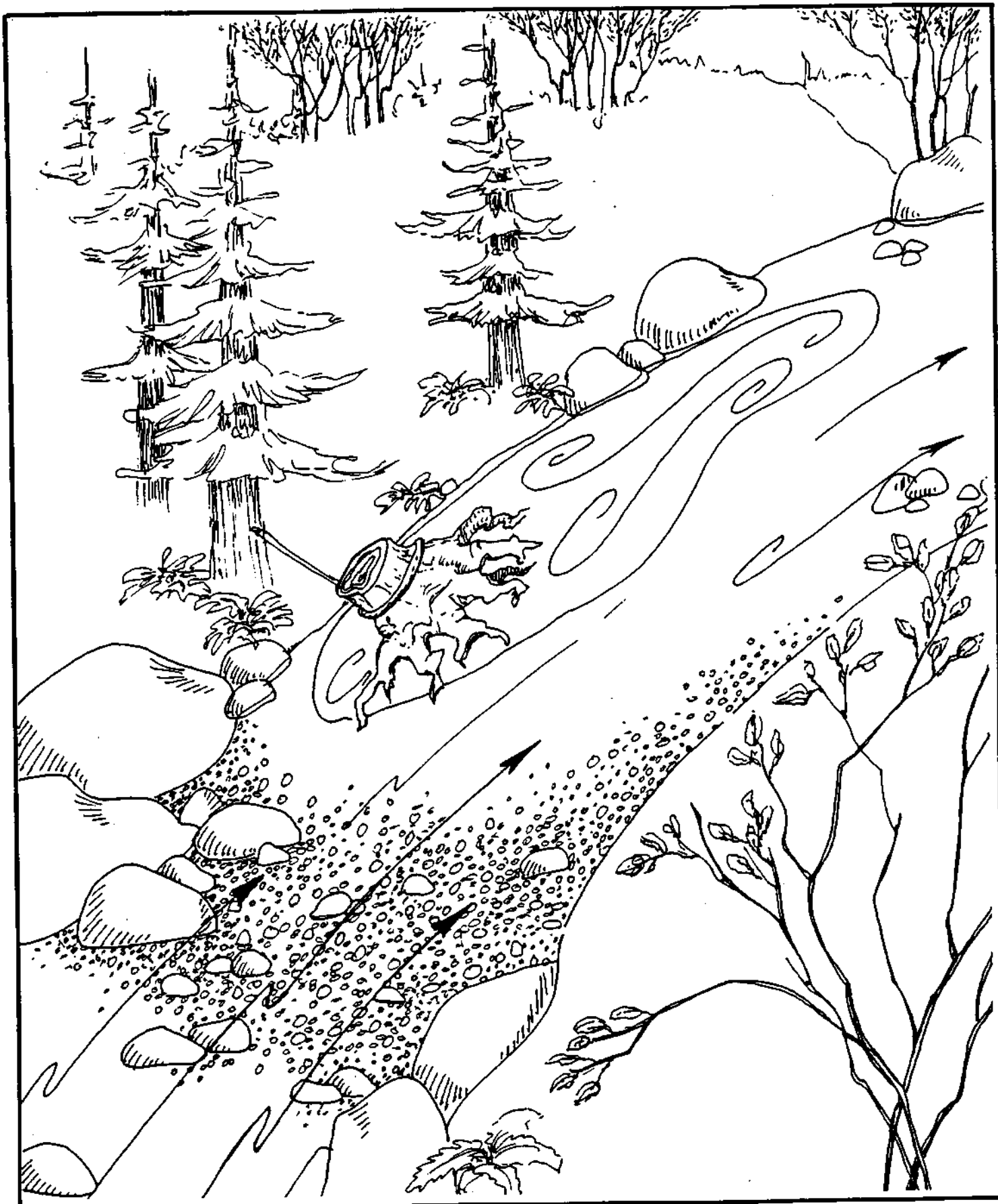
DRAFTED BY: SH

Tethered Log for Summer Escape Cover

At Installation

Figure 13



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Tethered Root Mass for Summer Escape Cover

At Installation

Figure 14

channel double log structure (Figures 7 and 8), the single oblique obstruction log (Figures 9 and 10), the double oblique obstruction log (Figure 11), tethered tree tops (Figure 12), tethered logs (Figure 13), and tethered root mass (Figure 14). The amount of this type of woody debris that is needed is governed by the number of pools in the system that are escape cover deficient.

Location of Woody Debris Treatment Sites

Field investigators walked the riparian corridor between Peters Dam and Tocaloma to identify specific sites where woody debris would enhance the four functions described above. Investigators also evaluated the existing woody debris projects. Sites were visited during both low and high flows. The following 42 sites are located on either MMWD land or state park property and are shown on Figure 6. No priority has been given to these sites.

WD.l (concrete weir). Install a large woody debris (LWD) structure at the base of the poor quality riffle to create a constriction above the existing broken concrete weir. This will be a key site for spawning gravel introduction and retention. An access road to the channel is located at this site.

WD.2 (TU cover log). On the left bank opposite the TU cover log, downstream of the small low quality riffle, install a LWD structure or a boulder weir to span half the channel length. The structure's primary purpose is to retain spawning gravel and enlarge the riffle size, while providing additional adult holding and winter refuge cover. This site is also a site for the placement of spawning gravel below Peters Dam.

WD.3 (upstream of left bank culvert). A deep, bedrock pool upstream of the left bank tributary confluence will be enhanced by installing a small woody debris on the left bank of the upstream end of the pool for summer rearing habitat cover.

WD.4 (downstream of left bank culvert). Downstream of the left bank tributary confluence, there is a riffle with low habitat value due to the coarseness of the gravel. This is a candidate site for a LWD structure at the downstream end of the riffle, creating channel constriction to retain upstream spawning gravel migration and to enhance downstream pool cover attributes.

WD.5 (yellow fire hydrant). A long, lateral scour pool on the right bank could be enlarged with a LWD obstruction structure (digger log) to increase the pool's volume through scour. Additional habitat enhancements will be achieved by the structure for summer rearing, adult holding, and winter refuge cover.

WD.6 (Shafter Bridge parking lot). Approximately 100' upstream of the inner gate to the MMWD parking lot on the left bank, there is a shallow, lateral scour pool. Placing an oblique log off the left bank across one-fourth of the bankfull channel will scour the pool and create cover. A log with a root wad would be ideal to enhance cover complexity.

WD.7 (parking lot pool). The first pool ± 50' upstream of Shafter Bridge and downstream of the first riffle lacks cover. A single, large tree top or several tree tops should be tethered to the right bank to provide summer rearing and adult holding cover.

WD.8 (MP 15.33). The first plunge pool 30' downstream of the turquoise guard rail on Shafter Bridge should have a tree top tethered to the right bank for summer escape cover for years when the high quality pools are open. In years when Kent Lake does not spill, the pools in this area are filled with bedload from San Geronimo Creek.

WD.9 (MP 15.40). Spawning fish are observed not to use this riffle, which is located approximately 100' downstream of MP marker 15.38. The area below the riffle is a candidate site for a LWD structure, i.e., a cross channel double log structure to build the riffle with usable spawning gravel, while creating an obstruction for winter refuge and downstream pool enlargement. Because of proximity to the fill slope supporting Sir Francis Drake Blvd., installation of this structure should take place after other cross channel double log projects have been fully evaluated.

WD.10 (MP 15.43). A small pool on the left bank downstream of a riffle at MP 15.43 (MP marker is adjacent to a culvert) is lacking cover and will benefit from a tethered tree top by increasing pool complexity.

WD.11 (MP 15.46). A TU structure that consists of several cabled logs is located on the left bank. Additional woody debris tied to the structure would add complexity to the small pool, improving summer rearing and adult holding cover. New cables need to be installed to resecure the logs to adjacent bedrock.

WD.12 (MP 15.53). Approximately 200' downstream of MP 15.49 is a candidate site for a LWD cross channel structure. The site is downstream of the incipient riffle and upstream of two fallen bay trees on the left bank. There is a senescent redwood leaning on the right bank and a 24" x 20' tree on the right terrace 100' upstream. Because this site is at an MMWD streambed monitoring location, no construction will occur before 2001.

WD.13 (MP 15.62). This site at a large, downed redwood (48" diameter) is the top candidate for a LWD structure. A large, cross channel double log structure should be placed at the downstream end of the low quality riffle to create an obstruction. The structure will provide habitat for summer rearing cover, winter refuge cover, and adult holding cover and will enlarge the spawning area by induced gravel retention. Approximately 100' upstream of the down redwood is a large, 18" diameter, downed Douglas fir that can be used as the additional crosspiece.

WD.14 (MP 15.90). This barren pool was a previous TU treatment site. Anchor woody debris on right bank at upstream end of pool to create low flow cover. Material will need to be imported to this site, where there is room for two or three tree tops.

WD.15 (MP 15.93). This pool, another existing TU site with some woody debris for cover, would benefit from an additional LWD tree top or root wad on the left bank to increase summer escape cover. There is an existing Douglas fir log at MP 15.97 above Sir Francis Drake Blvd.

WD.16 (MP 15.99). This site had a large, fallen tree that created a debris jam, which broke and washed out in the New Year's (1996-97) storm. The woody debris jam created a large, highly productive riffle upstream that is now

actively downcutting and has washed out this winter's redds. Install a LWD cross channel double log structure at this location to re-establish the riffle. The location of the structure will need to be determined during the design phase to achieve optimum downstream pool enhancement due to exposed channel bedrock. The broken log remains on the right bank and can be used for cross channel material. Alternatively, woody debris could be placed on the left and right banks.

WD.17 (MP 16.04). A long pool runs downstream to site WD.18. Install woody debris for cover complexity on both sides of the upstream end of the pool where habitat quality is better due to higher food production. There are several downed trees (bay, tan oak, 12" diameter) on the terrace about 200' downstream of the bottom of the riffle at this site.

WD.18 (MP 16.11). A candidate site for a LWD cross channel double log structure or an oblique obstruction log on the right bank is located downstream of the riffle in the streambed monitoring site KH "Kelly's Upper." The area has poor summer rearing habitat. Because this site is at an MMWD streambed monitoring location, no construction will occur before 2001.

WD.19 (MP 16.21). Woody debris cover (tethered tree tops or anchored root wads) should be placed at the left bank on the upstream end of the pool for summer escape cover. There is a bedrock outcropping on the left bank of this existing TU site.

WD.20 (MP 16.27). This pool has some instream vegetation with the possibility that the channel has moved to the right. Additional woody debris should be added to the right bank below the riffle at the head of the pool to increase pool complexity. There is room for two tree tops here. Material on the right bank is useful winter refuge habitat and should not be removed or disturbed. A tributary enters the channel at the downstream end of this pool on the right bank.

WD.21 (MP 16.29). Approximately 250' downstream of site WD.20, install additional woody debris for summer cover on the left bank at site of existing TU tree top.

WD.22 (MF 16.36). Place LWD cross-channel, double log structure below the small, low quality riffle that is characteristic of this stream reach above Irving Campground.

WD.23 (MP 16.42). The sites upstream of Irving Bridge and the main campground have been noted historically as having incipient riffles. The historic first riffle upstream of the furthest downstream TU cover log has been washed out and currently acts as a run. Install a LWD cross channel double log structure at the downstream end of the run to create an obstruction. The purpose is to re-establish the riffle and scour a downstream plunge pool. This site is the second highest candidate site for a LWD cross channel double log structure installation due to poor fish habitat and stable streambanks. A fallen Douglas fir (2.5' x 70' with a root fan) is available on the left terrace. Additionally, there is a large Douglas fir on the right bank above the bike path.

WD.24 (MP 16.51). The small, bedrock pool upstream of Irving Bridge has water in two channels with good root wad cover from a downed tree. Woody debris should be added at the upstream end of the pool on the left bank for additional cover complexity.

WD.25 (MP 16.60). First pool downstream of Irving Bridge should have woody debris cover anchored to bedrock on left bank for summer rearing cover and high flow refuge habitat. A log found on the right bank could be used for cover on the left bank. Branches should be attached annually.

WD.26 (MPs 16.62 to 16.65). This long pool between Irving Bridge and the bike bridge would greatly benefit from woody debris anchored on the upstream end of the left bank for summer rearing cover. Additional woody debris should be added to the bedrock outcropping on the right bank at the upper end of the pool. The pool has some overhanging vegetation, undercut banks, and tree roots present.

WD.27 (MP 16.66). This long pool under and downstream of the bike bridge could use some woody debris for summer rearing, winter refuge, and adult holding cover. Woody debris should be placed at the head of the pool on the left and right banks. Riparian revegetation could provide additional cover and food production on the right bank. The pool has good freshwater shrimp habitat.

WD.28 (MP 16.89). This pool between the bike path bridge and the campground entrance has some good root wads providing cover. Additional woody debris cover could be added at the very downstream end of the riffle at the pool. Summer cover should be provided on both banks.

WD. 29 (MP 16.93). Place woody debris for summer rearing cover and winter refuge. Material should be placed in upstream portions of the pool near the downstream end of the riffle.

WD.30 (MP 17.04). The pool near the big rock on the left side is a site for woody debris cover.

WD.31 (MP 17.05). Just upstream of the campground entrance and downstream of the big rock, attach woody debris, tethered tree tops, or small woody debris to the right bank for summer rearing cover in addition to the existing undercut banks.

WD.32 (MP 17.15). The barren, bedrock pool at the upstream end of the picnic area is downstream of an important spawning area in the state park. The pool would benefit from some low flow cover habitat. When sampled in 1995, few juvenile fish were found using the pool despite good insect production upstream (Davis, 1997). Attach woody debris to left bank and potentially to the right bank.

WD.33 (MP 17.24). Just downstream of the campground bridge is an incipient riffle/glide area with little habitat. A double log cross structure or a single log weir drop structure could be placed to develop a new pool and to retard downstream gravel migration. A lateral scour pool at the base of a 40'

rootwad could benefit from a single or double obstruction log to increase pool volume and provide cover. Because this site is at an MMWD streambed monitoring location, no construction will occur before 2001. Another potential site is approximately 260' downstream on the right bank.

WD.34 (MP 17.37). A shallow, lateral scour pool on the left bank directly downstream of a riffle with boulder outcropping should be enhanced with an obstruction log. The digger structure will increase pool volume and provide summer habitat cover.

WD.35 (MP 17.50). This long pool is at the downstream end of the campground and is a potential site for a LWD cross channel double log structure or oblique logs at the upstream end of the pool. If a cross channel structure is not used, the pool will benefit from woody debris cover on the left bank.

WD.36 (MP 17.60). Woody debris could be used to enhance this pool's cover complexity at the upstream end near the rock outcropping on the right bank. This is a monitoring site in the San Geronimo Program; therefore, no action should be taken until at least 2005.

WD.37 (MP 17.70). This is a candidate site for a LWD cross channel structure downstream of the incipient riffle below "Big Rock." Because this site is at an MMWD streambed monitoring location, no construction will occur before 2001. An alternative site is downstream 150' at MP 17.73.

WD.38 (MP 17.73). A LWD double log cross channel structure could be placed at the incipient riffle just downstream of the scoured left bank. A single, large, diagonal log weir or a double log cross structure may be used at the stream bend to retard migration of upstream gravel and to scour a downstream mid channel plunge pool. Additional riparian revegetation may be established on the left bank of this site for further macroinvertebrate production, cover, and bank stability.

WD.39 (MP 17.98). The pool could be enhanced with some woody debris attached for low flow cover on the left bank downstream of bedrock.

WD.40 (MP 18.00). The barren, bedrock pool could be improved with some woody debris for summer escape cover. There is a slightly undercut bank on the left bank, but, other than that, the cover is limited. The substrate is bedrock in the pool and riffle upstream. Tree tops could be tethered to the left bank for cover.

WD.41 (MP 18.41, 200' upstream of bridge). Install a woody debris for summer escape cover near the pool that currently has a cross channel log jam. The log creates a gravel bar, although it is not good for spawning.

WD.42 (MP 18.45). Deep, barren, bedrock pool under the green bridge would be improved with the addition of low flow summer habitat cover. Attach small woody debris to upstream end of bedrock on left bank.

Material for these woody debris structures is available in the watershed. Specific sources of the wood for each structure will be finalized at the time of installation. Candidate sources are woody debris removed by MMWD from Kent Lake or the Peters Dam spillway, other trees removed from MMWD watershed lands by MMWD, eucalyptus in Devil's Gulch on state park lands, naturally fallen Douglas fir, redwood and hardwoods along the riparian corridor, and standing trees along the riparian corridor.

Maintenance of Woody Debris Projects

Stream channels are dynamic environments. Small changes in the channel form and features occur regularly. Major changes occur periodically. Pools and riffles move. Some woody debris in channels is stable; some is unstable. Nothing is permanent. The woody debris projects listed above are not expected to be permanent. They are intended to be enhancements to the channel's fish habitat as it is configured at this time. Maintenance of these structures will require judgment. Ultimately, all of the woody debris structures installed by MMWD under this plan will likely be washed out by action of the flows in Lagunitas Creek, as is the nature of woody debris in streams.

When a woody debris structure is damaged or lost, MMWD will assess whether or not the function provided by the structure is still appropriate for the individual site. If it is, then the structure will be replaced. If the function is no longer appropriate for the site, MMWD will determine if there is similar habitat nearby that is appropriate for improvement with woody debris. If there is an appropriate nearby site, MMWD will place woody debris at the new location. If there is not an appropriate site nearby, no action will be taken.

Maintenance of the woody debris structures will also be needed to correct improper functioning. If the structures are not meeting their individual objectives, or if the structures are found to be causing a net negative impact, then the structures will be modified to correct their function or be removed. If a structure is removed, MMWD will search for a replacement site as described above.

Maintenance will occur annually, as needed, between May 15 and October 15.

4.3.3 Specific Public Outreach Projects

In addition to the eight public outreach efforts that are described in Section 3.3.4, MMWD will also:

- **Install informational signs.**

  New informational signs will be installed at three locations that are accessible to the public:

  On the bike path above the Irving Bridge picnic area. This sign will describe the woody debris projects and be located near site WD.23.

  Near Irving and Madrone Campgrounds. These two signs will describe the value of understory, streamside vegetation to fisheries habitat.

  All of the signs will contain information about coho salmon and steelhead, how visitors can help protect habitat, and list agencies involved in the project.

- **Continue outreach with the San Geronimo Valley Planning Group.**
  MMWD will work with the SGVPG's Creek Committee to encourage landowners along San Geronimo Creek and its tributaries to leave woody debris in the creek as a beneficial feature for fish habitat.

- **Continue to make the woody debris brochure available.**
  In 1995, MMWD produced and mailed a brochure on woody debris management to all property owners in the San Geronimo Creek watershed. These materials will be available at local libraries and the San Geronimo Valley Cultural Center.

4.3.4 Specific Policy Development Projects

- **Develop and implement an internal woody debris management policy.**
  MMWD will develop and implement a clear, internal policy for managing woody debris. The policy will address both trees that have fallen into the creek and trees that fall across roadways near the creek. The objective of such a policy will be to guide MMWD staff regarding what actions they should take in managing woody debris along the riparian corridor.

- **Work with DPR to develop and implement a woody debris management policy.**
  MMWD will work with DPR to create and implement a similar woody debris management policy for Samuel P. Taylor State Park.

- **Develop MOUs with local agencies**
  MMWD will seek to enter into Memorandums of Understanding with DPR, MCOSD, NPS, and MCFD to foster the working relationship between these agencies in terms of woody debris and riparian management.

- **Restrict foot traffic along the creek banks through the state park.**
  MMWD will work with DPR to restrict foot traffic along the creek banks of Samuel P. Taylor State Park by closing streamside trails on a rotating basis. This will contribute to the natural regeneration of low

growing, overhanging, understory vegetation along the edge of Lagunitas Creek.

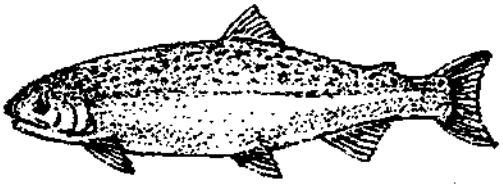
- **Maintain existing horse crossings.**

  Equestrians use three main horse crossing areas: Devil's Gulch, Inkwells/Shafter Bridge, and Cheda Creek. MMWD will coordinate with DPR, NPS, and the Marin Horse Council to maintain these existing crossings and discourage creation of new crossings. MMWD will work with Marin Horse Council on outreach to discourage riders from riding on creek banks and in the creek.

4.4 Riparian Management Plan Flexibility

Watershed conditions are not fixed. If conditions in the watershed should change in such a way as to make implementation of any of the measures specified in this plan unfeasible, MMWD will identify alternative measures and implement them as a substitute.

If an individual landowner does not wish to cooperate with MMWD for an erosion control project, MMWD will seek to implement an equivalent project on a different site.



5.0 Monitoring and Reporting

SWRCB Order WR 95-17 states that a monitoring program and reporting procedures will be included in the Lagunitas Creek Sediment and Riparian Management Plan.

5.1 Sediment Monitoring Program

SWRCB Order 95-17 states,

> "Permittee shall prepare a Sediment Management Plan that describes measures that should be taken to reduce sediment and to provide an appreciable improvement in the fishery habitat with the Lagunitas Creek watershed." (SWRCB, 1995)

An appreciable improvement is one that can be noticed, measured, or estimated. Collecting and evaluating data will determine whether or not an appreciable improvement has been achieved. It will be important to be able to compare the new streambed data with information gathered in previous years.

Geomorphic studies of Lagunitas Creek were conducted in 1979, 1980, 1981, and 1982. The *Sediment Overview Report* compiled by Balance Hydrologies, Inc., (1992) gives a chronology of these studies. As described in the *Overview Report,* geomorphic studies were conducted to determine the type of sediment that impairs streambed conditions, where this sediment comes from, at what flows and rates it is transported, how delivery of impairing sediment varies from year to year, the effect of fine sediment, and what sediment management efforts are underway in the watershed and surrounding area.

5.1.1 Streambed Monitoring

In 1992, MMWD and consultant Barry Hecht developed a monitoring program to quantify changes in streambed conditions in Lagunitas and San Geronimo Creeks and to describe the events and conditions that affect changes in the streambed. The monitoring program was designed to closely

parallel the field studies conducted during the 1979 through 1982 geomorphic studies (Hecht, 1992). Monitoring was conducted in 1993.

In 1993, MMWD created the San Geronimo Bedload Sediment Reduction Program, which includes a 10-year maintenance and monitoring program. The annual maintenance and monitoring program budget is $55,000. The monitoring is currently conducted by the MCRCD and funded by MMWD. Streambed monitoring occurred in 1995 and 1996.

The streambed monitoring program started under the San Geronimo Program will be used as part of the monitoring program for the Lagunitas Creek Sediment and Riparian Management Plan. The monitoring protocol is presented in Appendix I.

Under this monitoring program, two types of monitoring are conducted each year. The first is a qualitative channel evaluation that consists of walking Lagunitas Creek from the Inkwells to Tocaloma to determine whether any geomorphologic changes have occurred since the last sample collection and preparing an annual report of the observations. Streambed monitoring, a quantitative analysis of the streambed and bed core condition, is also conducted. At seven sites in Lagunitas Creek, data are collected to characterize the configuration of the channel and analyze the particle size distribution of the streambed. Specific parameters monitored include bed elevation, classification of streambed particle size, estimates of cobble embeddedness and cobble abundance, percent of bed covered by impairing particle sizes, and bed core samples. Bed core composition data are also gathered at two sites in San Geronimo Creek.

5.1.2 Sediment Management Project Monitoring

Following each winter rainy season, specific sediment projects described in Section 3 will be inspected to see if they are performing as designed. This will include monitoring of source control, off site control, and the spawning gravel projects.

Source control projects will be inspected in April of each year. This will allow MMWD time to perform maintenance or structural repairs if needed. When evaluating the source control projects, MMWD will consider:

- Are the structures still in place (fences, rock, etc.)?
- Are the structures functioning as intended? For example, has movement been stopped by headcut or other repairs?
- Downstream of the structure, is the channel downcutting and threatening the structure?
- Are maintenance repairs needed, and, if so, what types of repairs are necessary?

Off site sediment traps will be inspected in April of each year. When evaluating off site control projects, MMWD will consider:

- Are the traps more than 60% full and in need of cleaning?
- Are areas upstream of the traps threatening to erode as a result of the operation of the trap?
- Are the embankments or weirs that create the trap intact and stable?
- If the trap fills and is not emptied, will sediment and water runoff pass through the trap without damaging the trap or surrounding area?

Spawning gravel projects will be evaluated in May of each year. When evaluating spawning gravel projects, MMWD will consider:

- Are the structures (weirs) that were placed to back gravel still in place and stable?
- If structures are not in place, not stable, or are functionally damaged, what repairs are recommended?
- Is spawning gravel present?
- If spawning gravel is not present, should more be placed? How much should be placed, and when should placement occur?

Under its Aquatic Resources Monitoring Workplan (see Section 5.5 below), MMWD conducts annual coho spawner surveys during the coho spawning season (late October to early February). In addition to the gravel monitoring that will be conducted in May of each year, MMWD will pay particular attention to the gravel placement areas during the coho spawner surveys to note any spawning activity and/or spawning redds developed at these sites.

5.2 Riparian Monitoring Program

5.2.1 Inspect Riparian Revegetation and Woody Debris Projects

Riparian revegetation and woody debris projects will be evaluated annually to see if they are performing as designed.

Riparian revegetation projects will be inspected in April, July, and October for 10 years, beginning in 1998. When evaluating revegetation projects, MMWD will consider:

- Are plants surviving and thriving? If not, does replanting need to occur?
- Do plants need additional watering?
- Is additional weed or exotic plant removal needed?
- If an irrigation system was installed, is it intact and working?
- Do browse protectors need to be reinstalled?
- Are other actions needed to maintain the plants during establishment? When should these actions occur?

Woody debris projects will be inspected in May of each year, as well as during high winter flows. When evaluating woody debris projects, MMWD will consider:

- Are the logs, tree tops, or root crowns in the original placement location?
- Are the logs, tree tops, or root crowns stable?
- Are the woody debris anchors intact and functioning?
- Are gravel and cobble being retained upstream of cross channel double log structures?
- Is local scour occurring and pools being enlarged or scoured by oblique and cross channel double log structures?
- Is woody debris stacking up naturally behind structures, creating high flow refuge and summer escape cover habitat?
- What repairs are necessary to maintain or improve the intended function of each woody debris structure?
- Are any adverse or unacceptable changes occurring in the channel bed and banks as a result of the structure (i.e., bank erosion)?
- Is the structure a barrier to fish passage?

MMWD will establish photo points for woody debris sites and take annual photos of the projects.

5.3 Monitoring Program Flexibility

The purpose of the monitoring program is to evaluate whether or not the sediment and riparian management measures are functioning as designed and to determine if there has been an appreciable improvement in the fisheries habitat. If the data collected for the sediment and riparian monitoring programs do not provide appropriate information for these purposes, MMWD shall identify and implement improvements to the monitoring program.

5.4 Formation of a Technical Advisory Committee

As part of the monitoring program, MMWD will form a Technical Advisory Committee (TAC). The purpose of the TAC will be to provide MMWD with constructive review of the implementation of specific programs and projects, as well as to provide continuing consultation and advice on the management plan. The TAC will be composed of representatives from MMWD, SWRCB, RWQCB, CDF&G, NMFS, USFWS, and the NPS. A charter will be developed, and the format of the TAC will be solidified with input from the participating agencies. It is anticipated that the TAC will meet at least once a year subsequent to MMWD's issuance of its year-end compliance report (see Section 5.7), and perhaps more frequently.

5.5 Aquatic Resources Monitoring Workplan

Order WR 95-17 required MMWD to prepare and implement a workplan for monitoring coho salmon, steelhead, and freshwater shrimp populations in Lagunitas Creek. MMWD's Aquatic Resources Monitoring Workplan was approved by the SWRCB after review by NMFS, USFWS, and CDF&G. The workplan is included in the plan as Appendix J.

Annual juvenile surveys will gauge of the status of the fishery population in Lagunitas Creek. With this information, MMWD can estimate the juvenile population for the creek, as well as for specific habitat types. The coho spawner survey will indicate the number of redds able to be counted and if spawning occurs at woody debris project sites. Under the Aquatic Resources

Monitoring Workplan, MMWD will collect data on coho salmon, steelhead, and California freshwater shrimp. During the 10-year time frame, MMWD should be able to identify trends in these populations.

Members of the public have suggested that MMWD count out-migrating fish smolts to monitor the success of the plan. Public agency representatives and others have pointed out that it is very difficult to use numbers of fish as a target goal. Fish populations are dependent upon a number of factors, such as climate changes, pollution, and harvesting—many of which are beyond MMWD's control. It would be nearly impossible to attribute a rise or fall in fish population to MMWD's actions taken under the sediment and riparian management plan. Furthermore, both NMFS and CDF&G have indicated that smolt out-migration surveys have a high probability of significant mortality to young fish (C. Mobley, 1997; M. Bowers, 1997; and Cox, 1997a).

The SWRCB Order WR 95-17 does not direct MMWD to increase the number of juvenile or out-migrating smolts, but it does require MMWD to improve habitat conditions. Therefore, MMWD believes that it is more appropriate to evaluate changes to the physical habitat that may result from sediment and riparian management projects.

5.6 Public Outreach

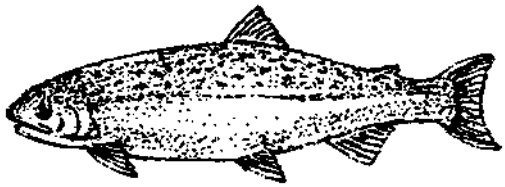
As part of MMWD's public outreach efforts described in Sections 3 and 4, MMWD will also communicate the results of the project and all of its Lagunitas Creek monitoring efforts.

5.7 Reporting Procedures

SWRCB Order WR 95-17 states,

> "Permittee shall submit a report to the State Water Resources Control Board by December 31 of each year that verifies Permittee's compliance with permit conditions for the previous water year ending September 30. The report shall be submitted to the Division of Water Rights in a format designated by the Chief of the Division of Water Rights." (SWRCB, 1995)

MMWD will prepare an annual monitoring report for the sediment and riparian management plan. This monitoring report will include data from the streambed monitoring program and descriptions of how well the specific source erosion control, off site control, spawning gravel, woody debris structure, and riparian revegetation projects are functioning. The monitoring report will be submitted to the SWRCB by December 31 of each year.



6.0 Implementation Schedule, Responsibilities, and Costs

SWRCB Order WR 95-17 requires that this plan identify the party responsible for each program or project, the estimated costs for each program or project, and the time schedule for implementation of each program or project (SWRCB, 1995). In addition, this section presents a summary of design considerations for sediment controls, woody debris placement, and riparian revegetation.

6.1 Implementation Responsibilities

MMWD is responsible for the implementation of this plan. Cooperation will be required from the public landowners and leaseholders of public lands in Lagunitas Creek watershed. This includes DPR, MCOSD, NPS, and private ranchers leasing land from NPS. Several projects are specified on private land in San Geronimo Valley. Cooperation from these landowners will be needed in order for MMWD to implement this plan. Cooperation with MCFD will also be necessary to implement maintenance and possible closure of fire roads in portions of the watershed. MMWD will not be able to implement most of the site specific measures included in this plan without the cooperation of DPR and NPS.

Conversations with representatives of DPR and NPS during the preparation of this plan have indicated a desire to achieve the goals and objectives set forth in this plan. They have indicated that their agencies will cooperate. These agencies have not, however, agreed to the specific measures included in this plan. In the past, these agencies have demonstrated a very high level of responsibility for the actions that are occurring on their lands. They have required detailed review of each measure before it is taken. Such detailed review and coordination with these agencies will need to occur as this plan is implemented.

This plan takes into consideration programs of other agencies. MCOSD has plans for road closure and repair on their lands. Roads are identified in this plan as an important area requiring ongoing sediment management work. NPS is in the early stages of an extensive program to examine the status and to implement enhancement of the coho salmon and steelhead habitat on its

lands. MMWD is responsible for cooperating with and supporting these other agency programs. MMWD is not responsible for the implementation of these other agency programs.

Individual project agreements should be formed where possible to share responsibility and resources where the individual program objectives coincide.

6.1.1 Specific MMWD Implementation Responsibilities

The specific tasks for which MMWD is responsible to implement this plan are:

- Form agreements with each public landowner, each lessee of public lands, and each private landowner to allow installation of erosion control and habitat enhancement measures specified on their lands;
- Prepare construction designs and construction documents for the 34 sediment source control sites specified in Section 3.3.1 or their substitutes as specified in Section 3.4;
- Prepare construction designs and construction documents for the 49 riparian management sites specified in Section 4.3;
- Prepare designs and construction documents for the four large gravel and cobble placement sites specified in Section 3.3.3 or their substitutes as specified in Section 3.4. Three of these sites are also riparian management sites;
- Prepare construction designs and construction documents for the two sediment traps specified in Section 3.3.2 or their substitutes as specified in Section 3.4. This plan specifies that four sediment traps be operated. However, two sediment traps are currently in operation.
- Prepare and distribute the brochure specified in Section 3.3.4.
- Prepare the design and construction documents and form an agreement with DPR for the placement of the public information sign specified in Section 4.3.3.
- Acquire all permits required by local, state, and federal law.
- Make courtesy notifications to MCDPW regarding each construction project which occurs on private property, within the corridor of public roads or in the Lagunitas and San Geronimo Creek channels.

- Install sediment source controls at the 34 sites specified in Section 3.3.1 or their substitutes as specified in Section 3.4.
- Install the riparian management measures at each of the 49 riparian management sites specified in Section 4.3.
- Construct sediment traps 3 and 4.
- Maintain and operate the four sediment traps as specified in Section 3.
- Place large gravel and cobble at four placement sites between Peters Dam and Shafter Bridge in years following spills from Kent Lake.
- Maintain the installed measures at each of the 34 sediment source control sites as specified in Section 3.
- Maintain the installed measures at each of the 49 riparian management sites as specified in Section 4.
- Construct educational signs along Lagunitas Creek as specified in Section 4.3.3.
- Annually, make the presentations specified in Section 3.3.4.
- Annually, monitor and report the streambed conditions in Lagunitas Creek as specified in Section 5.
- Annually, monitor and report the status of the sediment management measures and riparian management measures as specified in Section 5.
- Cooperate on an ongoing basis with the parties other than MMWD specified in Section 3.1.3 of this plan who are implementing their own programs for sediment and riparian management.

6.2 Implementation Schedule

Following is a general implementation schedule. The schedule is organized according to the major tasks required to implement this plan.

CEQA and Permits

Pursuant to CEQA Title 14, Section 15308, CEQA exempts actions taken by regulatory agencies, as authorized by state or local ordinances, to assure the maintenance, restoration, enhancement, or protection of the environment where the regulatory process involves procedures for protection of the environment. MMWD has concluded that approval of the sediment and riparian management plan is exempt under the California Administrative Code because it is required by SWRCB Order WR 95-17 to mitigate the impact

of the District's water supply projects. NEPA applies to federal undertakings and is not required for the sediment and riparian management plan.

Many projects described in Sections 3 and 4 will require permits from the COE. For special status species such as coho salmon, steelhead, and California freshwater shrimp, this process will entail formal consultation with NMFS and USFWS. Many projects will also require a permit from the California Department of Fish and Game. MMWD will also obtain a creek permit and, if necessary, an encroachment permit from DPW. For projects located on NPS lands, MMWD will comply with the NPS project review.

The permit process was initiated in May 1997. Under the permitting process, potential impacts to aquatic species will be addressed.

Landowner Agreements

Obtaining agreement from landowners and public land lessees for the installation of the measures will occur throughout the construction phase of the program.

MMWD will consult with other landowners such as DPR, MCOSD, and NPS regarding site specific details for projects located on their lands.

Project Design and Contractor Procurement

Site design began in May 1997 and will be ongoing throughout project construction. Design will include site survey, construction drawings, specifications, and construction documents. Contractor procurement will begin in the summer of 1997 and will occur annually as needed.

Where feasible, MMWD plans to use community volunteers to help implement erosion control and riparian revegetation projects. When projects needing volunteers are slated for implementation, MMWD will contact interested groups to solicit their participation.

Construction of Sediment Management Sites

Construction of priority sediment source control projects, off site sediment traps, and placement of gravel and cobble will begin in the summer or fall of

1997. It is anticipated that there will be a construction period during the summer and fall each year for the first five years of plan implementation. In order to meet this construction schedule, MMWD anticipates constructing four to eight sediment control projects each year. MMWD will select projects annually based on project priority and willingness of the landowner. Gravel placement will coincide with the appropriate woody debris placement projects.

Construction of Riparian Management Sites

Construction of riparian management sites will begin in the summer or fall of 1997. Installation of woody debris projects will occur between July 1 and October 1. Installation of revegetation projects will occur between November 1 and December 31. It is anticipated that installation of woody debris projects will occur each year for the first five years of plan implementation. In order to meet this construction schedule, MMWD anticipates constructing five to nine woody debris projects each year. Most of the riparian revegetation will occur in the first year.

Monitoring

- Streambed monitoring will occur between July 1 and September 30 of each year.
- Source control projects will be inspected in April of each year, beginning in 1998.
- Off site sediment traps will be inspected in April of each year , beginning in 1998.
- Spawning gravel projects will be evaluated in May of each year, beginning in 1998.
- Riparian revegetation projects will be inspected each April, July, and October for 10 years, beginning in 1998.
- Woody debris projects will be inspected in May of each year, beginning in 1998.

Maintenance

- The four sediment traps described in Section 3.3.2 will be emptied before September 1 of each year, when necessary.
- Gravel and cobble will be placed at the four sites described in Section 3.3.3 between Peters Dam and Shafter Bridge in years following spills from Kent

Lake. Placement will be completed between July 1 and October 1 in years when this is necessary.

- Structural repairs of sediment source control projects will occur between June 1 and October 1. Biotechnical repairs may need to occur as late as January.
- Maintenance of riparian revegetation projects will occur between April and December of each year during a three-year establishment period.
- Maintenance of woody debris projects will be completed prior to October 1 in years when this work is necessary.

Public Outreach and Policy Development Projects

- Brochure preparation should be completed by June, 1998.
- Press coverage will occur as described in Section 3 following the issuance of MMWD's year-end compliance report.
- Presentations to local groups described in Section 3 should occur each year following the issuance of MMWD's year-end compliance report.
- Annual meeting of the public forum organized by MMWD will be held following the issuance of MMWD's year-end compliance report.
- Integration of descriptions of the plan into information disseminated by MMWD will be done as appropriate. An annual flyer will be sent to MMWD customers regarding the plan.
- Support of community-based watershed restoration efforts will occur periodically.
- Copies of reports will be made available to the public as appropriate.
- Cooperation with parties specified in Sections 3 and 4 of this plan who are implementing their own programs for sediment and riparian management will be ongoing.
- Development of watershed protection agreements described in Section 3 will be ongoing.
- MMWD will seek to develop MOUs with local agencies by March 31, 1998.
- Informational signs in Samuel P. Taylor State Park and on MMWD land will be installed in 1998.
- MMWD's woody debris brochure will be available to the public on an ongoing basis.
- Development and implementation of an internal woody debris management policy will be done by July 1, 1998.

- Development and implementation of a woody debris management policy with DPR will be done by December 31, 1998.
- Efforts to restrict foot traffic along Lagunitas Creek through SPTSP will be on-going.

Reporting

- Complete the annual reporting as specified in Section 5. Complete the preparation of a Lagunitas Creek sediment and riparian monitoring report (including the streambed condition monitoring and sediment and riparian management monitoring) prior to December 31 of each year.

6.3 Sediment Management Sites Design

Individual designs for each of the sediment management sites should be prepared. Appendix E presents standard specifications for the repairs suggested with the site descriptions in Section 3. Each of these standard specifications needs to be modified for site specific application. In accordance with standard practice in the fisheries restoration and erosion control construction industries, additional specifications and drawings will need to be prepared. Construction observation and inspection will be necessary for all projects.

6.4 Woody Debris Placement Design

Figures 7, 8, 9, 10, 11, 12, 13, and 14 show schematic representations for placement of woody debris at each of the sites. Detailed analysis at each location is needed. For each site, the design should address the following considerations:

- Place the woody debris structure within the specified site so that it has the greatest probability of achieving its objective.

- For summer escape cover, the primary design consideration is where additional cover is most critically needed.

- For obstruction logs and cross channel structures, geomorphic and hydraulic considerations are fundamental concerns.

- In all cases, anchoring the structures is a critical design consideration.
- Cross channel structures should be anchored so that they do not move.
- Oblique obstruction logs can tolerate limited movement.
- Tethered material can be allowed to move substantially as long as it does not move away from the spot where it is intended to provide summer escape cover.
- Cross channel and obstruction logs have the potential to induce streambank erosion. During the design phase, the sites should be carefully evaluated for risks associated with streambank erosion.

In addition, DPR has recommended that the "natural character of the park not be jeopardized" by the woody debris placement projects. Site design and implementation will also consider:

- The source of material may be live trees located adjacent to the creek if the stand density is great enough to allow the sacrifice of a very occasional tree. Trees to be utilized for this purpose must also be growing in locations where they can be uprooted and placed in the creek without unacceptable heavy equipment impacts or damage to other standing trees.
- Disturbance of vegetation and soil by heavy equipment used to procure or place trees must not be significant. The impacts of equipment used to place woody debris should be minimal.
- Trees (or portions of trees) placed in the stream as woody debris should have the root balls attached whenever possible. This will avoid the unnatural appearance of saw cut log ends.
- Material should be placed so that these saw cut surfaces are not clearly visible.
- Anchoring methods using cables or other devices should not be visible.

- Cables must be placed so that park visitors cannot be not injured.

The *California Salmonid Stream Habitat Restoration Manual* (Flosi and Reynolds, 1994) contains substantial additional information regarding the placement and anchoring of woody debris in streams.

MMWD will consult with DPR on selection of trees, placement, and installation details for projects located in SPTSP. MMWD will conduct public outreach in the local community prior to cutting trees in SPTSP.

Construction observation and inspection will be necessary for all projects.

6.5 Riparian Revegetation Sites Design

Specific native plant species are prescribed for each site on the data sheets in Appendix G. All plant material should be from collections made within Marin County, preferably within the Lagunitas Creek watershed. Arrangements should be made in advance with a nursery to collect seeds and make cuttings in the fall to propagate container grown plants. This requires 16 to 18 months advance planning.

Container grown plants should be planted in March and April at the listed sites and watered and weeded on a regular basis for the first two summers of the establishment period. Container plants must have well formed roots, not be root bound, have stems of sturdy caliper (3 mm diameter or better, except for California blackberries, which can be smaller), and be grown in Deepots™, Treepots™, or a deep-root pot equivalent.

Direct sprigging of unrooted three foot long willow cuttings on site is acceptable during the months of December through February. Plant spacing guidelines for ground covers is approximately two feet on center, for shrubs is approximately six feet on center, and for trees is ten to fifteen feet on center. Many of the plants will require deer browse protectors. Plants within the high water channel should receive protectors after the annual threat of flooding has passed.

All disturbed soil on steep slopes adjacent to streambanks will be seeded and mulched before November. Acceptable mulches include straw at a rate of ± 3000 pounds per acre or biodegradable coir and straw erosion control blankets. Only native grass seed should be used. MMWD will work with public landowners to develop planting specifications for projects requiring reseeding.

6.6 Estimated Costs

Table 2 is a summary of the cost estimate for the implementation of this project. Additional detail regarding costs is presented in Appendix K. The cost estimates presented in this report are for program budgeting purposes and are calculated in 1997 dollars.

The construction cost estimates are based on the potential range of alternatives available for each individual project, difficulty of access, and related construction details that are likely to be specified for each site. Previous experience with similar projects is taken into consideration. The cost estimate for each site is based on observed conditions, ocular estimates of dimensions, mental calculation of quantities of material and their unit prices, types and quantities of equipment, and personnel resources needed and the time anticipated for those resources. The construction cost estimates are not based on actual designs as the projects identified in this plan have not yet been designed.

The actual cost for construction of each site will not be equal to the estimate presented in this plan. Actual costs may be higher than the estimates presented. Landowner and permit requirements may require actions that are not included in the estimates. Designs and detailed investigations of each site for design preparation may result in construction requirements not envisioned at the time these cost estimates were prepared. The estimates are representative of the order of magnitude of the construction costs.

The design cost estimate is 25% of the construction cost estimate. This is an approximation based on experience with similar projects. Small projects will tend to require a higher percentage of the construction cost to prepare the

design than will larger projects. Cost savings are available by combining several small projects into a single design effort.

The basis of the cost estimates for the operation of the sediment traps is the previous experience of MMWD and the MCRCD in operating the sediment traps for the San Geronimo Program.

The basis of the cost estimates for the placement of gravel below Shafter Bridge is mental calculation of time needed for personnel and equipment resources to sort material from the sediment traps, transport it to the site, and complete its placement in the channel.

The basis of the cost estimates for maintenance of the sediment control sites and riparian management sites is evaluation of previous experience with similar sites adjusted for the unique conditions of this program. Maintenance costs are expected to vary widely from year to year. In years when historically large quantities of rainfall occurs, maintenance costs could be several multiples of the annual cost estimate presented in this plan. In years when rainfall is low by historical standards, it is possible that no maintenance will be required.

The basis of the cost estimate for the streambed monitoring is MCRCD's previous experience with monitoring the San Geronimo Program.

This plan does not present cost estimates for tasks that MMWD staff anticipates performing during the normal course of MMWD business.

Table 2

Cost Estimate Summary

Task and Subtask	Estimated Cost
Sediment and Riparian Management Measures:	
Landowner Agreements	MMWD Staff
Permit Acquisition	$5,000 ¥
Prepare Design & Construction Documents subtotal	$221,000
Notify Public Agencies, Contractor Procurement, and Construction Observation	MMWD Staff
Install Sediment Source Controls - 34 sites	$566,500
Construct Sediment Traps - 2 sites	$15,000
Install Riparian Revegetation Projects - 7 sites	$77,000
Install Riparian Management Measures - 42 sites	$267,000
Public Outreach	$10,000 ¥, *
Sediment & Riparian Management Measures Subtotal	***$1,161,500***
Annual Maintenance and Monitoring Costs:	
Maintain Sediment Source Control Sites	$60,000
Operate Four Sediment Traps	$20,000
Gravel and Cobble Placement	$10,000
Maintain Riparian Management Sites	$70,000
Streambed Monitoring and Reporting	$60,000
Reporting	MMWD Staff
Annual Maintenance and Monitoring Costs Subtotal	***$220,000***

¥ MMWD staff time is not included in this estimate

* logistics and equipment

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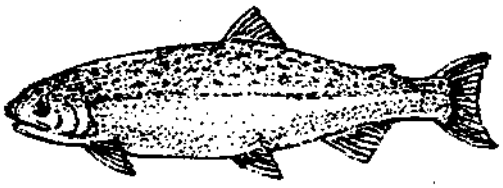

8.0 GLOSSARY

afflux — increase of water level upstream of an obstruction.

aggrade — to build up a river bed and flood plain with deposited sediment; is the opposite of degrade.

alevin — hatchling salmon larvae with the egg sac still attached.

alluvium — sand, silt, and clay deposited by moving water as it slows down. The shape of the deposit depends upon the size of material and the characteristics of the flow.

alluvial fans — form when a swift stream flows down from higher land onto a nearly level valley floor. The abrupt change in gradient causes the sediment to be deposited in a fan that radiates from the point where the stream meets the broader valley floor.

alternate channel — a former and possible future location of the active channel if the flow should suddenly shift due to formation of a log jam or debris flow. In Lagunitas Creek, these changes occur abruptly, often in the same reaches of the channel. The active and alternate channels are delineated by mature alder and other riparian vegetation and are most distinctive where the valley bottom is widest.

anadromous fish — fish that migrate from the sea to freshwater for reproduction.

armor layer — layer of coarse material such as gravel and cobble on a streambed, which is highly resistant to erosion.

background erosion — the amount or rate of erosion that occurs within a region because of local geology and climatic conditions. This is different from erosion that is caused by particular disturbance events, such as the installation of roads, the harvesting of timber, overgrazing, etc.

bankfull flow — the discharge or flow at which the water level begins to exceed the height of the most pronounced banks.

bar — an alluvial deposit of sand, gravel, or other stream sediments that forms when a decrease in flow velocity causes deposition of sediment.

bedload — large, heavy material that moves along the streambed by rolling, sliding, or bouncing. Generally refers to material larger than 0.5 mm in diameter, such as sand, gravel, cobble, and boulders.

bedrock — the solid rock that underlies all soil, sand, clay, gravel, and loose material on the earth's surface. When exposed to the air, it may be referred to as an outcrop.

benthic — the bottom surface of a stream or waterbody. Benthic organisms (macroinvertebrates and algae) provide essential nutrients for salmonids.

berm — in this document, refers to an artificially placed, continuous earthen embankment or mound. A berm can also refer to a level area at the summit, sides, or base of a slope.

bioassessment — an evaluation of the biological condition of a stream through biological surveys and other direct measurements of resident biota in surface waters. Surveys usually examine fish, aquatic macroinvertebrates or algae.

borrow pit — an excavation site from which material is taken for nearby construction use.

bulk bed deposits — the sediment below the surface of the streambed that can be mobilized and moved downstream during high flows.

canopy — in this report, canopy refers to the branches of trees adjacent to the stream that cast a shadow on the streambed. Canopy closure describes the proportion of the sky that is blocked by the foliage of trees on the streambank.

cfs — cubic feet per second. A unit of measurement used to describe the quantity of water that passes a fixed point per second.

checkdam — a structure built across a watercourse to trap sediment and slow erosion.

chronic — prolonged, continuing, or consistent condition. Chronic erosion is that which will continue to occur unless physical conditions change.

coarse sediment — is a broad category that includes both coarse sand and gravel particles that are smaller than 6.4 cm in diameter.

cobble — rocks that are larger than gravel and smaller than boulders. While the definition of size range may vary, it is usually between 6.4 cm and 25.6 cm in diameter. Small fish seek refuge from predators by hiding in the space between cobbles. The space between cobbles is reduced by the accumulation of fine sediment.

colluvium — loose soil and material that has accumulated at the base of a slope.

cover — the area of shadow cast by a light source directly over objects that can shade the channel bottom. Such objects include debris, root wads, rocks, overhanging vegetation, turbulence, or sufficient depth to limit visibility.

CTM — critical thermal maximum, the temperature at which an organism dies.

degraded — reduced in quantity or value.

degradation — the geologic process by which streambeds and flood plains are lowered in elevation by the removal of material. It is the opposite of aggradation.

detritus — recently dead or partially decomposed organic matter.

dissipator — an energy dissipator is an apron of rocks, logs, concrete baffles, or other material that slows down water flowing through a culvert or ditch or over a checkdam, thereby reducing its erosive force.

downcutting — a decrease in streambed elevation caused by erosion.

eddy — a current moving contrary to the main current, often in a circular motion.

embedded — rocks or portions of rocks at the surface of a streambed that are buried in finer sediment. Measurements of embeddedness provide information about the amount of resting or refuge habitat available for juvenile and yearling salmonids.

endemic — native or confined to a certain region; having a comparatively restricted distribution.

entrained — carried along; used to refer to woody debris or sediment that is carried by or entrained in flowing water.

episodic — related to an incident or series of separate incidents that are relative to a continuous event, for example, a landslide that is activated periodically by storm events.

ESA — Endangered Species Act.

estuary — semi-enclosed coastal body of water connected to the sea where freshwater derived from streams is mixed with sea water.

ESU — Ecologically Significant Unit. Regional designations established by the National Marine Fisheries Service. These designations recognize individual ESUs as distinct populations of coho salmon and steelhead in the various drainage areas of the west coast. Lagunitas Creek is in the Central California Coast Ecologically Significant Unit.

exotic — from another part of the world; not indigenous to the region; non-native.

fines — small particles of gravel and sand, usually defined as particles smaller than 6 mm in diameter. Gravel with a high proportion of fines tends to have low dissolved oxygen levels, which delay or limit embryo development.

first order stream — Stream order is a classification used to describe the branching pattern of river systems. A first order stream is the smallest unbranched tributary to appear on a 7.5 minute USGS quadrangle. When streams of equal order converge, they form the next higher order of stream. For example, when two first order streams join, they form a second order stream. When two second order streams join, they form a third order stream.

fluvial process — formed or produced by the action of flowing water.

Fredle Index — evaluates permeability and pore size in sediment samples. These two factors regulate intragravel water velocity and oxygen transport to incubating salmonid embryos and control intragravel movement of alevins. The Fredle Index is used to predict survival of salmonid eggs and alevin.

gabion — a wire basket that is filled with stones. Can be filled in place to stabilize banks or act as a retaining structure.

geomorphology — the landscape and physical processes that shape land forms. The form of a stream channel is influenced by the hydrology of the stream as well as the underlying geology — the presence of large rocks, the gradient, stability of bank material, sediment supply, etc. The term hydro-geomorphology is often used to describe the combination of these factors.

glide — habitat category characterized by moderately shallow water (10 to 30 cm deep) with an even flow that lacks pronounced turbulence. Frequently located at the transition between a pool and the head of a riffle or in low gradient streams with stable banks and no flow obstructions. Substrate usually consists of cobble, gravel, and sand.

graded stream — a stream that transports its load of sediment on a smooth gradient.

gradient — a slope or rate of inclination.

gully — a depression or channel that is formed when water flows over the surface of the land. Erosion at the head of the gully lengthens it, and water washing down the sides widens it.

habitat — the physical environment in which an organism lives. In streams, aquatic habitat is created and maintained by the physical interaction of the hydraulic forces in the stream acting on the bank of the channel and the sediment deposited in the streambed. Examples of important habitat for salmonids include riffles, pools, and glides.

habitat unit — a term used to establish the minimum size of a habitat that will be included in a habitat survey. By convention, a habitat unit must be twice as long as wide.

headcut — a break in slope at the top of a gully or section of gully that forms a waterfall, which in turn causes the underlying soil to erode and the gully to extend uphill.

high flow refuge habitat — a pool or protected area of a stream where the water velocity is slower than the current in the main channel. The presence of large woody debris or boulders provides protection from objects that are transported by the stream.

hungry water — clear water released from an impoundment into the river channel that possesses an increased capacity for erosion, incision, and movement of the bedload.

hydraulic — of, involving, moved, or operated by the movement of a fluid, especially water.

hydrology — study of the properties, distribution, and effects of water on the earth's surface, in the soil, in underlying rocks, and in the atmosphere.

incised — extensively eroded or downcut; used to describe a stream or river bed.

impairing or detrimental sediment — sediment that diminishes the quantity or quality of salmonid habitat. For example, increases in the proportion of fine sediment in a redd reduces the number of salmonids that will emerge from the gravel.

inboard — refers to a road graded into the cut slope. An inboard ditch is located along the cut slope side of the road. Water from the road and the hillside above it collects in a ditch and either runs the entire length of the hill or exits through culverts or waterbars.

incipient riffle — a riffle that is just beginning to form or appear.

large woody debris (LWD) — in this report, LWD is used to describe wood that is at least 12 inches in diameter and 6 feet long or larger (Flosi and Reynolds, 1994).

left bank — refers to the streambank on the left side looking downstream. This is the convention used by hydrologists and the authors of this report.

low flow channel — the river channel containing the lowest or residual flow reached in a given year; also called the wetted channel.

macroinvertebrates — organisms that have no internal skeleton and are larger than 0.3 mm in length. Benthic macroinvertebrates are found on top of or between the particles of the streambed. They include aquatic insect larvae, as well as California freshwater shrimp and other arthropods, annelids, etc.

mass wasting — erosion that has occurred on a large scale, such as landslides and debris torrents.

morphology — the scientific study of the form or structure of an organism or physical process.

non-native — see exotic.

non-point source pollution — a general category that includes organic and inorganic pollutants from an undetermined origin.

oblique angle — either an acute or obtuse angle, but not a right angle of 90 degrees.

outboard — see outsloped.

outcrop — a portion of the bedrock under the earth's surface that is above ground.

outfall — the area where water from a culvert is discharged.

outsloped — refers to a road constructed with a cross slope so that water runs away from the cut side and toward the uncut, downhill side.

overhanging banks — undercut banks that occur when water velocity is sufficient to erode the lower portion of a stable streambank. The stability of the bank depends upon a combination of geology, protective vegetation, and the magnitude of flows.

overstory — the highest canopy; uppermost layer of foliage and branches.

periphyton — benthic algae and the organisms that feed upon it.

pool — depression in a streambed that is formed by scouring or removal of sediment during periods of high flow. After formation, the velocity of water within the pool is reduced, causing the surface of the water to appear smooth. The velocity of the water is different depending upon the location within the pool. The boundary of the pool may be composed of solid material and/or gravel and sand deposits. Pools are usually described in terms of location within the stream channel or by the type of structure(s) contributing to the formation of the pool.

reach — sections of a stream or river between two specified points or possessing some common characteristic(s).

redd — fish spawning nest or group of nests dug in a gravel bed. Usually located in the tail of a glide, 25 to 50 feet upstream from a riffle. It is very important not to walk on or disturb the redd.

reference conditions — the chemical, physical, or biological qualities or conditions exhibited at either a single site or an aggregation of sites that are representative of the least impacted and attainable condition.

refuge — a place providing protection or shelter from danger or hardship. Refuge habitat is essential for aquatic life throughout all seasons of the year.

residual dry matter (RDM) — the amount of protective vegetation or mulch that is left after the grazing season. When present in significant amounts, RDM reduces the potential for erosion from wind and water.

riffles — stream reaches with moderate turbulence caused by water falling over rocks.

- Low gradient riffles are shallow (<20 cm deep) with moderate current velocity (20-50 cm/sec) and moderate turbulence. Partially exposed substrate is dominated by cobble sized particles (2-256 mm). An upper limit for gradient is usually set at 4%.

- High gradient riffles exceed 4% and are moderately deep, swift, and turbulent. The amount of exposed substrate is relatively high and is dominated by boulders.

right bank — the streambank on the right side looking downstream. This is the convention used by hydrologists and the authors of this report.

rills — small channels that form when loose particles of soil and rock are transported downhill by water. With increasing erosion, rills enlarge and become gullies.

riparian — pertaining to the environment of river, streambanks, and flood plains. Sometimes used more broadly for wet, mostly terrestrial environment around any freshwater body including seeps or springs.

riparian forest — trees that grow adjacent to streams or rivers.

riparian vegetation — vegetation associated with riparian ecosystems. Includes living as well as dead plant material both on the ground and in the water. The root systems of trees and understory vegetation contribute to the stability of soil and influence the direction of water currents. The canopy of vegetation near the stream limits the amount of sunlight reaching the stream, which helps to maintain water temperatures. Plant material also provides essential nutrients as well as refuge habitat.

riprap — heavy stones used to protect soil from the action of fast-moving water.

root wad — the bases of dead trees are called root wads if they are no longer attached to the earth by their roots. This distinguishes them from stumps. They are also called root fans, root masses, and root crowns.

run — swiftly flowing water with little surface agitation and no major flow obstructions. Often appears as flooded riffles. Typical substrate consists of gravel, cobble, and boulders.

salmonid — common name for the family Salmonidae, an assemblage of several genera, that include *Oncorhynchus.* Within the genus *Oncorhynchus,* there are several species including steelhead *(Oncorhynchus mykiss)* and coho salmon *(O. kisutch).*

scour — localized erosion by flowing water.

sediment — rock fragments that range in size from clay particles to boulders.

sediment transport — the movement of sediment by water.

sediment yield — the amount of sediment transported from a river basin that can be used to compute the average rate at which the basin landscape is lowered by erosion.

senescent — growing old or aging.

sheet erosion — the loss of thin, even, sometimes microscopic, layers of soil from a slope.

sloughing — discarding or shedding a layer of material. For example, tilted beds of sedimentary material tend to slough (fall away) in layers.

slumping — movement of earth and rock that occurs when supporting material is removed. For example, streambanks slump when the toe of the streambank is washed away.

smolt — life stage of juvenile salmon or steelhead when they migrate out to sea. Smoltification refers to the physiological changes that are necessary for fish to tolerate salt water and typically occurs after the first summer and winter spent in freshwater.

spawning habitat — habitat with suitable velocity, depth, and substrate characteristics to foster spawning. Though requirements are slightly different for coho and steelhead, studies conducted by Bratovich and Kelley (1988) reported that all fish in Lagunitas Creek spawn in velocities higher than 0.7 feet/second, depths ranging from 0.5 to 3.0 feet, and spawning substrate with a mean particle diameter D50 = 0.8-4.5 cm.

spawning adult holding habitat — pools or other areas where adult fish may rest and find shelter from predators.

spoils pile — the area where excavated soil and rock not used for fill is placed.

substrate — any object or material upon which an organism grows or is attached; the underlying layer or substance.

stability — absence of fluctuations; ability to withstand perturbations without large change in composition. The stability of a stream channel is an indication of its ability to withstand channel-altering effects of large storm events; it determines the availability of suitable aquatic habitat.

structural complexity — the arrangement of different sizes, shapes or types of material into an interrelated entity. For example, log jams that accumulate debris may include rocks and small branches that provide shelter and nutrients for fish.

suspended load — clay, silt, and sometimes sand that are held in suspension by the turbulence in river water.

toe — the base or lower edge, such as of a checkdam or streambank.

trash rack — a barrier placed at the upstream end of a culvert to trap debris but still allow water to flow through.

understory — the lower layers of the canopy; plants that live in the shade of others.

waterbar — a shallow ditch and small berm constructed diagonally across a road or trail to divert water away from the road surface.

watershed — the land area that drains into a particular stream or river. It includes major and minor creeks and seasonal drainages. Large watersheds often have distinct subwatersheds that drain into the main creek. For example San Geronimo Creek and Nicasio Creek watersheds are subwatersheds in the Lagunitas Creek watershed. Watersheds are sometimes referred to as drainage basins or catchment areas.

weir — a structure across a ditch or stream used to divert water flows.

windthrow — material that is transported by wind and deposited in ridges or piles.

woody debris — pieces of wood that vary in shape and size. Wood contributes to the formation and maintenance of pools, provides refuge for fish and aquatic insects during periods of high flow, contributes to the retention of beneficial sediment, and contributes to the supply and duration of nutrients in the system. The loss of woody debris from streams has been clearly linked to the decline in salmonid populations.

WR 95-17 — State order issued by the State Water Resources Control Board in 1995 for fishery protection and water rights issues in Lagunitas Creek. Order 95-17 affects MMWD, North Marin Water District, and Waldo Giacomini. The order directs MMWD to prepare and implement the Sediment and Riparian Management Plan. See Appendix A.