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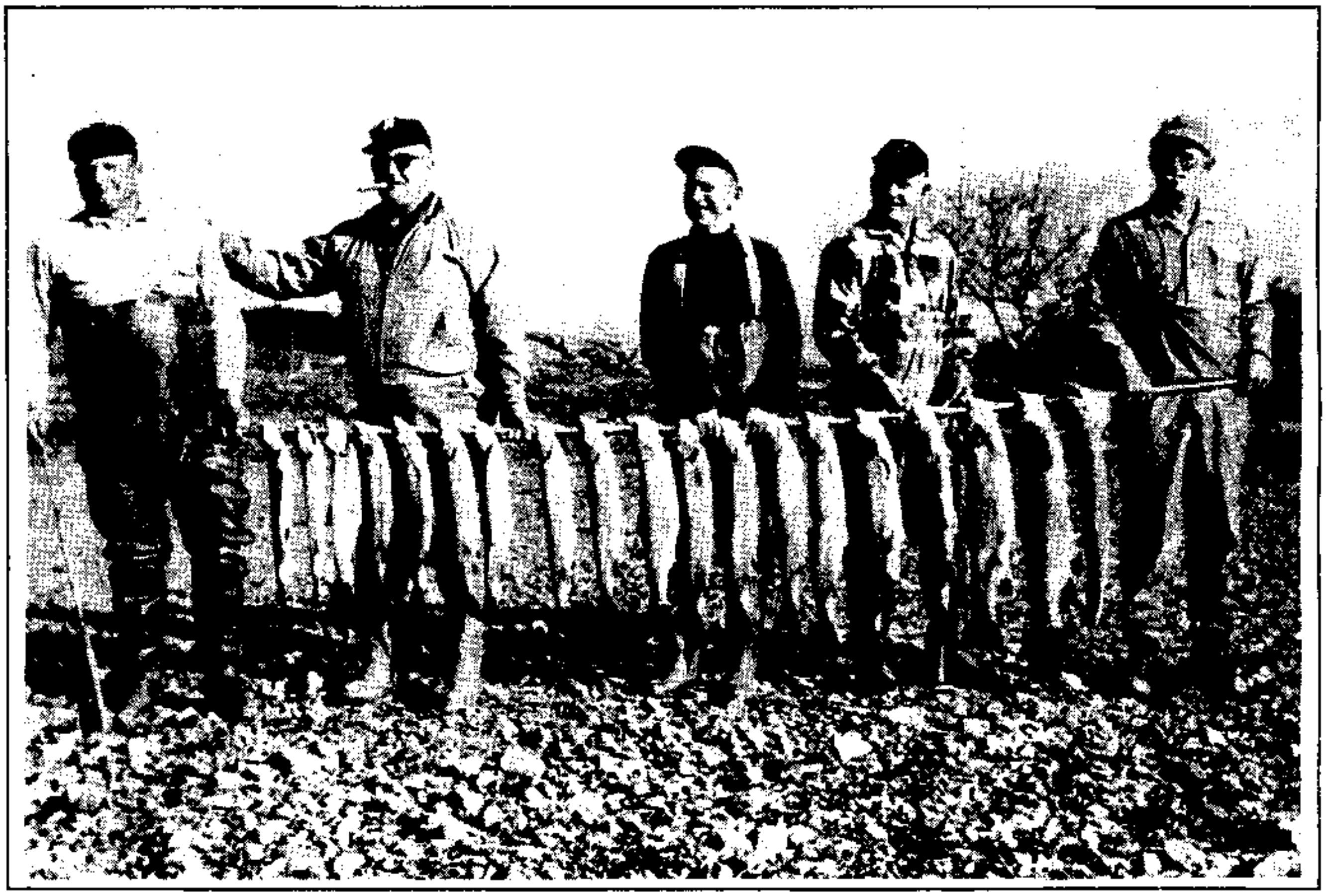
# GARCIA RIVER WATERSHED ENHANCEMENT PLAN



Mendocino County Resource Conservation District

October 1992

# The Garcia River Watershed Enhancement Plan

October 1992

Prepared for California State Coastal Conservancy

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# Table of Contents

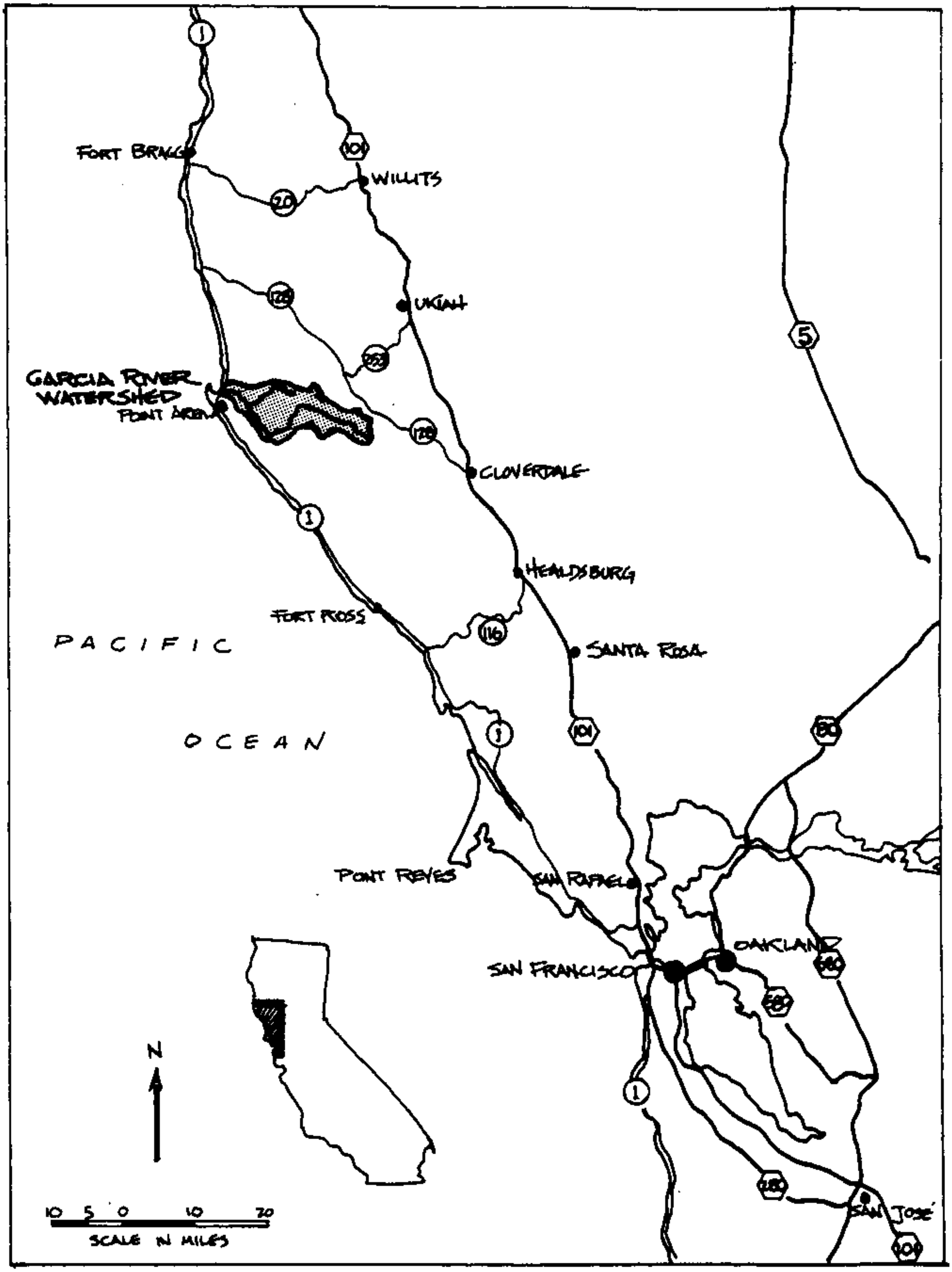
## LIST OF MAPS

## LIST OF FIGURES



## APPENDICES

MAP A: LOCATION OF GARCIA RIVER WATERSHED



# PART 1 : History and Purpose

## Goals and Purpose

The Mendocino County Resource Conservation District (RCD) received a grant from the State of California Coastal Conservancy to develop a resource enhancement plan for the Garcia River Watershed. In keeping with the role of the RCD in the county, which is to assist private landowners and government entities study, plan, and implement soil and water conservation projects, the goal of this project is to develop a plan that would guide the restoration of the natural resources of the Garcia River Watershed.

The Plan reviews historical changes in the watershed and provides extensive field investigation in portions of the watershed to analyze present conditions. The Plan objective is to develop feasible, cost-effective techniques to reduce erosion and sedimentation, and to restore the fishery, riparian and estuarine resources of the Garcia.

A critical element of the Plan is to understand and respond to the needs and visions of the property owners and residents of the watershed. To this end a Watershed Advisory Group (WAG), made up of interested members of the Garcia Watershed community, was formed. The WAG consisted of representatives of major interests in the watershed including: gravel operators (Bedrock Inc. and Gualala Aggregates), the timber industry (Louisiana Pacific Corporation and R & J Timber), environmental (Friends of the Garcia "FrOG" and CalTrout), agricultural and tribal interests, and commercial and sport fishermen. Technical advisors included staff from the Department of Fish and Game (DFG), Soil Conservation Service (SCS), Mendocino County Water Agency (MCWA), The North Coast Regional Water Quality Control Board, and the County Farm Advisors Office. The group met throughout the planning process to develop plan goals, review and make recommendations for the Plan. Each of the recommendations included in this Plan have been developed by the consensus of the landowner interests of the WAG.

The following goals for the Garcia River Watershed Enhancement Plan were developed and adopted by the members of Watershed Advisory Group:

1. To foster the conservation, restoration and sound management of the Garcia River's natural resources.

2. Restore, to the extent feasible, the salmonid fishery in the Garcia River.

3. Identify limiting factors and adverse impacts that contribute to the decline of salmonid populations. Such factors include 1) habitat conditions, i.e., condition of spawning gravels, availability of deep pools; 2) sediment sources in upland areas; 3) gravel deposition characteristics and recruitment; and 4) functions of debris and riparian vegetation in supporting the fishery resource.

4. Develop approaches for restocking the river with native as well as artificially propagated salmonid stocks.

5. Identify and target opportunities for treatments that will improve fish habitat.

6. Identify and target, for treatment, areas of accelerated erosion which impact water quality and fisheries. These areas include roads and other land-use associated problems.

7. Based on the gravel management plan to be developed by Mendocino County Water Agency, consider the possible development of gravel extraction approaches which may enhance fish production and flood control.

8. Identify recreational opportunities within the watershed that may be enhanced by the Plan.

9. Recognize the rights of private property owners to prevent unauthorized access to the river through their property, while supporting legitimate public access to the river (at legal access sites) for recreational uses, including boating, rafting, and fishing.

10. Identify funding sources that may be available to implement recommended treatments.

11. Enhance watershed protection for water quality, including drinking water, through consideration of the beneficial uses as identified in the North Coast Regional Water Quality Control Board Basin Plan.

12. Build a sense of stewardship among the landowners of the Garcia River Watershed to promote the sound management of all the natural resources of the river.

The Watershed Plan is the first step. Once the Plan is completed, it is the further goal of the RCD to work with landowners over the long-term to find ways and means to implement the recommendations laid out in Part 3 of the Plan. Landowner participation in carrying out these recommendations is strictly voluntary. None of the practices or treatments set forth in this plan are required, or should be construed, in any manner, as compulsory. While the District is available for assistance, all District services and programs are voluntary and open to property owners who are interested in stewardship of their soil and water resources.

## Introduction

The Plan focuses on three main areas in an effort to understand the watershed as a whole:

(1) The Estuary (that part of a lower river that is affected by tidal influence). The Garcia Estuary extends approximately from the ocean to the confluence of Hathaway Creek (River Mile 1.38).

(2) The Lower 7-Mile Reach, which extends from the confluence of Hathaway Creek to the mouth of the North Fork Garcia (River Mile 8.72).

(3) Two representative sub-drainages: the North Fork Garcia and Pardaloe Creek.

In particular, the Plan examines the process of sedimentation from the small upslope tributaries, where sediment enters the system, to the estuary, and addresses possible causes and effects of sedimentation on the resources of the watershed.

> Any effort to control erosion and sedimentation should be based on an understanding of the natural watershed. Every watershed is an integrated unit in which soil, vegetation, parent rock and climate are all related to the shape of hillslopes and stream channels. A watershed may be thought of as an open system tending toward a steady state, in which the rate of energy expenditure by flowing water is equalized throughout the length of the watershed ... A change in land use activity at the head of the watershed may change the delivery rate of water of sediment or both, to the stream channels, causing readjustments in stream channel geometry until a new steady state is reached. In short, each watershed is the sum of many parts and processes. Treating any part or process of a watershed in isolation runs the risk of creating costly and unwanted impacts elsewhere... The recognition that activities in one part of a watershed may affect erosion and sedimentation in another part is fundamental to any attempt to control these processes. (Weatherford, 1979).

The fisheries resource is an area of special focus in the Plan for several reasons:

1) The fish population has apparently declined from historic levels.

2) The Garcia community is united in a desire to restore the salmonid fishery.

3) The fisheries resource can be seen as an indicator species for the health of a watershed.

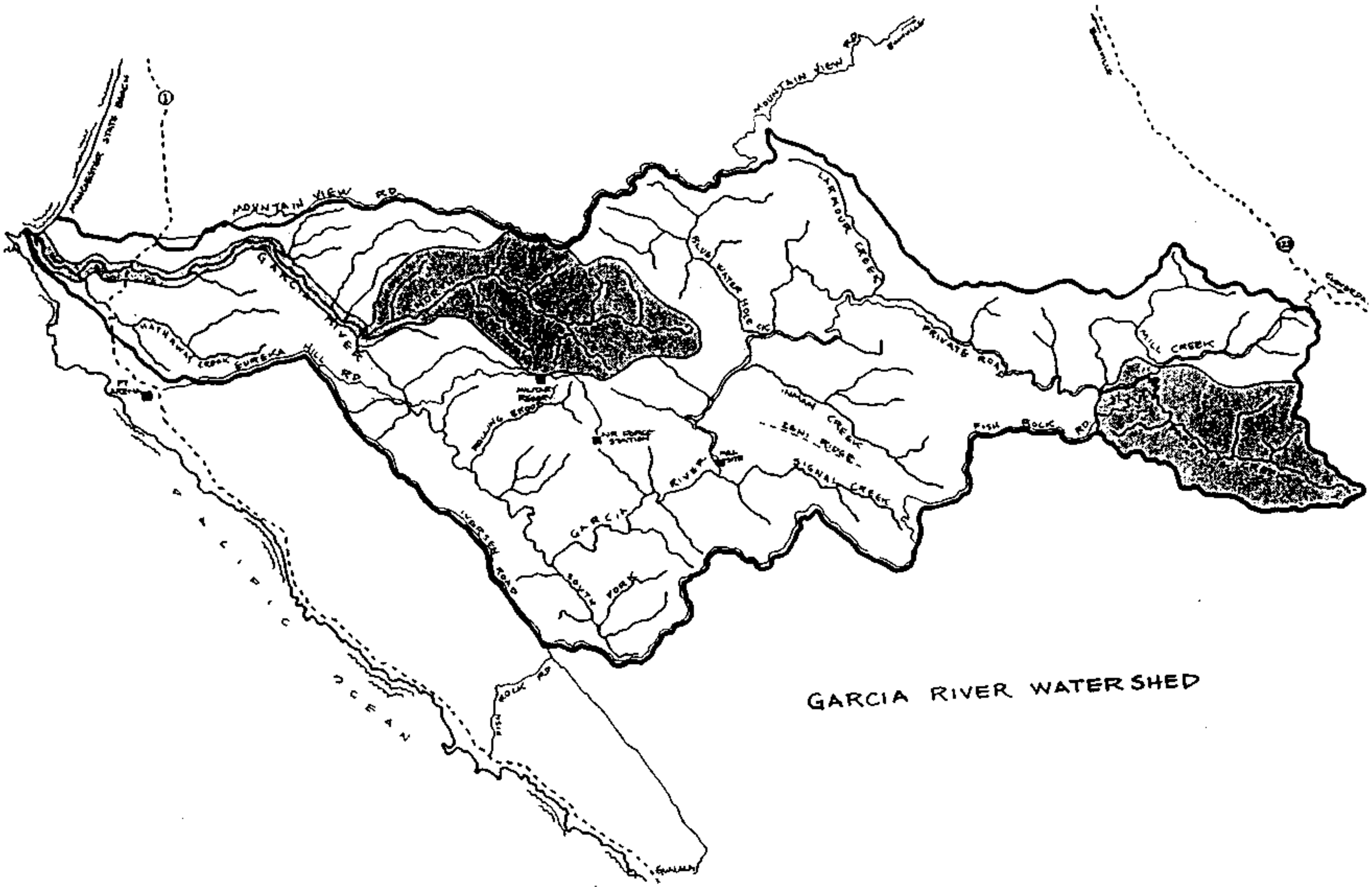
## Location and Description

The Garcia River is located in southwestern Mendocino county, California, at longitude 123 degrees 44' W and latitude 38 degrees 56'N, approximately 120 miles north of San Francisco and 40 miles south of Fort Bragg.

The Garcia Estuary is just north of the coastal projection of Point Arena and near the small coastal town of the same name. Point Arena ("Punta de Arena" in Spanish) signifies Point of the Ring or Circle, and should one have any doubt as to the title being appropriate, he should climb to the summit of the mountain range on the east. With the great Pacific far below and every curve and angle of its coast plainly visible, one discovers that to the north of this bold headland, the shoreline swings far east in the form of a semi-circle, of which Point Arena is the extreme southern point. (Fairbanks, 1907)

The Garcia River Watershed drains approximately 72,000 acres (114 square miles). The mainstem of the river is approximately 44 miles from the mouth to Pardaloe Peak, and the combined length of this mainstem and its blueline tributaries is approximately 105 miles. Elevations range from 2470' at Pardaloe Peak, near one of the headwaters and the highest point in the watershed, to sea level. The upper watershed is characterized by extremely steep and rugged forestland, much of which has been harvested, and is scarred by erosion from past logging and associated road construction. The more gently sloping lower portion, with coastal terraces and alluvial bottom lands, is used for agricultural production, including potatoes, silage, forage, livestock grazing, and dairy. Residential development is limited. Coast Highway 1 crosses the Garcia approximately 2 miles from the ocean. The relatively small estuary area (approximately 80 acres of open water and mud flats and 150 acres of more upland type vegetation) serves as an important habitat for anadromous (and other) fish, many species of shore birds and waterfowl, and numerous other forms of wildlife. Species of special interest in the Garcia Watershed are the whistling swans, *Olor columbianus,* which winter in the area near the estuary, and the Point Arena Mountain Beaver, *Aplodontia rufa* (Hood, 1977) which is on the federally proposed Endangered Species List (DFG Natural Diversity Data Base, 1992).

## MAP B: GARCIA RIVER WATERSHED SHOWING STUDY AREAS



Other nearby stream systems to the south are the Gualala River and a number of smaller coastal drainages. To the north are Brush, Alder, Mallo Pass, Elk, and Greenwood Creeks and the Navarro, Albion, Big, and Noyo Rivers.

## Climate

Temperatures in the Point Arena area are among the most constant in the state, reflecting the strong maritime influence. The mean annual temperature is 54 degrees F (13 C). Mean temperatures of the coolest and warmest months differ by less than 10 degrees F (6 C). Although summers are generally cool and foggy, brief hot spells can occur with extreme maximum temperatures from 85-90 degrees. The freeze-free growing season is approximately 290 days (Ott, 1979). The length of the irrigation season varies from year to year, depending on the amount of rainfall during February to April, but generally extends from mid-May through mid-October.

Annual precipitation averages approximately 40" at Point Arena and 60+" in the upper watershed, most of which occurs between October 1 and April 30. It is important to note that there is a substantial variation in temperatures and precipitation between upper and lower areas of the watershed, but continuous data has not been recorded from the upper basins. (Hecht, 1983)

The USGS maintained a stream gaging station on the Garcia at River Mile 8.2 from August 1, 1962 to September 30, 1983. (Drainage area = 98.5 square miles.) Mean annual flows during the period of record varied from 712 cubic feet per second (cfs) in water year 1974 to 20 cfs in water year 1977. The lowest recorded flow was 2.3 cfs on September 16, 1977. The largest flood recorded on the Garcia River during the period of record was 30,300 cfs, which occurred January 16, 1974. (Ott, 1979)

## Beneficial Uses of Water in the Garcia River

California laws, both those governing the right to use streamflow and those used to curb water pollution, refer to the "beneficial uses made of water", a term that gets shortened to beneficial uses. These 'uses' form the basis for all water quality protection efforts. Beneficial uses include domestic and municipal water supply, preservation and enhancement of fish and wildlife, and recreation and are identified in Regional Water Quality Control Board Basin Plans. The quality of water needed to protect each beneficial use, expressed in physical or chemical parameters, is also set forth in these Basin Plans. Each beneficial use, together with the physical or chemical criteria necessary to protect it, becomes a separate "objective" or standard by which to achieve or maintain the water quality.

In its 1990 Water Quality Assessment, the North Coast Regional Board listed the water quality condition on the Garcia River and its North Fork as "intermediate" — meaning that its waters generally support the beneficial uses with an occasional degradation of water quality (SWRCB, 1990). This report listed the suspected cause of water quality impacts as sedimentation from natural and man-made sources. The Assessment is scheduled to be updated by late 1992.

The beneficial uses of the Garcia River are identified in the North Coast Water Quality Control Plan (North Coast Regional Water Quality Control Board, 1972). The uses that must be maintained and protected in the Garcia River include:

**Municipal and Domestic Water Supply,** uses in community water systems and domestic uses from individual supply systems.

**Agricultural Supply,** includes crop, orchard, and pasture irrigation; stock watering; and support of fanning and ranching operations.

**Industrial Service Supply,** includes uses which do not depend primarily on water quality such as mining hydraulic conveyance, gravel washing and fire protection.

**Rec 1 — Water Contact Recreation:** includes all uses that involve body contact with water such as swimming, wading, and sport fishing where ingestion of water is possible.

**Rec 2 — Non-contact Recreation:** recreational uses which do not require contact with water such as picnicking, hiking, camping and pleasure boating.

**Cold Water Habitat:** provides protection needed to support aquatic resources associated with the cold water environment such as cold water fishes.

**Wildlife Habitat:** provides a water supply and vegetative habitat for the maintenance of wildlife.

**Fish Migration:** provides a migration route and temporary aquatic environment for anadromous or other fish species.

**Fish Spawning:** Provides a high quality aquatic habitat suitable for fish reproduction.

Many of these beneficial uses demand different physical or chemical criteria for their protection. Because of this, water quality regulators gear water quality protections to the "most sensitive use". Of these, cold-water fisheries, and spawning are considered the most sensitive uses because, in order to support the use, narrow temperature, dissolved oxygen and turbidity requirements must be met. This means that in the Garcia River cool temperatures necessary to support cold water fish are important objectives to be maintained, even though temperature may not be important for other uses such as domestic water supply. For this reason, surveys of the fisheries resource and habitat included temperature measurements as a critical factor in determining the health of the fishery. Understanding the Garcia's critical beneficial uses and their corresponding protective criteria was key in developing the recommendations for the plan, and will continue to be important to any future monitoring and assessments of the river.

## Recent Social History, 1800-1990

For unnumbered generations before White settlers arrived in the coastal area of what we now call the Garcia River, the land was inhabited by a native people known as Bokeya, or Central Pomo. The ancestral lands of this tribe extended along the coast from just north of the Navarro River southward about 35 miles to near the mouth of the Gualala river. The entire Bokeya population was probably less than 400. They were a part of a large inter-related civilization of Pomo peoples who inhabited much of what is now Mendocino and northern Sonoma counties, trading resources, traveling extensively between the coast and inland valleys, and seeming to co-exist in harmony.

The coastal Redwood zones were the least favored for permanent dwellings, mainly because of their dense, dark harsh forests and coastal climate. However, these regions offered many special foods and recreational pleasures, and coastal settlements were often seasonal campsites. Some permanent villages were established where basic needs for food, water, and sunshine could be fulfilled year round, and one of these villages was located on the Garcia River not far from the present Rancheria. This village was known as "pdahaw," which means "at the stream mouth," and probably had a population of around 200.

In 1811 the first White men appeared on the northern California Coast as the Russians landed at Fort Ross, some 35 miles south of the Garcia River. They traveled extensively in the area; timbers from the forests near the Garcia supplied the tall, straight masts for their ships. The sea otter was their main quarry, and they generally followed a policy of peaceful coexistence with the Native Americans. The Russians stayed approximately 30 years and then moved on, never claiming legal possession of the land.

In 1822, when Mexico won independence from Spain, California became part of the Mexican Republic. The Mexican Army fought to "secure" their new possession, and raids into Pomo territory, the taking of Pomo slaves, and the newly imported diseases such as cholera and smallpox brutally decreased the population of the native people. In 1838, hard Mexican boundaries were established in the area, and the Bokeya were nearly eliminated.

In 1844 Rafael Garcia, a general in the Mexican Army and majordomo at the Mission San Rafael, was given a piece of land on the coast in payment for military service. The "grante del norte" (grant of the north) extended from the Gualala River to the Malpaso (Mallo Pass) and "one league back," and

MAP C: MAP OF GARCIA LAND GRANT

*Map of Garcia Land Grant (Sullenberger, 1980)* included approximately 40,000 acres. In 1844 it is said Garcia built a vacation home and ranchero on the river near the present junction of the Mountain View Road and Highway 1. The family used the home mainly for summers and holidays but left their large herds of cattle to graze and grow fat on the meadows and bluffs year round. Local tradition states that Garcia built a water-powered sawmill at Allen Gulch on the north bank of the Garcia to cut lumber for his ranch buildings.

In 1848, when California became a territory of the United States, the U.S. Land Commission ruled the Garcia Grant invalid on the grounds that its title had not been recorded in Mexico City, and although Garcia fought the decision through the courts for nine years, the decision was finally upheld by the Supreme Court in 1860.

During this period of consideration, in 1854 Garcia sold his grant to Don Jose Leandro Luco for $10,000.00. In 1858 the first Anglo-American settler, Dr. Julius G. Morse, a New York physician, arrived to serve as agent for Luco. When the Garcia grant was rejected in 1860, Morse bought Luco's land and remained on in his house in the Garcia bottoms. He opened the first school in the area, conducting classes in the cabin of a boat that had wrecked near the mouth of the Garcia River, and he was named the first postmaster of Point Arena.

The first homesteaders that moved into the area "squatted" and "patented" their land. (Patenting was a practice wherein contracts were drawn up between the government and individuals, assuring that sought-after land parcels would eventually be handed over to settlers in return for support for the government.) Most of the early settlers were farmers, coveting the rich loamy soils of the bottom lands. Although there was an abundance of natural resources, it was a rough life, full of hardship and privation for those earliest settlers: there was no easy transportation for travel or trade, no regular steamers (a trip from San Francisco could take weeks in the face of a head wind), storms were severe and the coast uncharted, and their homes, fields and livestock were constantly threatened by grizzlies, coyotes, wild cats of several kinds, foxes, raccoons, etc. In spite of these challenges, there was a rush of settlers to the area. By the late 1860's-70's, there were roads, bridges, mail service (on a 4-horse stage), schools, churches, the first regular steamer service, and the first sawmills began to be erected in every timbered gulch and on every stream. Shipping facilities were desperately needed; in 1866 the Point Arena Wharf was constructed, and schooners were built and launched. The Point Arena Lighthouse began operating in 1870.

While fertile bench lands and bottom lands were being settled by farmers, dairymen and stock raisers, lumbermen began making inroads into the thick Redwood and Douglas Fir forests to the east. The first sawmills were water powered and housed a "muley" saw, a vertical single blade saw propelled up and down by a wooden beam attached to a crank on a water wheel. These were quickly replaced by the more efficient steam engine and more sophisticated saws. The small mill built in the 1840's by Garcia was the first mill on the river and probably was operated later (1890's) by the Lawson family as a shingle mill. The "Garcia Mill," 5 miles east of Point Arena just above the North Fork confluence, was built in 1869 and by 1876 was cutting 45,000 board feet/day. There are many great stories recorded about this mill and the 7-mile flume and rollers that carried the milled lumber to the wharf to be shipped for sale. This mill was sold to the L. E. White Co. of Greenwood in 1891 and ran as a railroad tie mill until it burned down in 1894 (Moungovan, et al, 1968).

By the late 1870's it is said there were a dozen saw and shingle mills within 7-8 miles of Point Arena. A shipping memo from the Wharf in 1879 lists: 2300 tons of merchandise, 70,000 posts, 233 cords of bark, 13,500,000 shingles, 228 rolls of leather, 1042 bags of potatoes, 940 boxes of butter, 274 cases of eggs, 130 sacks of wool, and 4000 reams of paper (from the paper mill on Brush Creek near Manchester).

Around 1880 the Garcia flume network sent over 8 million board feet of lumber off to distant ports, but by the 1890's the lumber industry was in decline, and lumbering activities in the area were confined to making and shipping railroad ties (for which there was a rapidly growing demand), posts, shakes, and staves. This was due in part to the national financial crisis which brought down lumber prices, the high cost of transporting logs to the mill and finished lumber to the schooners, and finally the depression of 1893 which caused a further slump in demand for lumber. Shortly after 1900 there were still several large tie lumber camps in the Garcia. From about 1909 few ties were flurried, and in 1912 the last tie was carried by the Garcia flume and rollers. By 1915 most reminders of lumbering activities had disappeared:

Point Arena, now (1915) in the midst of a prosperous farming and dairying community, was once supported almost entirely by lumbering, which overshadowed every other industry. Redwoods reached almost to the town limits, and at various times no less than fourteen saw and shingle mills might be counted within a radius of seven miles. Not a mill has operated here for the past ten years (Sullenberger, 1980).

By 1912 the White Lumber Co. had put several thousand acres of their cutover timberland into range land. Slashing camps were started, with axmen cutting all young virgin and second growth trees. The slashings were burned after two years, and grass seed was sown. The success of this project encouraged the company to expand the program. In 1915 the White Lumber Co. sold all of their holdings, and much of the timbered land in the Point Arena area was sold as small ranches and farms.

Although the lumber industry rose and fell, agriculture and livestock operations continued to prosper. The dairy industry flourished, and the area became famous especially for "the" butter, which was shipped as far as Alaska and Japan. As tangled masses of brush and slash were burned and cleared, grazing land supported great herds of cattle.

Around the turn of the century the Point Arena Hot Springs, located at around River Mile 17 on the mainstem Garcia, was opened to the public and developed into a popular resort. In 1907 a newspaper clipping in the Ukiah-published Northern Crown states: "the tourist travel to this section is yearly becoming larger and is now an important factor both socially and financially."

Historical research turned up little significant material and few facts about the area during the next few decades. Extensive interviews with long-time residents of the Garcia community give a general sense of life in the area from the 1920's-30's. After World War I life settled down, and the Garcia community, considerably smaller than it had been earlier, was fairly autonomous and independent, somewhat insulated from the changes of the outside world. Agriculture, stock raising, and dairy farming were the major sources of income, with some woods work and small businesses in town. The depression hit hard, and there are stories of scraping by, depending on the resources of the land for food. People worked hard, fished and felt they had some control over decisions about their environment, their economy, and their life-styles.

Logging on the northern California Coast has been characterized as a "Boom and Bust" industry, and this seems to fit the history of the industry in the Garcia area. It boomed before the turn of the century, and it boomed again in the 1950's, in response to the post-World War II demand for new housing and the new logging machinery, which allowed for cheaper cutting and transportation. The period of heaviest cutting in the Garcia Watershed was 1954-1961. During this later boom, most of the timber was hauled east to mills in Cloverdale and Ukiah, so that the local community and economy were not as strongly affected as they were before the turn of the century. During the 1950's there were only 3 mills on the Garcia. Throughout this period most of the watershed was still held in large blocks of land, owned by ranchers or timber companies.

In the late 1960's changes began to occur. Some timberland, cleared of marketable timber, began to be converted to sub-divisions, and "new settlers" began to arrive who were not long-time members of the community. The newcomers were not necessarily dependent on the natural resources, and had different ideas about the resources in the watershed. At the same time, government agencies were charged with a more active role in resource protection. Such changes were not always welcomed by the community who had lived in the valley for generations.

Today there are many varied interests among landowners in the Garcia River Watershed. It is hoped that this Watershed Plan will help to establish a framework in which seemingly conflicting resource protection needs can be evaluated and that various interest groups can agree on ways to achieve their mutual goals of wise use of the Garcia River resources.

## Physical History of the Garcia River

The North Coast of California is geologically young. The landscape has been shaped by the crushing pressure of the Gorda Plate and North American Plate collision to the north, and the San Andreas Fault to the south and west (Higgins, 1992). In the Garcia, this results in steep terrain and drainages. The lowest reach of the river and estuary have been profoundly impacted by the San Andreas fault. The lower river meanders back and forth across the San Andreas Fault (see Geologic Map, Appendix I) and the estuary follows an old fault trace to the ocean (Wagner and Bortugno, 1982). Tectonic movement, although immeasurable in the field on a given day, has impacted the stability of the Garcia landscape, soils and streams for millions of years and continues to do so today (Howell, 1991).

In addition to the effects of plate tectonics, there have been major changes in climate and sea level brought about by shifting glacial weather patterns over thousands of years. The river has repeatedly undergone downcutting phases during cold and wet glacial periods, and sediment build-up during warmer and drier interglacial periods. While the shape of the estuary was partially created by the San Andreas Fault, a rise in sea level 5,000 and 7,000 years ago, after the last Ice Age, drowned the lower river valley leading to its formation. Prior to White Settlement, the estuary had maintained its depth as a result of flushing by high river flows and tidal flux. The river system, at that time, was in equilibrium, capable of maintaining a fairly deep channel despite floods and the slowly rising sea level.

The watershed east of the San Andreas is entirely composed of Franciscan Formation. The parent rock in these formations is often weakly consolidated or sheared, leading to a high erosion risk. Detailed geologic surveys to define the extent of sheared materials have not been conducted in the Garcia Watershed, but geologic studies in adjacent areas yield some insights. Ancient or active faults often cause increased erosion risk due to shearing of Franciscan rocks. Maxwell et al. (1981) found evidence of upland thrust faulting in the Cape Viscano area to the north, and Suppe (1978) found numerous thrust faults in the Gualala Watershed to the south. It is likely that numerous unmapped faults run through the upper Garcia Watershed causing slope stability problems.

The upper watershed areas of the Garcia River are deeply incised by tributaries. High rainfall and the steep gradient of these streams give them a high capacity to transport sediment. The lower Seven Mile reach flows through an alluvial valley of lower gradient where sediments tend to remain in residence longer. There is no record of the nature of historic riparian zone along the lower river; however, it probably had large amounts of downed logs characteristic of such low gradient reaches below steep forested land (Sedell et al., 1988). The pre-settlement river channel would have had some meanders and side channels with pockets scoured around large woody elements. Overstories of old growth conifers on river terraces would have provided additional shade and a cooling microclimate effect. This lower stream reach also would have had the prime sites for spawning gravels for salmonids.

Before the influence of White settlers, the watershed was predominantly forest lands with a mixed conifer overstory and hardwood understory. Disturbance of the inherently unstable landscape by these settlers led to large scale and chronic sediments influx into the river and its tributaries. Upper tributaries may have had faster recovery due to the capacity to actively downcut through sediment deposits, but the lower river and estuary have been unable to flush sediment due to the lower stream gradient.

It is important to understand historic and current physical conditions of the watershed because such information provides a basis for determining the contribution of past impacts to today's problems and in defining the potential for maintaining a healthy watershed.

## FROM EARLIEST RECORDED HISTORY TO 1910

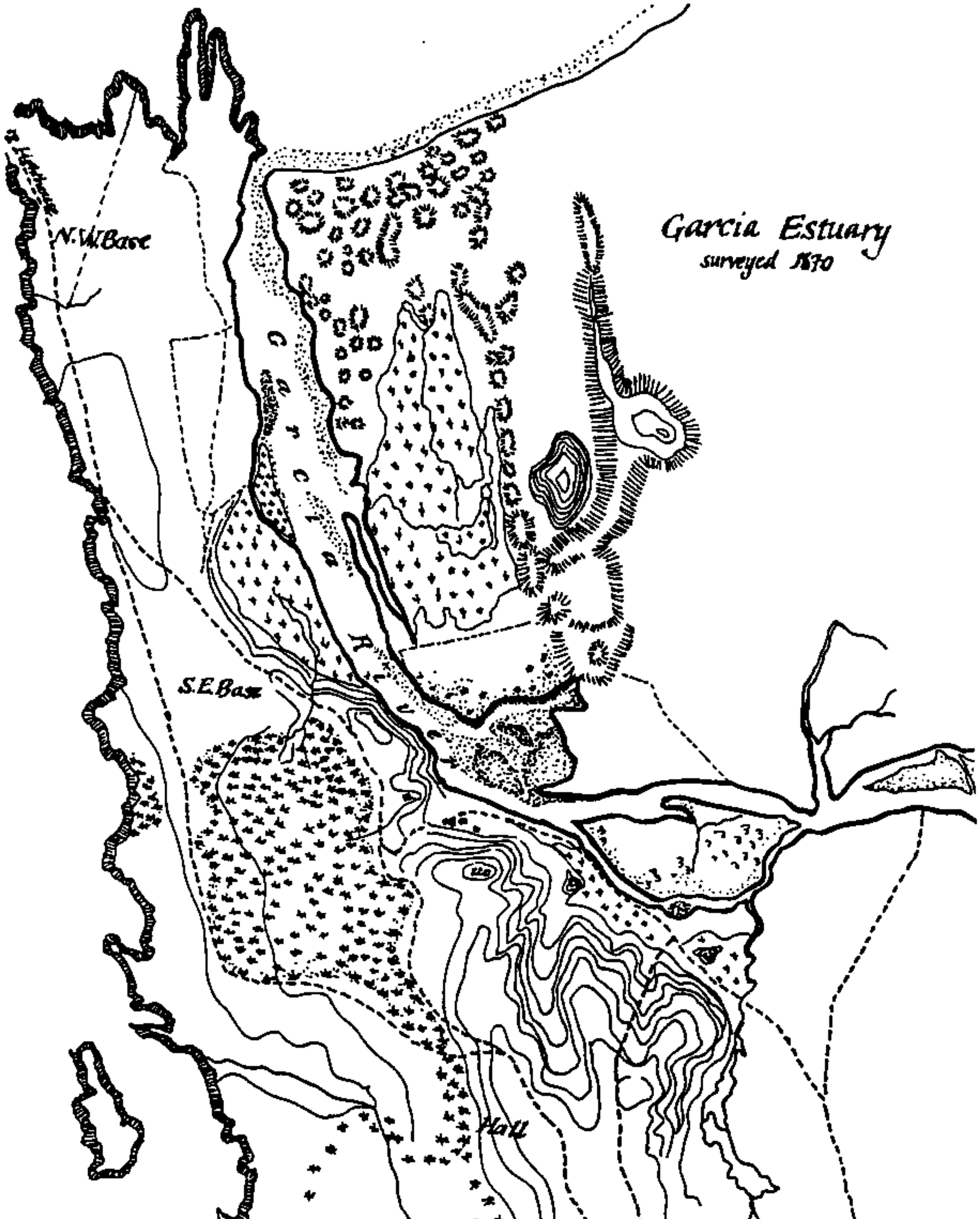
The earliest non-Native American impact on the resources of this area was the Russian fur traders, whose main quarry for the 30 years of their stay on the north coast was the sea otter. The Mexicans arrived next with herds of cattle and some farming. This probably began the introduction of non-native grasses into the area.

As the Americans began arriving in the 1850's-60's, dramatic changes in population and land use brought dramatic changes in the watershed. Bottom lands were cleared for farming, trees were cut for lumber, and animals were trapped for furs or killed if they threatened homes and livestock. (Elk and grizzlies were among the first species to be eliminated.) Salmon from the Garcia River were netted by the thousands, smoked and shipped to San Francisco.

The timber industry boomed. Around 1870 a dam was constructed at Buckridge, just above the North Fork on the Garcia, as a part of the largest mill operation in the area, possibly blocking and certainly impairing fish migration for a number of years. There were many aspects of the logging practices of this era that were disastrous in terms of erosion and sediment load in the watershed. For example, hillsides with freshly cut Redwood logs were burned before hauling the logs to the mill to bum off the sapwood and thus lighten the weight of the load. Splash dams were built on the mainstem Garcia to collect the logs at various points on a stream, and during high winter flows the dams would be dynamited to wash the logs down as far as possible. It is recorded that in one winter the pond behind the mill dam at Buckridge filled in so much that they had to add temporary summer dams to keep the logs afloat after the first year.

This early logging boom mainly affected the mainstem of the Garcia and the lower parts of tributaries on the lower 15 miles of the river. The North Fork was probably

MAP D: GARCIA ESTUARY ~ 1870 MAP




*(Source: U. S. Coast Survey, Point Arena and Vicinity Map, surveyed 1870 by Luis A. Sengletten, from Point Arena Lighthouse.)*

logged farther upstream than any other tributary. There is no evidence of commercial logging in the Pardaloe Creek Basin during this early logging era.

It is interesting to note that one historical source states that from 1900 the river flow in the Garcia had decreased so that the flume and rollers could not function well to transport the ties being cut, although the cause of this decrease in flow is not addressed. (Moungovan, et al, 1968)

The 1906 earthquake had a major effect on the area, causing heavy damage to the town of Point Arena and the Lighthouse, and causing major slides in the Garcia Watershed.

It is impossible to know the long-term effects of these combined early impacts to the watershed. Timber harvest activities must have caused tremendous problems with erosion, specifically the waves of sediment unleashed from the blasting of splash dams and the removal of the mill dam at Buckridge (Higgins, 1992). It is probable that there was a decrease in the salmonid population, a decrease in the general wildlife population (including fish predators), a decrease in native timber and vegetation, an increase in erosion and sediment loads, and major changes in fish habitat. Due to the lack of records of river depths and configurations, it is impossible to know exactly when and/or how the river changed. An early map of the estuary, drawn by government surveyors in 1870 records the estuary as a narrow channel, significantly different from the estuary we know today. By the time the Hydrographic and Topographic Survey maps were compiled by the U.S. Coast and Geodetic survey in 1929, the estuary was recorded as wider, and by the earliest aerial photo in 1937, the estuary appears wider still, occupying former wetlands to the northeast of the original channel. (See Appendix I.) Comparison of these maps and further discussion of these changes follows in Part 3: Enhancement Recommendations, Area 1: The Estuary.

### 1910'S TO 1950

Historical research indicates that the intense impact by man that began around 1860 began to taper off by around 1910. The logging industry had declined dramatically, and the closing of the flume in 1912 symbolically and realistically marked the end of an era. Conversion of timberland to grazing land still occurred (as late as the 1960's ranchers burned their grazing lands in an attempt to limit reoccupation by forest), but it appears that generally resources were less impacted by man.

The main source of information for this time period is the personal interviews which were conducted with long-time residents of the watershed (GRV Enterprises, 1991). These interviews were an invaluable resource for learning about the Garcia Watershed and its people; they provided insight, wisdom and a feel for the area and the community. Although there are apparent inconsistencies at first review, careful and repeated reading brings a picture of the area and its people into clear focus.

Some pertinent information taken from the interviews about the watershed and river during this period follows:

1) The holes along the river were generally deeper in the past. Names and depths of holes were very consistent.

2) The earliest and biggest change in both depth and configuration of the river was at the estuary, which became wider and shallower. ( (The lack of old cross-sections or bathymetric (depth) records makes it impossible to verify that the holes were deeper, but the changes in the configuration of the estuary are substantiated by historical maps and aerial photographs.)

3) All the fish were much more abundant, although some people felt that the King (Chinook) Salmon began declining in the late 1930's-40's.

   ...the limit was 25 then, but no one ever stopped at 25; they'd bring back as many as they could catch...

   After the first rains in the fall, those salmon would be going up by the dozen, you know, on the riffles. They'd hang out in the holes during the day and would move on up the next night... and so forth, and there was fish in every one of those holes ... you know, 15 to 20 fish in every hole.

   Back then there were so many fish and so few people that whatever fishing, no matter where or how they did it, it didn't really matter.

Official documentation of the decline of the Garcia River fishery does not exist. Personal photos as well as the testimony of every person familiar with the river support the fact there were many more Silver and King Salmon, as well as Steelhead, during these earlier years than there are today.

4) Water temperature was lower during the summer. This observation was partly subjective, based on how cold the pools used to be while swimming, and based on the fact that "...the suckers moved in after they logged, you know, and they were thicker than flies. You'd see schools of them." There are no water temperature records on the Garcia in the 1940's, but the removal of cover from tributaries and the widening of the flood plain of the lower river with loss of streamside trees would have caused the river to warm.

Other general observations are that the river seemed to rise and fall less quickly during winter storms than it does today; there were more water fowl; there were fewer predators ("...you didn't see them (predators) in the old days because every rancher back in the hills had his own pack of dogs, and they would kill anything that showed up to threaten their stock"); and the deer

*Garcia fishermen. 1940's and 50's*

population is "about the only thing that hasn't changed."

Meanwhile most of the upper tributaries of the river were structurally untouched before the logging of the 1950's. They were heavily overgrown with much large woody debris in the channels. The largest and deepest holes were filled with fish and could usually be found where logs or an accumulation of debris created scour and thus depth, and provided complex cover. Early foresters who cruised the land before it was logged found it hard to imagine that fish passage was possible up many of these streams because of the maze of fallen trees and overgrown riparian vegetation. These virgin upper tributaries were the lifeblood of the larger river system.

**THE 1950's-60's**

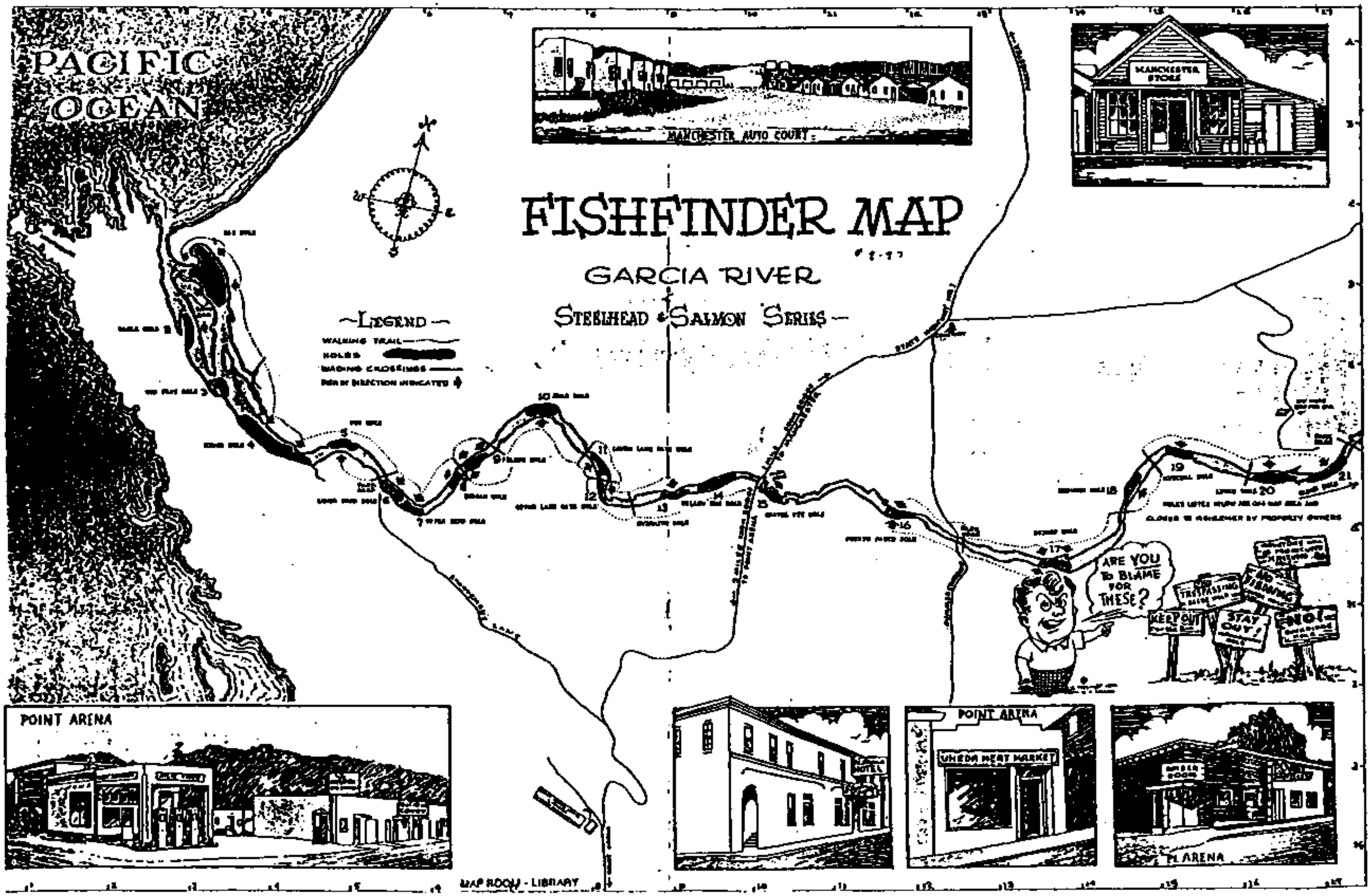
The 1950's brought big changes to the Garcia Watershed. Before 1950 the only roads in the upper watershed were jeep trails into old homesteads and a few ranches. In a period of 10 years almost all of the forested land in the Garcia River watershed was roaded and logged. The first logging in the 50's was mostly highgrading (only taking the best trees) using tractors. Later in the 60's and 70's the same areas were re-entered, and most of the remaining merchantable trees were taken. There were few regulations and fewer people to enforce the regulations that did exist. Most of the larger streams were used as roads, landings, and/or skid trails. Roads that were neither maintained nor drained diverted water from many smaller watercourses, often causing extensive gullies. There were also a number of landslides, mostly triggered by road cuts. The land was often burned after logging operations, creating even more unprotected soil subject to erosion. Slash (leftover logging debris) was left in streams (or slid into streams) often creating impassable fish barriers and massive sediment traps. In some areas with established ranches conversion to grassland was a priority, and the recently logged forestland was burned repeatedly.

In earlier times gravel extraction from the river was mostly accomplished by hand shoveling into a wagon or trailer. This all changed in the 1950's when tractor loaders and dump trucks hauled large quantities of gravel from the river during construction and improvements to three local roads: Highway 1, Eureka Hill Road, and Ten-Mile Road. There were no regulations about river gravel mining at this time, and it can be assumed that there was extensive damage to fish habitat.

During construction of the US Air Base east of Point Arena (1952) water was pumped from the Garcia River to such an extent that it almost dried up that summer. (There are also rumors of toxic spills from the Air Base which could not be verified, but there are no known fish kills in that area.)

In December of 1955 a large flood occurred that caused extensive damage to the area. "Fish Rock road was totally gone ... it took 28 days to just open

MAP E: FISH FINDER MAP ~ 1952



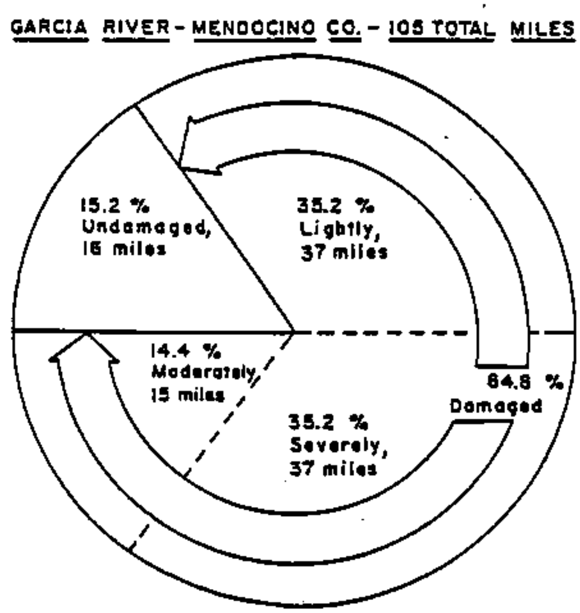

(ACCARDI, 1952)

Map E: FISH FINDER MAP ~ 1952

the road." There were three more floods with similar peak discharges according to the USGS Gaging Station records on the Garcia between 1964 and 1970 (USGS Gauging Station, flow data, 1963-83). These are rated as 10-year floods on a Flood Frequency Analysis Table, and the 1974 storm is rated as a 20-year event on the same table (Ott, 1979). These storms, combined with extensive soil disturbances on upslope forestlands and concurrent gravel operations, had major effects on the entire drainage system.

California Department of Fish and Game (DFG) and the Salmon and Steelhead Advisory Committee have done studies that support this observation. Although efforts to locate raw data and field notes in agency files have been generally unsuccessful, results such as the following chart indicate damage to fishery habitat in the Garcia (Fisk et al, 1966).

FIGURE 1: STATUS OF FISHERY HABITAT IN GARCIA RIVER-1966
(FISK ETAL., 1966)




Status of Fishery Habitat in Garcia River (1966):

Historic damage caused by road building, logging, overgrazing and poor land management practices, aggravated by the 1964 flood.

Source: Citizens Advisory Committee on Salmon and Steelhead Trout, An Environmental Tragedy, 1971.

*FIGURE 1: Status of Fishery Habitat in the Garcia River, 1966*

## THE 1970's - PRESENT

The 1970's and 80's were generally a period of lower human impact on the watershed compared to earlier periods. New rules and tougher enforcement by California Department of Forestry (CDF), California Department of Fish and Game (DFG), and the North Coast Regional Water Quality Control Board (NCRWQCB) were initiated during this period. There were also government programs that helped to fund rehabilitation and restoration projects, although the Garcia River has not received a significant amount of funding from these programs to date.

Probably one of the greatest positive changes for the watershed was the reform of timber harvest practices brought about by the enactment of the Z'berg/Nejedly Forest Practice Act of 1972. The watershed again experienced widespread timber harvest from the 1980's to the present, but improved practices, including stream course protection, shade canopy retention, and new road construction requirements have been fairly effective in preventing the types of problems evidenced in the past.

Given the past history, nature has been very forgiving of the Garcia Watershed. Hillslope and riparian areas in the upper watershed have begun to recover either naturally, or in the case of the North Fork, with landowner assistance. In the North Fork basin second growth conifers and hardwoods have reoccupied most of the logged sites. Aerial photos from the 1960's reveal hundreds of miles of roads and skid trails, and a definite lack of riparian cover along streams. The same set of photos taken in the late 1980's shows most roads and skid trails were no longer visible from the air, and many streams could be recognized by the ribbon of lush vegetation. Even along the mainstem, willows and alders have reestablished riparian cover in sections where it had been lost during earlier floods.

While hillslopes may have begun to recover, the effects of past logging operations and gravel mining continue to impact the river channel, itself. There are two main areas of gravel extraction: at the mouth of the North Fork, and just above the Windy Hollow Road. (Although some additional gravel was removed from the rancheria(s), this was not extensive nor has it reoccurred.) Gravel extraction has caused localized effects adjacent to the river, but there are two projects underway to devise better gravel extraction practices. The first is an Environmental Impact Report currently being developed through the County Planning Department. The second is a Gravel Management Plan for the river that will be developed by the County Water Agency; it is scheduled for completion by the end of 1993.

Much of the sediment currently stored in the river channel was generated largely by past and, to some extent, recent timber harvest activities in the upper watersheds. Because of its lower gradient and the lack of major storm events, this sediment remains in the lower river channel and estuary and continues to work its way slowly downstream. The upper watersheds also retain a large amount of stored sediment in the stream channel. As this sediment gradually is moved out of these streams, it continues to exacerbate the sediment problem in the lower river and estuary. The legacy of old roads and erosion scars, coupled with this stored or perched sediment, may pose significant erosion risk in the event of another major flood.

Some salmon and steelhead restoration activities were begun on the Garcia, carried out by local groups and concerned individuals. Their activities included barrier removal, rearing ponds, and fish stocking, although the number of fish actually stocked in the Garcia was relatively small. Save Our Salmon was the most active local group.

By the 1970's the numbers of fish had definitely declined according to those interviewed who had fished in the 1920's-40's, but for the younger generation and newcomers the Garcia was still considered a great fishing river.

"In the 70's every hole had its handful of fish..."

"In 1979 there were Silvers and Kings rolling in the tidewater...."

"In '86 we'd have from 7-12 strikes in a day...."

Department of Fish and Game studies conducted at the time supported the opinions of local fishermen. While a DFG electrofishing study conducted in 1987 and 1988 confirmed the existence of juvenile Silver (Coho) Salmon on the South Fork Garcia, only a few were observed in a riffle section in the mainstem which is atypical habitat for this species. Repeated electrofishing in the same areas has not turned up any Coho since that time (Wendall Jones, 1992). It is possible that lower stream flows resulting from drought conditions experienced in the 1970's and 1980's, combined with a trend towards later onset of winter rains, has adversely affected salmonid populations. Department of Fish and Game surveys of coastal rivers conducted in 1992, after the period of this study, appear to show an increase in Coho populations over the 1991 surveys, possibly due to the timing of winter storms (pers. comm. W. Jones, DFG, 1992).

Currently the Garcia River strain of Coho is considered a species of special concern (Nehlsen, et al, 1991) and may be at high risk of extinction (Higgins, et al, 1992). Recently, groups such as Salmon Unlimited have raised the possibility of petitioning to list the Garcia River Coho as an endangered species under the federal Endangered Species Act. If the Garcia Coho is listed, specific population and habitat studies and a recovery plan will be required.

At the present time use of lands in the Timber Harvest Zone may be undergoing a major shift as has already occurred in other areas in Mendocino County. This shift entails increased logging of hardwoods and conversion of timber lands to rural subdivisions with attendant road construction. This change in land-use has not surfaced as an issue in this Plan, but should be monitored for future potential impacts and sources of sediment into the system.

During recent years there appears to be an increase in population of some animals that were once trapped or hunted to near extinction. Among these are sea otter, sea lions, river otter, black bear, and mountain lion.

The watershed is apparently on the mend with some help from new programs, regulations and citizen's involvement, but where are the fish? It was that question that inspired this plan and brings us to the present.

# PART 2: Methodology

Field studies of the Garcia River were conducted from early 1991 through January 1992. The study plan began with the general goal of identifying historic and existing conditions, and problems on the river. (The specific goals of this project were drawn up as a part of the project by the Watershed Advisory Group and can be found on pages 1-1 and 1-2.) In addition, because most of the Garcia community shared the goal of improving the salmon and steelhead fisheries, which historically were abundant and in recent years have declined, watershed problems were identified on the potential to adversely impact fish. To begin to determine the possible cause(s) of this decline, observations of the physical characteristics of the river were made and information concerning the types and numbers of fish present was gathered. This information was compared to available historical information in an effort to determine what changes, if any, have occurred that may have caused the decline in the resource, and to identify enhancement measures that would improve fish habitat and other resources in the watershed.

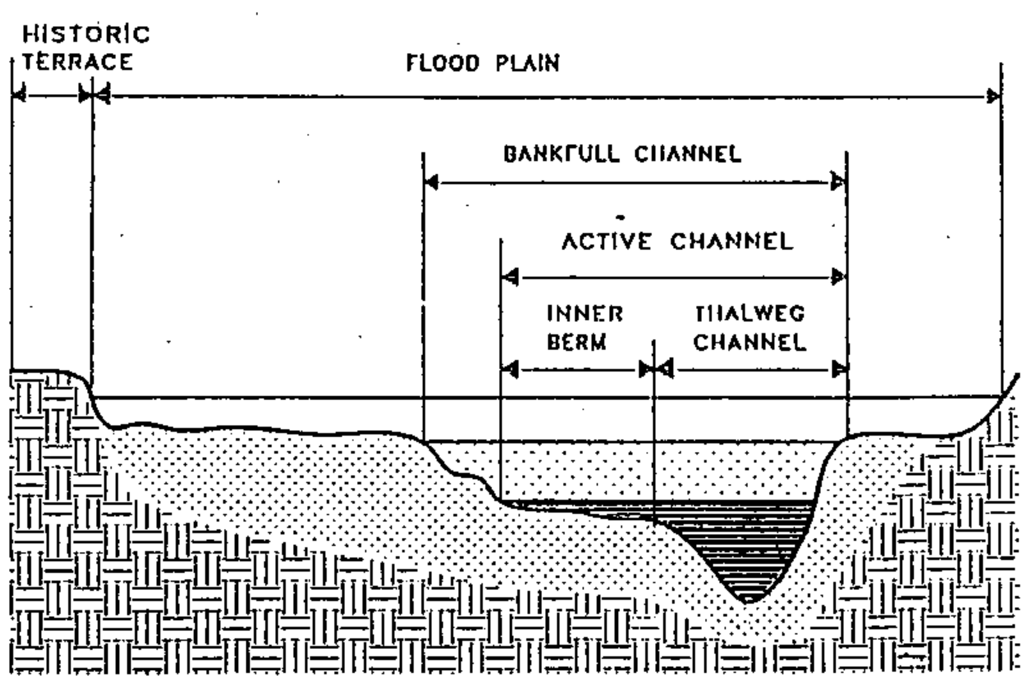
Following is a description of the types of information collected on the Garcia as a part of this project, an explanation this information, and how it is used to understand the river.

## MEASUREMENTS OF PHYSICAL CHARACTERISTICS

The study of rivers is called HYDROLOGY. It involves studying channel forms, the movement of water through the system of channels, and the effects of the water's energy. CHANNEL FORM, or MORPHOLOGY, is an important factor. The shape of river channels often changes over the course of the years due to floods and high flows or in response to increased sediments. Observing changes in the form of the channel provides an understanding of CHANNEL STABILITY which can depend on many factors, such as increased erosion caused by land use (roads, timber harvesting, grazing), landslides, or stream bank failure. Information about channel form and stability can be obtained by looking at historical information, especially aerial photographs, and by making CROSS SECTIONS and LONGITUDINAL PROFILES of the river.

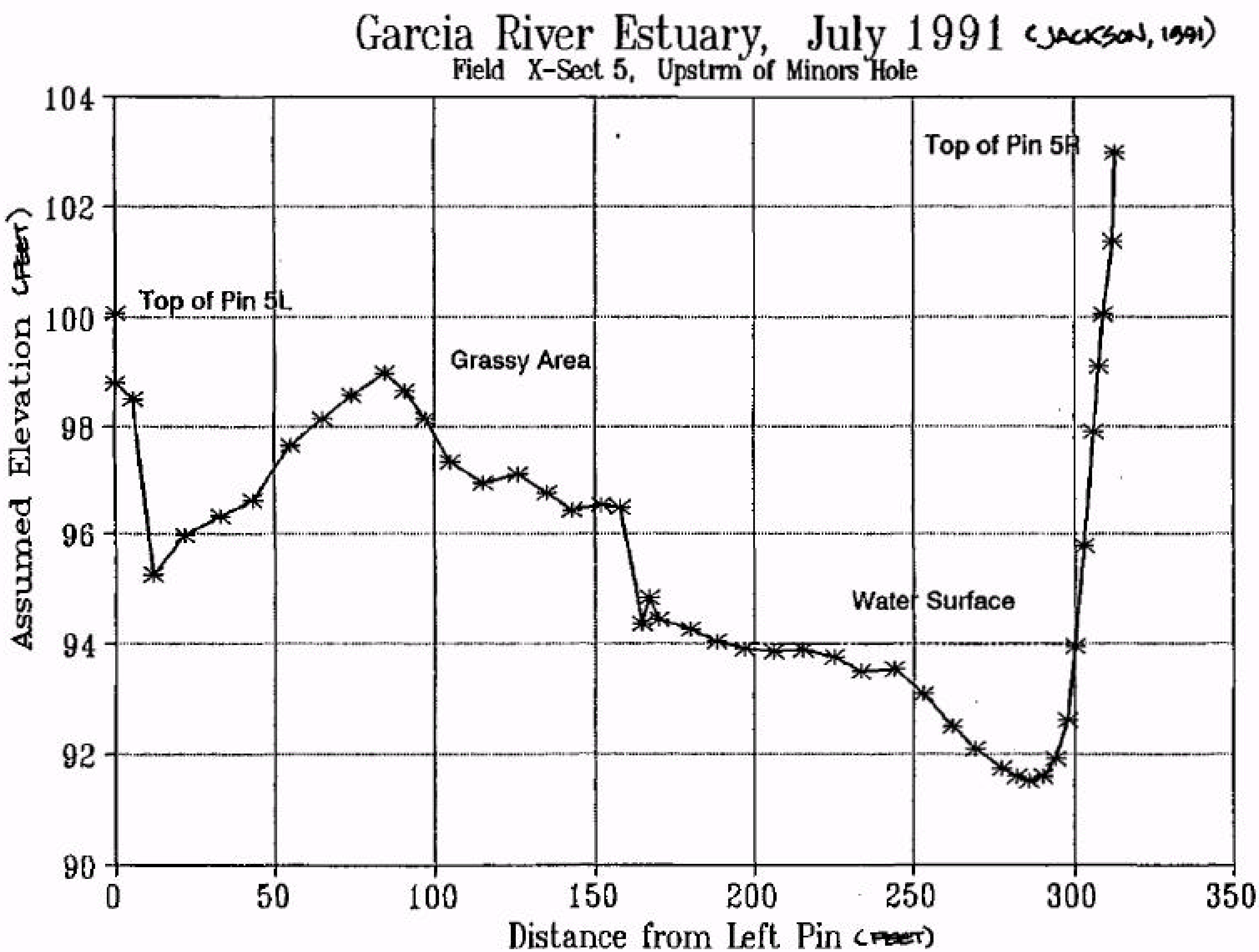
A CROSS SECTION is a diagram of the river's shape taken at right angles to the direction of flow of the river, creating a picture of the bank and river bottom features. A cross section is made by first staking the point on the left bank of the river and then stretching a tape to the right bank, which has also been staked. Depth measurements along the bottom are made by reading the tape level next to the horizontal tape connecting the stakes, or by using more sophisticated surveying equipment which speeds up this process. Cross sections provide information about channel hydrology and fish habitat. Cross sections taken over time are a valuable tool for understanding a river and detecting specific changes in pool depth, bank stability, etc. For this project 9 cross sections were made in the estuary, and 40 cross sections were made in the lower 7-mile reach at the locations shown on the Cross Section Maps in Appendix I. Figure 2 shows the measurements made for cross sections. Figure 3 shows a sample cross section taken in the estuary of the Garcia River.

FIGURE 2: SAMPLE CROSS-SECTION SHOWING CHANNEL ELEMENTS



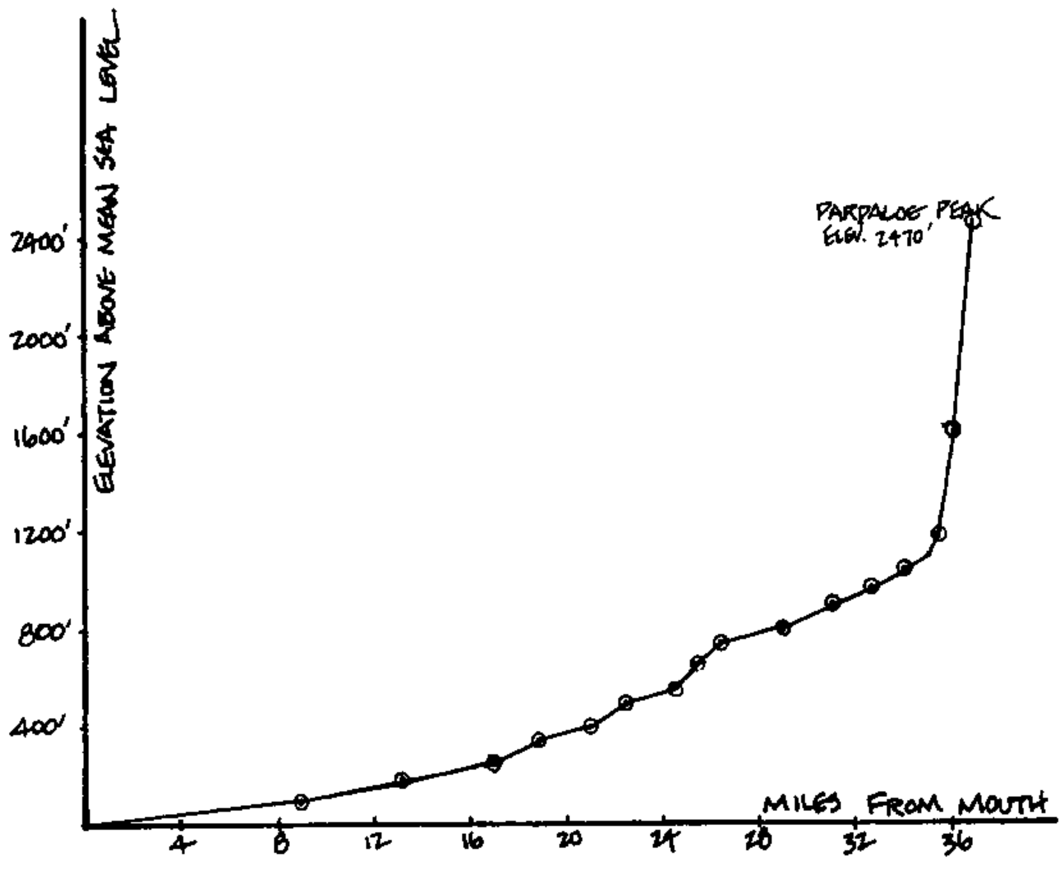

(FLOSI & REYNOLDS, 1991)

## FIGURE 3: SAMPLE CROSS SECTION OF GARCIA ESTUARY



A LONGITUDINAL PROFILE is a diagram of the slope of a stream or river. It shows the change in slope of the river as it travels its course downstream from the headwaters. Topographic maps and surveying equipment are used to gather the information necessary to develop a longitudinal profile. The profile helps to understand the energy that the stream flow produces. The steeper the stream, the faster and more powerful the flows. A steeper elevation along the profile means the river has more power to more larger debris and rocks as well as more soil or sediment. It is also possible to observe waves of sediment moving through a watershed system if profiles are repeated over time. Figure represents a rough profile of the Garcia River.

FIGURE 4: PROFILE OF GARCIA RIVER




from RAU, HAYDON, BORDESSA, FRANZ & ASSOC/5/29/90

SEDIMENT is made up of particles that have come from rocks or other biological material that are or have been carried by water. Depending on particle size sediment can be categorized as boulders (greater than 10" in diameter), cobble (2.5" to 10" in diameter), gravel (.16" to 2.5" in diameter), sand (.062 mm to 4 mm or .16" in diameter), and silt and clay (less than .062 mm in diameter), which are also called FINES (Rosgen, 1991). Data on the percentage of fines in spawning gravels is collected through substrate scores or McNeil samples taken from the streambed, see discussion on embeddedness below.

The movement of sediment in the river is part of the natural process of erosion. A certain amount of erosion is always occurring, and a stable river has evolved so that it can transport a "natural" sediment load. This is a state of EQUILIBRIUM, where the river's channels and banks do not change very much over time.

Stream channel problems can occur when erosion is accelerated by man's activities such as poorly constructed roads. Increased erosion and resulting increases in sediment load can cause a river to lose its equilibrium so that it is no longer able to move sediment efficiently through the system. An overload of sediment can effect river bottom changes as it accumulates silt and builds itself up. It also means that deep holes that are important for fish survival may be filled. This is known as AGGRADATION. Streams have the capacity to flush sediments and cut back through sediments in a process known as DEGRADATION. Stream bed aggradation is usually accompanied by increased fine sediment and a change in the average particle size of stream bed materials.

To understand the amount and types of sediment that are being moved by a river, PEBBLE COUNTS are made. Pebble counts involve counting the number and sizes of the particles on the river bed and banks. A number of counts are made along the reach of the river. The movement of different sizes of rocks depends upon the size of flow and the gradient. Gravel, cobble, and boulders can only be moved by larger storm flows, so these tend to be "stored" in rivers for long periods of time. In a stable stream the location of gravel bars will remain relatively stable, although the composition and size of the bar might change seasonally or as a result of an unusually large storm event.

For this project 5 pebble counts were performed in the estuary and 25 in the lower 7-mile reach at the locations shown on the Pebble Count and Substrate Score Maps in Appendix I.

Pebble counts may also indicate whether or not fine sediment is being flushed out of the system. Another indicator of this are core samples, or SUBSTRATE SCORES of the bed or substrata of the river. Taking core samples provides a relative measure of the presence of fine materials in the spaces between the gravel beds in the river. Percent substrate embeddedness is defined as the percent of larger substrate materials that are surrounded by silts and sands. For example, an embeddedness of 65% would mean that most of the gravel and cobble of a streambed has sand and/or silt in the spaces between the individual rocks such that only 35% of a rock protrudes above the fine sediment. This is important because salmon spawn in these gravels and prefer certain sizes of gravel to form their REDDS, or nests, for the eggs. As percent substrate embeddedness increases, i.e., if there are too many fines in the spawning gravels, then habitat suitability tends to decrease because the eggs do not get enough oxygen from the surrounding water to survive. The general rule is that embeddedness over 55% indicates unsuitable habitat, although the exact figure may vary depending on the stream (Platts, 1990). This condition can also make it difficult for the young fish (FRY) to emerge from the redd causing mortality. Fines can also smother many species of aquatic life that young fish depend on for food (Bjornn & Reiser 1991).

During the study six substrate scores were made in the lower 7-mile reach at locations shown on the Pebble Count and Substrate Score Map in Appendix I.

## RIVER CLASSIFICATION

A relatively new system for understanding river characteristics, developed by David Rosgen, was used in this Plan. The ROSGEN STREAM CLASSIFICATION SYSTEM distinguishes streams by CHANNEL MORPHOLOGY, or the study of the form and structure of the river channel. The system requires careful measurement and study of five characteristics of a reach of river (Rosgen, 1991):

1) The confinement of the river, or how the width of the flood plain compares to the width of channel when it is full.

2) The width/depth ratio of the channel when it is full. For example, is it narrow and deep, or wide and shallow? (Cross sections are used to determine this ratio.)

3) The sinuosity of the river, or how the course of the actual river compares to a straight line between two points on the river.

4) The gradient of the river, or slope of the stream bed. (The longitudinal profile is used to determine this factor.)

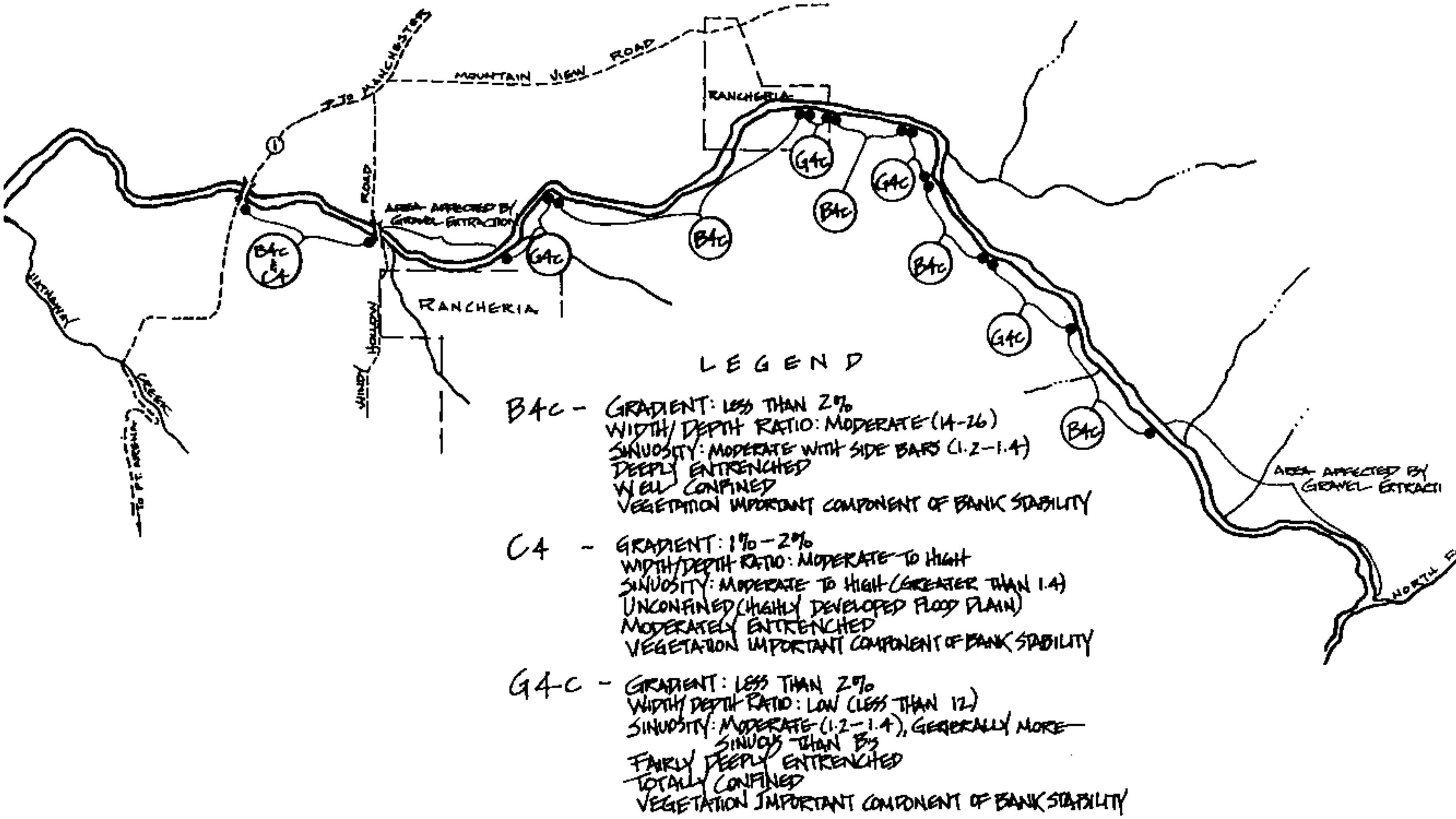
5) The makeup of bed and bank material, i.e., bedrock, boulders, cobble, gravel, sand, silt/clay. (Pebble counts are used in this element.)

Once these characteristics have been determined for a reach of channel, it is classified into a category using a key developed by Rosgen. The categories serve to predict the river's behavior, determine the need for restoration, and provide

MAP F: LOWER 7-MILE REACH

ROSGEN CLASSIFICATION SYSTEM

GARCIA RIVER - LOWER 7 MILES




MAP F: LOWER 7-MILE REACH GARCIA
ROSGEN CLASSIFICATION MAP

insight for recommendations for appropriate enhancement measures. (See Appendix II for further explanation of the Rosgen Stream Classification System.)

For this project the lower 7-mile reach of the Garcia was classified by the Rosgen stream classification method using cross sections, pebble counts, longitudinal profile, and other field measurements and observations, as well as aerial photo study. A preliminary classification of the main stem of the river using the Rosgen System is shown on Map F, however, this reach of the river does not fit easily into the Rosgen classifications applied here and required some "stretching". Several sections of this reach could not be classified at all because of human alterations to the natural channel: two gravel extraction sites and an area where the channel has been constricted by levee.

## FISHERY DATA COLLECTION EFFORTS

Salmon are ANADROMOUS fish, meaning they migrate from salt water to fresh water to spawn. For the salmon population to flourish, they need not only good spawning environments, but they also need to have good rearing environments where the young can feed and grow large enough to migrate downstream toward the sea. Good estuary habitat is essential because migrating fish (both juveniles going to sea and mature adults returning to spawn) need the brackish water of the estuary to adapt to the change in their environment. Finally, safe passage, free from physical barriers, is needed if the fish are to reach their spawning gravels in the upper reaches of the river.

A way to establish whether the river supports survival of fish is to map the areas along the river from the standpoint of being a fish. This is called FISH HABITAT TYPING. The river is surveyed by walking and observing the different channel forms and bank characteristics along it. The fisheries biologist or technician maps the presence and extent of such basic habitat types as POOLS, RIFFLES, and RUNS. The amount and type of cover, stream bottom composition, bank conditions, depth, and other features are noted. The system used for the Garcia River inventory is one devised by the California Department of Fish and Game (Flosi and Reynolds, 1991) and is modified from systems devised by Bisson et al (1982) and McCain et al (1990) A sample survey form is attached as Figure 5. Appendix II contains a more complete description of this inventory system and diagrams of basic habitat types excerpted from the California Salmonid Stream Habitat Restoration Manual (Flosi and Reynolds, 1991).

POOLS are probably better known to those who fish as "holes." These are the cool deep places in the river where fish like to gather during the summer when the flows are low, and in winter as resting areas while moving up river to spawn. Pools are needed to support the fish during critical low flow times, and without them, many fish cannot survive the summer months. Pools are categorized under habitat typing according to their position in the channel and by the elements around which they are formed such as bedrock, large logs, roots, or other features. Pools are depositional environments and can act to slow the flow of nutrients as they are flushed downstream by currents.

RIFFLES are areas of the stream with higher gradient. The falling waters have a turbulent surface which increases dissolved oxygen in these environments. Riffles are categorized by their steepness as low gradient (2% or less), high gradient (2-4%), or cascades (greater than 4%). The higher velocity of water flows through riffles and flushes fine sediments, often forming gravels suitable for salmon and steelhead spawning. Production of aquatic insects in the spaces within the gravel can also be quite high. Young of the year steelhead prefer the slower moving waters of low gradient riffles, while larger, one or two year old steelhead reside more in the swifter riffle habitats. If gravels in the riffles are clean, they offer excellent cover for young fish in spaces under the rocks.

RUNS are smooth water environments with less depth and greater flow than pools. A shallow flat water habitat is called a glide while one with greater depth is a run. In steeper tributaries, short water falls may separate runs in habitat units described as step runs. A run strewn with boulders with small pockets scoured behind them is called pocket water. If stream temperatures are cool, all types of runs will accommodate steelhead juveniles. Young of the year will most often use glides while older age fish will reside in deeper run habitats.

OBSTRUCTIONS or barriers to fish migration prevent migrating fish from reaching the upper reaches of the river preferred for spawning and building redds. Obstructions can be natural or man-caused. Culverts and road crossings are examples of man-caused barriers. Spawners can have a hard time swimming upstream through a culvert that is too high or that causes the water to flow too fast. Eliminating these kinds of barriers can increase the extent of the spawning areas and increase fish populations (Meehan, 1991).

Habitat typing includes identifying and rating shelter for fish in the river, such as undercut banks, large and small woody debris, root wads, vegetation, boulders, bedrock ledges, etc., and canopy, the vegetation that shades the stream. These are also critical factors to support an abundant fishery.

Recording water temperature is another part of habitat typing and a critical element for fish survival. Water temperatures are highest in late summer months when flows are low. This coincides with the period when young salmon (juveniles) need cool water to survive and grow. Cooler temperatures mean that more oxygen is available to the fish's gills, which allows them to be healthier and grow faster. Temperature levels and the resultant dissolved oxygen content of the water is another limiting factor for fish survival in a river.

The results of the habitat survey can show which habitats fish favor and therefore, can suggest some strategies for habitat improvement. Habitat conditions such as pool depth and frequency of occurrence of different habitat units can also suggest what impacts have occurred on the stream channel in the past and what stage of recovery the stream channel is in. Probably the most valuable aspect of habitat typing is that it can show changes in stream habitat over time if the same reaches are typed periodically. The habitat typing performed during this study will become the "baseline" survey against which all future surveys can be compared. (Flosi and Reynolds, DFG, 1991).

Finally, fish population estimates were done by DIRECT UNDERWATER OBSERVATION using methods devised by Hankin and Reeves (1988) in various habitat units throughout stream reaches surveyed. Divers with masks and snorkels swam upstream through habitat units and counted fish of various age classes. Field workers on the Garcia River survey used diagrams to show position of juvenile fish in the various habitat units and their use of cover.

Ocular fish surveys, Fish Habitat Typing Inventory, and Direct Underwater Observation Surveys were conducted in the estuary and lower 7 mile reach continuously (from River Mile 0.86 to River Mile 8.31, or from Minor Hole to the R & J crossing just below the North Fork Garcia confluence). In all 148 habitat units were measured and described on field forms covering 39,342 linear feet as measured by hip-chain along the thalweg (deepest portion) of the channel. DUO surveys were conducted in a random sample of habitat units, sampling every second pool unit, every third riffle unit, and every fourth flatwater unit. In all, 58 habitat units on the mainstem were inventoried by DUO. Habitat Typing Inventory and DUO were conducted on the North Fork Garcia between River Mile 0.5 and 5.05 (217 habitat units), and on the lower 4.1 miles of Pardaloe Creek (241 habitat units). Figures 5 and 6 are examples of the habitat typing forms used in this study.

Direct Underwater Observation and Habitat Typing surveys together show where the fish occur and whether or not a river is supporting the fisheries resource in a balanced way. **All data collected for this project, including Habitat Typing and DUO forms, is on file and available to the public at the Mendocino County Resource Conservation District Office in Ukiah.**

The fisheries data collected above has been summarized by computer and presented in spreadsheet and graphic form in "A Summary of Habitat Types and Biological Inventory of the Garcia River," prepared by Jan Derksen, Ph.D., December 10, 1991, and can be found in Appendix II.

# FIGURE 5: SAMPLE HABITAT TYPING INVENTORY FORM

**HABITAT INVENTORY FORM** Form # 23 of 24

Date 9/6/91 Stream Name GARCIA RIVER T 12N R 16W S 3 & 4
Surveyors GARY PETERSON & MAUREEN ROCHE & TERI BARBER Flow ____
Channel Type ____ Reach # 2 Time 1615 Water Temp 69 Air Temp 71

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Habitat Unit Number | 132.1 | 133 | 134 | 135 | 136 | 137 | 138 | 139 |
| Habitat Unit Type | | 5.2 | 5.3 | 5.2 | 5.3 | 5.1 | 1.1 | 5.2 |
| Side Channel Type | 6.4 | | | | | | | |
| Mean Length | 197 | 135 | 152 | 99 | 235 | 412 | 164 | 85 |
| Mean Width | 14 | 41 | 31 | 23 | 19 | 66 | 48 | 58 |
| Mean Depth | 1.8 | 1.4 | 2.5 | .4 | .7 | 2.5 | .3 | .4 |
| Maximum Depth | 4.2 | 3.5 | 3.8 | .8 | 1.9 | 5.2 | .7 | .9 |
| Depth Pool Tail Crest | | .4 | .7 | | | .4 | | |
| Pool Tail Embeddedness | | 2 | 2 | | | 2 | | |

**SHELTER RATING**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Shelter Value | 3 | 3 | 3 | 0 | 1 | 3 | 0 | 0 |
| % Unit Covered | 60 | 52 | 42 | | 20 | 45 | | |
| % undercut banks | 5 | 5 | 5 | | 5 | 5 | | |
| % swd (d<12") | 15 | 10 | 10 | | 5 | 10 | | |
| % lwd (d>12") | 20 | 20 | 5 | | | 5 | | |
| % root mass | | 2 | | | | 5 | | |
| % terr. vegetation | 20 | 15 | 20 | | 10 | 20 | | |
| % aqua. vegetation | | | 2 | | | | | |
| % white water | | | | | | | | |
| % boulders (d>10") | | | | | | | | |
| % bedrock ledges | | | | | | | | |

**SUBSTRATE COMPOSITION** (Select two most dominant compositions)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Silt/Clay | | | | | | | | |
| Sand (<0.08") | 1 | 1 | 1 | 1 | 2 | 1 | | 2 |
| Gravel (0.08-2.5") | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 |
| Sm Cobble (2.5-5") | | | | | | | 1 | |
| Lg Cobble (5-10") | | | | | | | | |
| Boulder (>10") | | | | | | | | |
| Bedrock | | | | | | | | |
| % Exposed Substrate | | | | | | | 5 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PERCENT TOTAL CANOPY | | | | | | | | |
| % Deciduous Trees | 80 | 20 | 10 | 5 | 20 | 20 | 0 | 5 |
| % Coniferous Trees | | | | | | | | |

**BANK COMPOSITION** (See bank composition types below)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Rt Bk Dominant Type | 7 | 7 | 4 | 7 | 7 | 7 | 7 | 7 |
| % Rt Bk Vegetated | 60 | 90 | 80 | 50 | 60 | 90 | 90 | 50 |
| Lft Bk Dominant Type | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| % Lft Bk Vegetated | 90 | 70 | 70 | 70 | 70 | 100 | 90 | 90 |

************* COMMENTS *************

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0.4' CRAYFISH CUTALDERS FOR FISHING (LB) (RO) STEEP GLASSY BEDROCK BEHIND | | | | (LB) UPSTREAM END OF ISHIZAKI BAR | REDD 3' x 4' | SEVERAL X-SECTION FLAGS @ DOWNSTREAM END OF UNIT |

**BANK COMPOSITION TYPES**

1) Bedrock
2) Boulder
3) Cobble/Gravel
4) Bare Soil
5) Grass
6) Brush
7) Deciduous Trees
8) Coniferous Trees

# FIGURE 6: SAMPLE DIRECT UNDERWATER OBSERVATION (BIOLOGICAL INVENTORY) FORM

**BIOLOGICAL INVENTORY FIELD FORM** Form # __ of __

Date 9/6/91 Stream Name Garcia River T 12N R 16W S 4

Observer T. Barber Time 13:30 Water Temp ____ Air Temp ____

Reach # 2 Habitat Unit # 133 Habitat Type LSL= 5.2

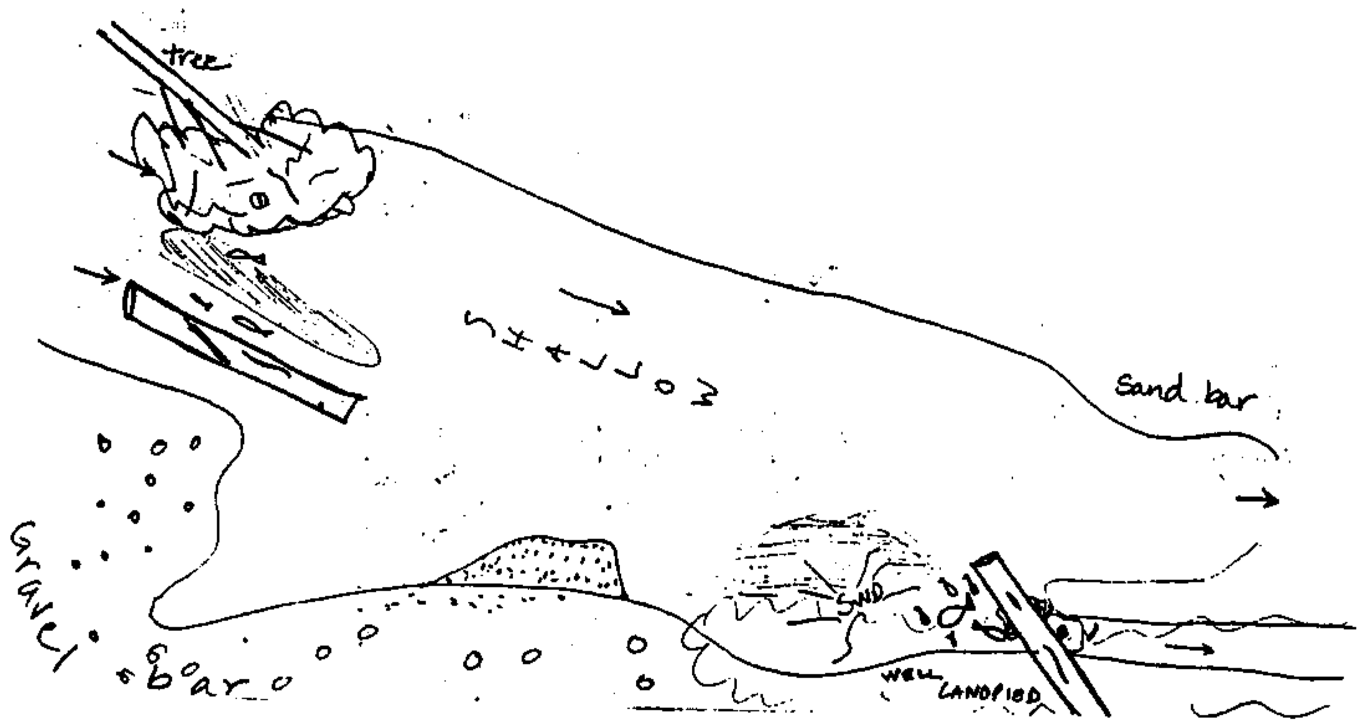
Method: Direct Observation ____ Direct Underwater Observation ✓

Seine ____________ Electrofishing ____________

Visibility excellent: 20'+

| Species | Size Class | Numbers | Species | Size Class | Numbers |
|---|---|---|---|---|---|
| Sh | 0+ (0-4") | 85 | | | |
| Sh | 1+ (4-6") | 215 | | | |
| Sh | 2+ (6-8") | 13 | | | |
| | | | | | |

Comments Pool is located upstream of tributary entering downstream right. Fish highly concentrated at top of long, narrow side water, above LWD & between boulders(6) and SWD. This portion of pool is very well canopied. Small school between LWD & tree at upstream end.



## ADDITIONAL INFORMATION

Following is a description of other methods used to collect information in specific areas of the Garcia Watershed as part of this project:

ESTUARY: (mouth to River Mile 1.38)

Depth measurements of estuary made by measuring rod and canoe at high and low tides.

Photo points were established to document future changes in estuarine configuration.

Sediment strata were observed at four sites in estuary bars and one site in an adjoining field. (This entailed the excavation of trenches to the depth of water level or to the extent of the reach of the trenching equipment to observe depth of various strata, sizes of material, etc., to gain information about sediment deposits over time.)

Three sites in the estuary were seined. (This entailed sampling of the fish population using a large net, a small boat, and a number of people. Fish collected were returned unhurt after being counted.)

LOWER 7 MILES: (River Mile 1.38 to river Mile 8.31)

Late summer flows were measured at 5 stations using a "pygmy" flowmeter. (Sites marked on Map I.)

Late summer water temperatures were monitored at two stations using maximum/minimum thermometers. (Sites marked on Map I.)

UPPER WATERSHEDS: (North Fork Garcia and Pardaloe Creek)

Late summer flows were measured.

Major water courses were walked and mapped noting stream characteristics, and current and potential erosion problems.

Roads were mapped noting stability, poorly placed landings, and current and potential drainage/erosion problems.

Unstable or problem areas upslope were identified and mapped for future treatment.

All fish surveys for this project were conducted by fisheries biologist Gary Peterson, who carried out work during summer and early fall of 1991 with the help of several assistants. Patrick Higgins, fisheries biologist, helped analyze and interpret the data collected for this Plan. Joe Friedkin was consulting hydraulic engineer on the project.

Finally, in conjunction with current technical information about specific reaches of the Garcia River, this project relied upon the following information:

1) Extensive research at libraries, historical societies, and agency and timber company files, which produced a variety of early maps and aerial photos, as well as some records and written material about the area.

**Historical maps:**
1870 U.S. Coast Survey Map of Point Arena and Vicinity, surveyed by Louis A. Sengletten (Pt. Arena Lighthouse)
1883 U.S. Coast and Geodetic Survey, Hydrographic Map and field notes (California State Lands Commission)
1915 U.S. Army Corps of Engineers, Point Arena Quadrangle Tactical Map (UC Berkeley Map Library)
1929 U.S. Coast and Geodetic Survey, Topographic Map and Field Notes (California State Lands Commission)
1942 and 1960 USGS topographical maps (USGS, Menlo Park, California)

**Aerial photographs:**
1937 (UC Berkeley Map Library)
1952 (SCS/MCRCD office, Ukiah, California)
1965 (SCS/MCRCD office, Ukiah, California)
1988 (SCS/MCRCD office, Ukiah, California)

**Rainfall records:**
1902-1941 Point Arena Lighthouse
1939-1988 (non-continuous) Point Arena
1965-1986 Manchester (Puffer, 1991)
1978-1991 Garcia River southeast of Eureka Hill Road (King, 1991)

2) About 20 extended interviews with long-time residents of the Garcia community, which included their memories, records, opinions, and hopes for the river.

3) Responses from questionnaires sent to landowners in the watershed. (Approximately 25%-30% responded.)

**All data collected for this project, including that discussed above, is on file and available to the public at the Mendocino County Resource Conservation District Office in Ukiah.**

All of these methods were used to collect information about the Garcia River. The combined information creates a snapshot or synoptic view of the conditions of the river at this point in time. Based on the analysis of the data, recommended treatments and actions were developed. These findings and recommendations for enhancement measures are discussed in Part 3 of the Plan.

# PART 3: Findings and Enhancement Recommendations

The main objective of this project is to recommend enhancement measures for the Garcia River Watershed in keeping with the Plan Goals of restoring the salmonid fishery and fostering the conservation, restoration and wise use of the river's natural resources. The following section sets forth an analysis of findings and the recommended enhancement measures for each area of the watershed studied: The Estuary, the Lower 7-Mile Reach, and the Upper Basins (North Fork Garcia and Pardaloe Creek) as well as General Recommendations that apply to the watershed as a whole.

Although extensive data was collected on the Garcia as part of this project (as noted in the previous chapter), the lack of recorded historical information made objective comparison and study of changes very difficult. The lack of hard historical data has two effects on the current study:

1) The current data base has become the beginning of a comprehensive study of the Garcia and provides the "baseline" data to which all future studies and monitoring can be compared; and

2) Objective analysis of data gathered has been limited to those areas where historical data did exist — for example, the shape of the estuary in the 1937 aerial photo can be compared to the shape of the estuary in the 1988 aerial photo, and certain conclusions can be drawn. Beyond those areas where comparison was possible, the findings and recommendations are based on the opinions of technical "experts" and their experience concerning the measures needed to restore the resources of the Garcia.

**This study did not reveal a few simple conclusive answers to the questions of WHY the Garcia River salmonid fishery is in decline. It did produce baseline data for future comparison and trend analysis AND the following analysis of findings. Based on these findings, long-term goals and short-term implementation priorities follow. Enhancement recommendations are then presented for each sub-basin, beginning with the estuary and moving upstream, although this order is NOT an indication of the treatment priority for the basin. The recommended measures are based upon the technical analyses and input from the Garcia community.**

### Setting Priorities

This Plan does not encompass the entire watershed. Due to limitations of both time and money, it focused on the major lower reaches, the lower seven miles of the river and the estuary, and used representative basins (North Fork and Pardaloe Creek) to draw some conclusions regarding other upper tributary basins and their potential effects on the downstream reaches. This approach is not without problems, particularly when determining priorities for implementing treatments in any given basin or river reach. This problem can be overcome by setting both long-term and shorter term implementation goals based on the overall findings of the study and practicability. Such goals enable a rational decision-making process to determine which treatments should be applied where, and in what order.

Given that a major Overall Goal of the community and the Plan was to restore the salmonid fishery (see page 1-2, No. 2), and that the condition of the fishery is an indicator of the overall health of the watershed, those findings related to improvement of the salmonid population can be seen as paramount in setting implementation goals. **Four key findings emerge from the analysis, and are summarized below:**

- Steelhead trout are relatively abundant compared to Coho Salmon populations; in fact, Coho may be at high risk of extinction in the Garcia.

- There are habitat areas in the mainstem, mainstem tributaries, and upper tributaries (based on North Fork) which currently support Coho and steelhead reproduction (see pages 3-26 and 3-43,44).

- **High chronic levels of in-channel sediment** have reduced channel diversity and depth of pools, and **represent a limiting factor for salmonids** in all three of the basins studies (pages 3-27, 3-43, 44), and presumably other tributaries in the watershed.

- High water temperatures were a limiting factor for all species in upper tributaries with inadequate riparian cover (based on Pardaloe, page 3- 44 top). Relatively high temperatures in the mainstem may be a limiting factor for Coho. The highest temperatures were noted on one upper tributary indicating that some, but not all, of the tributaries contribute to increased temperature levels in the mainstem.

**Based on these findings the Long-Term Implementation Goals, in order of priority, would be to:**

1. Protect existing habitat areas from further degradation, and extend habitat in areas that would be conducive to Coho spawning and rearing.

2. Restore the riparian corridor, to the extent feasible, to approximate the

historic extent and vegetation mix found prior to intensive logging and type conversion.

3. Reduce the limiting factors of lack of habitat diversity and high temperatures by restoration of upper tributaries first. **The overall finding of this project is that the key to improving the fisheries resource in the Garcia Watershed lies in the upslope tributaries where excessive sedimentation has had a major effect on the stream channel and habitat.**

4. Focus on the restoration and enhancement of fish habitat of the lower river, once upslope tributaries have been stabilized. Because many of the problems observed in this reach of the river are caused by excessive sedimentation from the upslope tributaries, reduction of these sediment sources should, in theory, allow for the river to naturally flush stored sediment over time. There are some existing sediment sources contributing directly to the sediment loading in the river, however, treatment of these sites may be considered a lower priority because their effectiveness would be doubtful given the overweighing effects of the upstream sediment contribution.

5. Focus on treatments in the estuary, if necessary, after completion and evaluation of the upslope restoration program.

6. Assess the effectiveness of treatments through a program of water quality and fish population monitoring.

Once the long-term goals have been set, the short-term implementation goals become apparent: that is, to concentrate initial implementation work on the upslope tributaries where there is the opportunity to satisfy elements of long-term goals 1, 2 and 3. This approach is also preferred because upslope treatments can be undertaken in the form of small-scale projects which involve relatively simple planning and permitting processes. These projects will require the voluntary cooperation of the landowners and could be carried out with the assistance of community groups. Such projects have been successfully carried out on other coastal streams by the Resource Conservation District and other local organizations which could be called upon for their assistance and expertise.

**Specific Short-Term Implementation Goals include:**

1) Continued evaluation and assessment of the remaining tributary subbasins in the watershed. Only those sub-basins that have been evaluated should be targeted for treatments.

2) Reduce sediment delivery from upslope erosion sources through implementation of conservation practices.

3) Stabilize eroding streambanks using large organic debris and revegetation to provide instream structure and habitat diversity.

4) Reduce temperature loadings by revegetating riparian areas to provide shade, bank stability and cover for fish populations.

5) Reduce stored instream sediment, where prudent and feasible, to prevent bank failure and improve aquatic habitat.

Based on these goals there are two sub-basins that are potential high priorities for treatment ~ the North Fork Garcia and Pardaloe Creek. Both are upper tributaries and have been evaluated for treatment. Of these two sub-basins the North Fork seems to be the best place to begin for a number of reasons:

- The North Fork (discussed later in this section) has special factors which favor recovery, including good riparian cover and lower water temperatures which favor Coho habitat.

- The majority of the watershed is owned by one landowner who has expressed a willingness to become a cooperator in such projects. (Voluntary cooperation of the landowner is needed before any of the proposed recommendations can be initiated.)

- Baseline data has been gathered which would allow for monitoring and evaluation of the effectiveness of the proposed treatments. This includes an ongoing monitoring study conducted by the North Coast Regional Water Quality Control Board (NCRWQCB). The study consists of monitoring of winter storm events at 10-15 stations. Parameters include turbidity, suspended sediment and photo-points. In addition, summer stream flow measurements (low flows) are taken once per year at five stations. At each of these summer sites pool surveys consisting of cross-sections, McNeil samples and substrate scores are made. (McNeil scores from 1989-91 can be found in Appendix II). To date, the Board has taken over 150 McNeil samples which have shown a relatively high percentage of embeddedness (i.e., fines in gravel, see page 2-5). The Board intends to continue the program for another 2- 3 years — interim analysis of the data is expected to begin in the fall of 1992 (pers. comm. Charles Green, NCRWQCB).

This recommendation does not preclude implementation of enhancement measures at work sites in Pardaloe Creek, which could occur simultaneously with work on the North Fork. Ultimately, the decisions regarding implementation of treatments will be set by the Watershed Advisory Group, the landowners, cost/benefit considerations and available funding. The recommendations presented below are applicable to many sites in the sub-basins of the watershed, preliminary cost estimates are presented in Appendix IV to provide a comparison among the treatments.

## Area 1 : The Estuary

The Estuary of the Garcia River, that part of the river where fresh water originating from land drainage mixes with seawater, extends from the outlet to the confluence of Hathaway Creek (River Mile 1.38). (On extremely high tides the current area of tidal influence extends beyond this point, but for the purposes of this report the estuary is considered to end at River Mile 1.38). The Garcia Estuary is somewhat unique among North Coast estuaries in that the mouth stays open to the sea year round. Estuaries serve as nurseries for the juvenile stages of many fish species. For anadromous species, estuaries act as a transition or buffer zone, where migrating juveniles and adults gradually adapt to environmental differences between freshwater and saltwater habitats. Juvenile King (Chinook) Salmon and, to a lesser degree, Silver (Coho) Salmon, live temporarily in estuaries before moving into the ocean. Their favorite habitats are tidal creeks, drainage channels, and marsh meadows, where the major food source tends to be organisms that feed on decomposing organic matter (invertebrate detritus feeders) (Adams and Whyte, 1990).

Estuary configuration is largely determined by the magnitude of the river flows, the volume of sediments entering the estuary, and the tidal prism (the space in the estuary at low tide that is filled at high tide). In general, the larger the inflows and the larger the tidal prism, the greater the scouring power for maintaining a deep entrance channel and for extending the area of tidal influence upstream. When the tidal prism is reduced by sediment deposits, land reclamation, or other causes, the energy source that scours channels and carries sediment to the ocean is also reduced. In their natural state, most estuaries have areas of tidal marsh, inter-tidal mud flats, sand flats, and deep slough channels with a variety of habitats.

As noted in the Physical History of the Garcia River (Part 1), major changes have occurred in the configuration of the estuary over the past 120 years. According to the earliest available map, drawn in 1870 by the U.S. Coast Survey, the river at that time ran against the west bank, along the rock bluffs near the mouth for approximately 2,100 feet. This configuration would almost certainly have provided scouring action that would have resulted in deep pools and well defined tidal channels. The mouth itself was constricted by sand dunes and vegetation and appeared to be a permanent feature, not significantly affected by high tides and swells, or by flooding of the river. This feature is believed to have confined all waters passing in and out of the estuary to a narrow outlet. It is impossible to estimate historical tidal prism in the estuary because of lack of bathymetric (depth) measurements and records of the upstream extent of the estuary. (See 1870 Map, page 1-15.)

By 1929 historical maps show a widening of the "Bay" as it has come to be called (See 1929 map, Appendix I). The actual cause of this widening is unknown, although study of maps and aerial photos suggests that other periods of widening may have occurred over the past centuries as the river attempted to establish equilibrium in its function of transporting water and sediment.

One possible cause of widening could have been aggradation, or filling in by sediments deposited by the river during major high flows or floods. It appears from estuary depths and cross sections taken in 1991 (see Appendix I, Cross Section sites) that the estuary may be generally shallower than it was in the memories of old-timers interviewed. However, excavation to examine sediment strata in the estuary — with the possibility of revealing thick layer(s) of coarse sediment and gravel or of silt deposited by major flood event(s) of the past — showed some stratification but not thick layers that could be identified as major flood deposit.

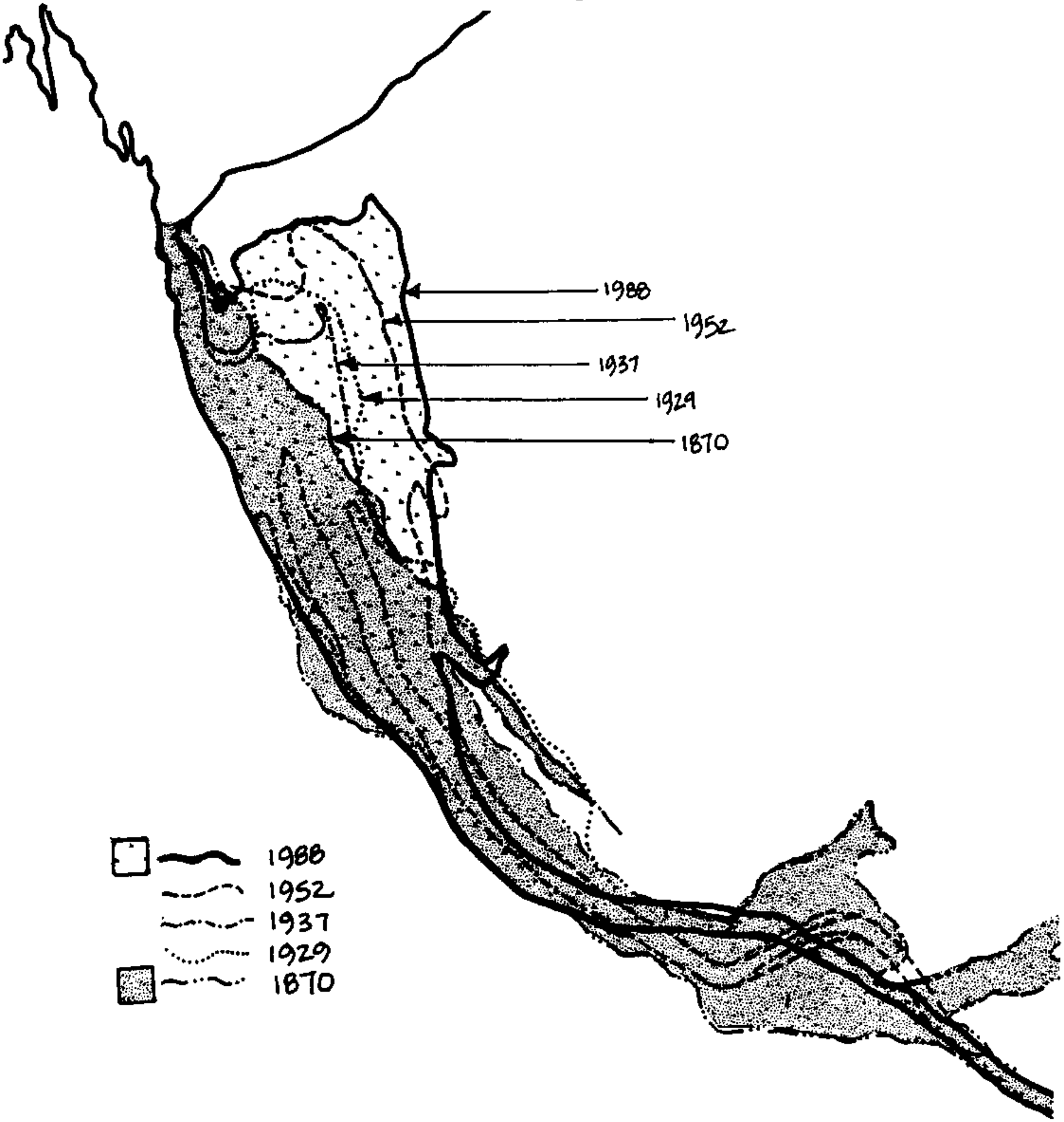
Map G shows approximate changes in the configuration of the estuary over the period from 1870 to 1988, as derived from aerial photos and maps.

Of specific interest are the changes that have occurred in what was once the east (right) bank, at the outlet of the estuary. Although the narrow outlet along the bluff has remained intact, the area on the east has changed from impenetrable vegetated dunes that provided a 650' wide buffer zone between ocean and bay in 1937 to a 250' wide low-lying sand bar today that is overtopped by very large waves at high tide. The continued widening of the bay (erosion of right bank) combined with the loss of size and stability of the bar separating bay from ocean suggest the possibility that the bar could breach. This would create a new outlet for the river, away from the bluffs, and could eventually result in the closing of the outlet during low summer flows. This would have a negative impact on the estuarine community, especially the anadromous fish, and could also cause flooding of adjacent agricultural fields.

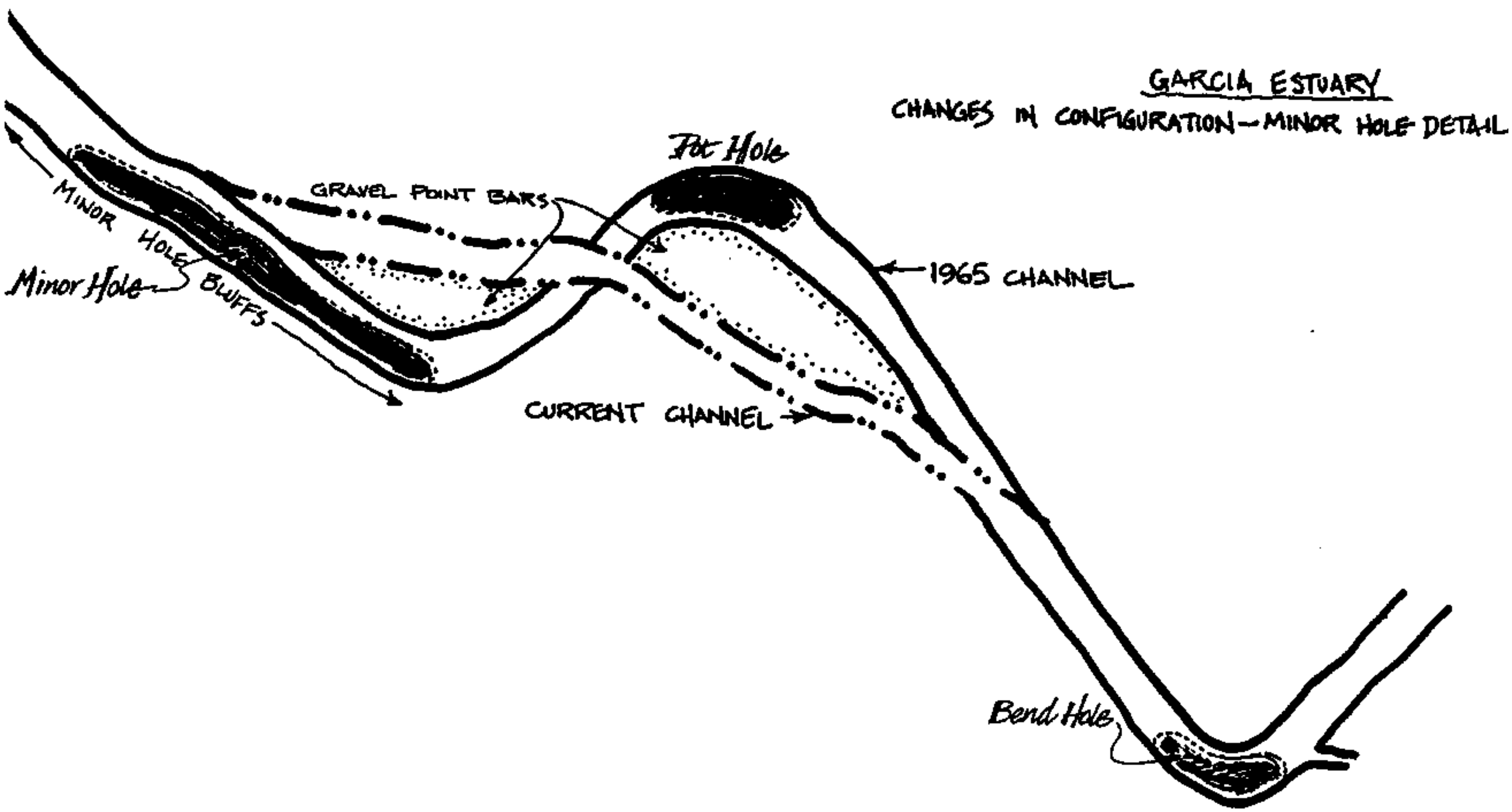
Changes in configuration also occurred in the upper estuary, where the river once made a sharp bend at Pot Hole and ran directly into the bluffs at Minor Hole, creating the "best" (or at least the biggest, deepest, and most talked about) fishing hole on the Garcia as late as 1965. Sometime between 1965 and 1988 the integrity of the point bars that defined the curves of the channel was breached. The river took on a new, straighter alignment, eliminating the direct force of the river against Minor Hole Bluffs and the scouring action that created Minor Hole. Map H shows approximate changes in configuration of Minor Hole.

It is difficult to determine the extent to which the changes in the estuary configuration have contributed to the decline of the salmonid population in the Garcia River.

MAP G: GARCIA ESTUARY ~ CHANGES IN CONFIGURATION 1870 – PRESENT



# MAP H: GARCIA ESTUARY - CHANGES IN CONFIGURATION MINOR HOLE DETAIL



According to information gathered from long-time residents of the Garcia community, the King (Chinook) Salmon were the first salmon species to decline. Chinook, the largest of the salmon, would have relied on lower river reaches for spawning and rearing. Juvenile Chinook salmon show extended periods of feeding in estuarine environments; the additional growth before ocean entry has been shown to be a key to high ocean survival. Chinook salmon survival would have been greatly decreased as critical spawning and rearing habitat in the estuary was filled in (Reimers, 1973). Estuary restoration could be one element of saving the remnant King (Chinook) salmon run which is rumored to exist. (No Chinook were observed during field surveys on this project.) However, loss of critical spawning habitat, especially in lower tributaries is one key to population decline.

In the estuary and lower Garcia, high summer water temperatures are a primary limiting factor for juvenile Silver (Coho) Salmon survival, although not for steelhead at present. Water temperatures in the estuary in early September 1991 ranged from 53 degrees F to 71 degrees F (11.7 degrees C to 21.7 degrees C) and averaged about 67 degrees F (17.8 degrees C). Overall these temperatures are above the preferred range for rearing juvenile Coho Salmon, and in fact, steelhead (0-2 years) were the only species seen during extensive snorkeling (DUO) in the estuary and lower 7 miles. However, seining done in late October 1991 at three sites in the estuary (Bend Hole, Upper Minor Hole, and Log Jam Hole) collected, in addition to 81 juvenile steelhead, 2 adult steelhead and one adult Coho Salmon.

Maintaining the open mouth of the river may be critical to the fisheries resource and the rest of the estuarine community in that it provides cooler estuary water temperatures (due to tidal movement) and unrestricted access to, and exit from, the river for salmonids. Beyond that, there are no conclusive answers to explain the decline.

Following are recommendations for restoration of the Garcia Estuary: (Please note that supporting information and diagrams for all the recommendations are found in Appendix III.)

**RECOMMENDATION 1.1A: Realign upper estuary channel to recreate the deep hole against Minor Hole Bluffs. Evaluate changes resulting from such realignment.**

Note: The first step in implementation of Recommendations 1.1A and 1.1B (below) would be to gain land owner approval for a feasibility study. Further, permits for such a project would be required from a number of agencies, including the Coastal Commission, DFG, Corps of Engineers, and others.

Realignment of the upper estuary would begin approximately 1000 feet downstream from Bend Hole (the confluence of Hathaway Creek and the Main Stem Garcia) and continue for approximately 1400 feet to the Minor Hole Bluffs. At the present time, the river crosses over to the left bank at this point during low flow. (See Work Site Map 1.1A & B: Proposed Estuary Realignment.)

The recommended realignment would create a gentle meander pattern which approximates the alignment of this portion of the estuary in 1870. Aerial photos from 1952 and 1965 show sharp bends at Pot Hole and Minor Hole, which are not the most suitable alignment for this reach for two reasons:

1) The flow tends to deflect off the Minor Hole Bluffs instead of following them, which limits the area of the hole; and

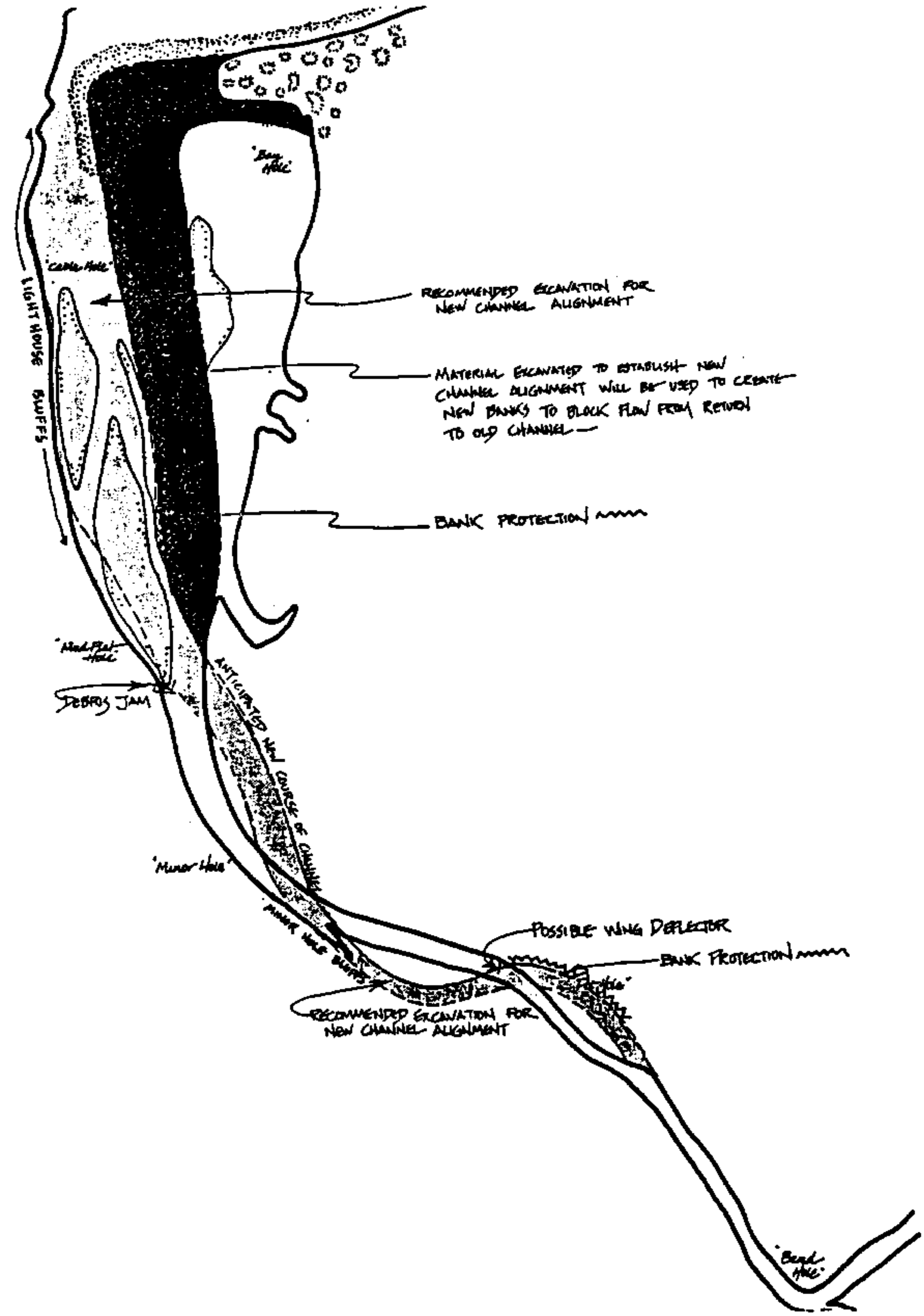
2) It appears that bank failure occurred at the apex of the curve at Pot Hole between 1952 and 1965. Bank failure is common on overly sharp bends. The new alignment should provide a more stable right bank, protecting the agricultural fields, and should create maximum scour along the bluffs, providing pool length and depth. It is recommended that the right bank of this new alignment be armored with large organic debris and large willow transplants. (See Appendix III, Large Debris Revetment Diagrams.) Other methods of bank protection, such as pilings, rock rip rap, etc., can be used as alternatives or in addition to organic debris. This realignment should reduce the force of the river flow against the left bank below Minor Hole, which is currently experiencing some failure. It may create some scour on the right bank in the future, although old maps show bars on the right bank with a very similar alignment. This is an area to watch carefully if this recommendation is implemented, and protection of any stressing banks should be provided as necessary.

**RECOMMENDATION 1.1B: Realign lower estuary channel from Minor Hole to mouth, following bluffs on west (left) bank and increasing wetland area near east (right) bank.**

(See Recommendation 1.1A above for note regarding land owner approval, feasibility study, and permitting process.)

Realignment of the lower estuary would start about 2600 feet upstream from the mouth of the river, near the site of the original Mud Flat Hole, and Just below the site of the current log jam which blocks the farthest upstream remnant of historic left bank channels. At present, this logjam provides the best fish habitat in the lower estuary and should be left intact, if possible, while excavating and armoring banks to create new alignment. The proposed realignment would extend approximately 2000 feet from this point toward

WORK SITE MAP 1.1A & 1.1B: GARCIA ESTUARY ~ PROPOSED REALIGNMENT



the mouth of the river. (See Work Site Map 1.1A & B: Proposed Realignment.)

If the proposed upper estuary channel realignment (Recommendation 1.1A) is carried out and the river follows the expected course in response to that change, the river should flow naturally into the proposed lower estuary channel realignment (Recommendation 1.1B). This would return the river to a channel that flows in a fairly straight line to the mouth, similar to that shown on the 1870 map (Map D).

This new alignment would provide the following:

1) Scour along the Lighthouse Bluffs for an additional 1500 feet, which should create high quality holding pools for cover, providing protection for returning spawners as well as excellent habitat for juvenile fish;

2) Protection against erosion of east bank of lower estuary, which has adversely affected fish habitat; and

3) A more efficient channel which would enable transport of sediment more efficiently because of the narrower configuration and scour potential of the rock bluffs.

In addition, to the extent that the channel alignment is straightened, flood flows and tidal flows will increase scouring action and help to deepen pools and transport sediment to the ocean.

It is recommended that the material excavated to establish the new channel alignment be used to create new banks to block the main flow from returning to the old channel. Engineering studies would be required to determine elevations for the newly created east bank to ensure that the main flow is confined in the newly excavated channel while allowing for overflow of flood waters and high tides into newly created wetlands (the current Bay area) on the east. Bank protection (See Appendix III, Large Debris Revetment Diagrams) should be placed along the newly built-up banks, using large woody debris found on-site and as much imported material as needed to stabilize banks. It may be necessary to use pilings in some places to secure debris and provide stability for fill. This structured bank protection will provide excellent fish habitat.

Woody debris, a natural part of the estuarine environment, can have an adverse effect on vegetation and intertidal habitat if it occurs in excess and/ or in compacted clumps on mud flats and marsh lands. In this case, however, it is suggested that large woody debris in the Garcia estuary be used for bank stabilization and/or fish habitat structures

Vegetative species adaptable to estuarine environments should be planted to protect banks and to provide habitat. For example, Eelgrass *(Zostera marina),* a marine grass-like seed plant which roots in firm sand or sand/mud substrates in low tidal zones of protected coastal areas, provides spawning and rearing habitat for fish and also traps and stabilizes sediments. Experimentation with transplanting of Eelgrass is currently being carried out with some success in several northern California estuaries (Adams and Whyte, 1990). Research into appropriate estuarine vegetation is needed to understand its role in providing bank stability and protection, and fish habitat enhancement.

**RECOMMENDATION 1.2: Reestablish high vegetated sand bar to ensure that it is impenetrable by high tides, swells and major floods. (Note: if Recommendations 1.1A and 1.1B are implemented, this recommendation may become unnecessary.)**

It is recommended that the sand bar currently separating the Bay from the ocean be built up and made wider to provide an impenetrable barrier against high tides and large swells as it did in earlier times and to ensure maintenance of an open river mouth.

This recommendation is related to lower estuary realignment Recommendation 1.1B above, in that sand and gravel excavated during realignment could be used to increase height of the existing bar. If material is not available from realignment, it must be obtained from another source. Large driftwood debris found on the site could help stabilize the sand bar until the root binding capacity of re-planted dune vegetation provides long-term stability. Special erosion fabric may be necessary as a temporary protection measure until the increased width and height of the bar, in combination with vegetation and large woody debris, could provide structural integrity.

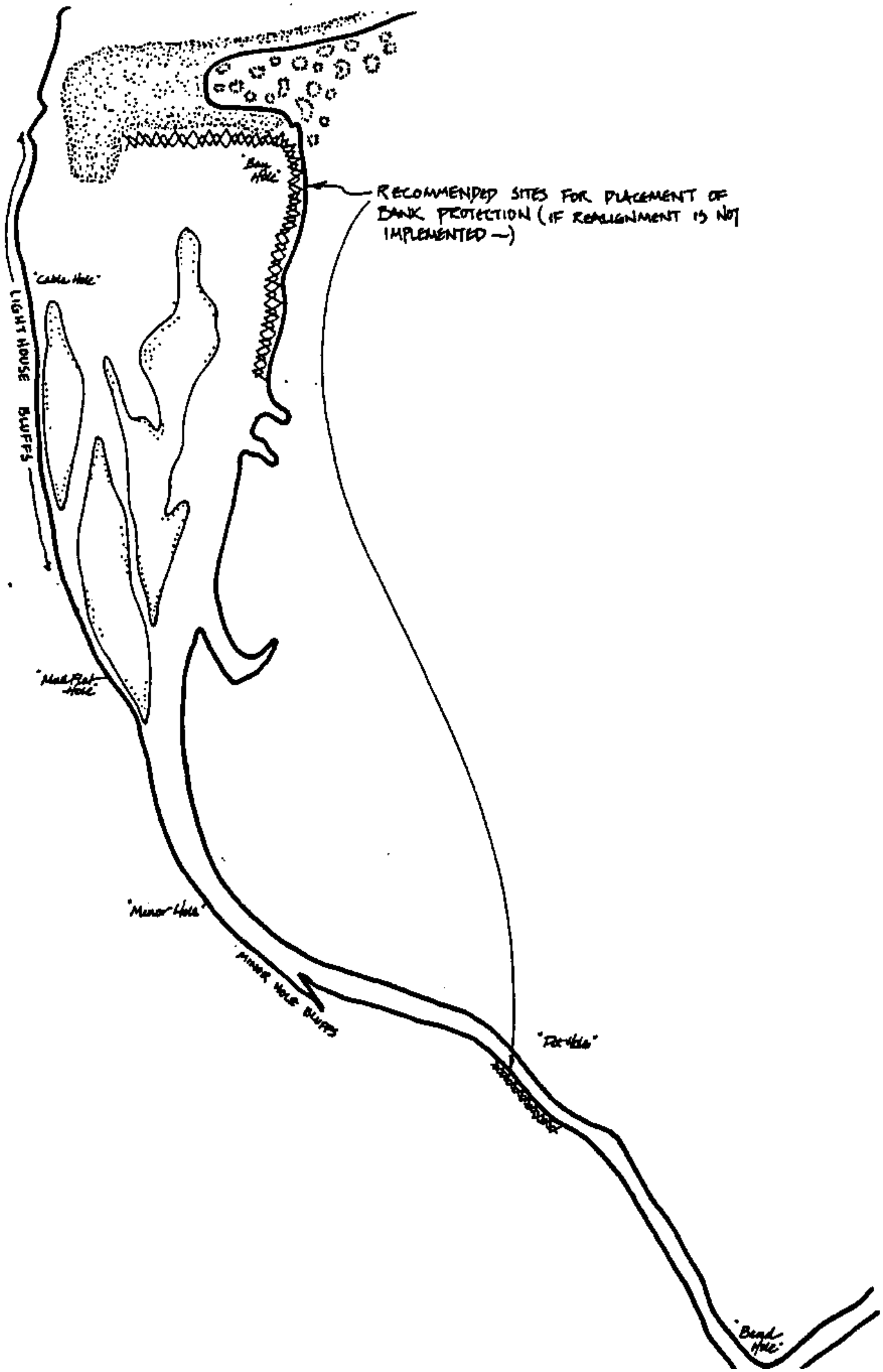
This type of treatment has not been attempted before. It is possible that implementation of Recommendations 1.1 A and 1.1 B could prevent future problems with the sand bar, but the effectiveness of these recommendations are unknown. Prior to undertaking Recommendation 1.2 intensive further studies should be conducted.

**RECOMMENDATION 1.3: Protect eroding banks if proposed realignment is not carried out.**

The lower east (right) bank of the estuary has been eroding since the 1920's and is one of the main factors causing a wider and shallower estuary. If channel realignment proposed in Recommendation 1.1B above is not carried out, bank stabilization of the lower east (right) bank will be necessary.

In this case, bank protection should be placed along the east bank, as shown on Work Site Map 1.3, using large organic debris on-site and as much

# WORK SITE MAP 1.3: GARCIA ESTUARY – PROPOSED BANK PROTECTION SITES



imported material as necessary to stabilize the area. (See Appendix III, Large Debris Revetment Diagrams.) It may be necessary to use pilings in some places to secure debris. This bank protection should also create excellent fish habitat by providing complex cover as well as a solid surface for scour which should result in deeper pools. Planting of vegetation adaptable to estuarine environments should be used to help protect banks and provide habitat as discussed in Recommendation 1.1B.

**RECOMMENDATION 1.4: Reestablish large complex organic and inorganic debris cover for fish in estuary area to provide cover, scouring action for deeper holes, and food for fish. Imitate structure and function of existing cover features in estuary, specifically the submerged jam debris accumulation at Mud Flat Hole.**

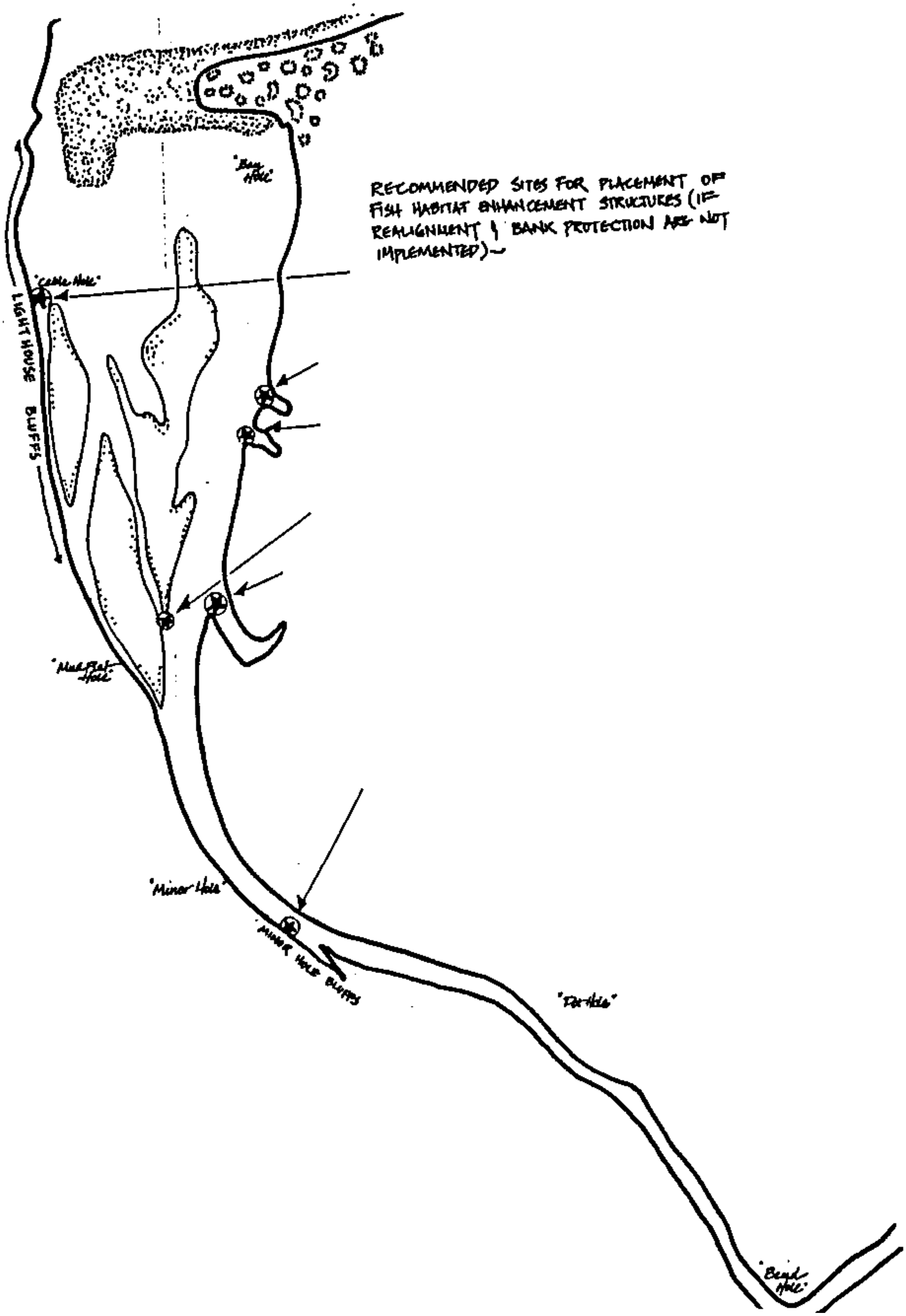
> One of the most critical components of salmonid habitat is cover.... Cover requirements vary between species and size of fish, and between time of day and season. For this reason, salmonid streams, especially those supporting more than one species, should contain a diversity of cover types. Submerged cover such as large organic debris, boulders, rubble, and aquatic vegetation provide protection from predators, while overhead cover, such as floating debris, undercut banks, turbulence and overhanging vegetation, provide shade and lower water temperatures, as well as protection. Pools are also an essential element of salmonid habitat. They provide refuge for salmonids during periods of flood and drought, and protection from predators. (MacDonald, 1990.)

If Recommendations 1.1 A and 1.1B (realignment) or 1.3 (bank protection) are implemented, large complex organic and inorganic structure will be incorporated into bank protection measures, and no additional structure will be necessary. If these recommendations are not implemented, Work Site Map 1.4 designates recommended structure sites. Appendix III, Large Debris Revetment Diagrams show recommended instream structures for enhancement of fish habitat and bank stabilization.

**RECOMMENDATION 1.5: Re-establish tidal marsh areas.**

The Garcia Estuary is lacking in tidal marsh areas. These areas are critical to the estuary environment both for providing refuge and food for a wide variety of fish species, including salmonids, and for stabilizing sediments and protecting against erosion. If lower channel realignment Recommendation 1.1B is implemented, the current Bay is ideally suited to becoming a marsh meadow. In any case, the creation of marsh areas in the estuary should be encouraged, if further study determines that a marsh restoration project would be cost effective.

WORK SITE MAP 1.4: GARCIA ESTUARY – PROPOSED FISH HABITAT ENHANCEMENT STRUCTURE SITES



# Area 2: The Lower 7 Miles

The lower 7-mile reach of the Garcia River (extending from River Mile 1.38 to River Mile 9.11) was selected as the mainstem study area for this project. This area was selected by estimating the distance on the topographical map from the estuary upstream to the confluence of the North Fork Garcia, one of the upper basins included in this study. It was felt that a study of this reach, combined with the estuary and two upper basins, would provide representative examples of the watershed from which recommendations for the entire area could be extrapolated if studies of the remaining portions of the watershed are not funded.

In hindsight (and a note for future students of watersheds) a better overall understanding of the river might have been gleaned from an intensive study of seven one-mile stretches located along the entire mainstem, rather than studying seven miles in a single stretch. Although some specific information might have been missed, more representative information on the stream channel and fisheries of the entire river system might have been obtained.

## STREAM CHANNEL ANALYSIS

The lower reach of the Garcia River was surveyed for indications of any changes in the physical elements of the river that would account for the decline in its fish populations and other resources. Long-time residents reported that such changes had started sometime before 1950 and had become marked in the 1980's. Unfortunately, no previous surveys of the river channel had been conducted; therefore, there was no basis from which a definitive comparison of changes in the channel over the past 40 years could be made.

Field observations of the lower nine miles of river were made in early April and late August 1991. In addition to the field surveys, examinations of limited records were made, including: reports of discharge of the river, area rainfall records, aerial photographs, cross section surveys taken in the summer of 1991, and field notes from the habitat survey also made in the summer of 1991. A summary of the stream channel analysis follows:

### The Lower 7 Mile Reach

The Garcia River from its confluence with the North Fork to the estuary flows in a fairly well defined channel. It is closely confined by the bordering hills of the river's narrow valley. The bed and banks are made up of the alluvial sediments eroded from its watershed. The sediments vary from cobbles, gravels, and coarse sands and silt near the mouth of the North Fork to gravels and coarse sands in the estuary. The channel is generally marked by a series of alternating bars adjoining one bank and then the other. The low water channel weaves between the bars to form a meander pattern. Typical of the coastal streams the river has steep gradients in the upper reaches.

**River Flows**

The records of river flows, 1951 to 1955, and 1963 to 1983 (USGS Gauging Station Flow Data, Jackson, 1991) show that the flows are characterized by the occurrence in the winter months of each year of one or two, and in some years as many as five very short duration peak flows in the range of 10,000 to 30,000 cubic feet per second (cfs), followed by seven to eight months of low flows, usually less than 100 cfs and as low as 10 cfs. Flows exceed 5,000 cfs only about 1% of the time, or an average duration equal to only 3 to 4 days per year. These are the flows which transport the bulk of the heavier sediments, the cobbles and gravels.

The highest flow of record occurred in 1974 and amounted to 30,000 cfs. High flows exceeding 15,000 cfs were fairly frequent in the period 1952 to 1974. Such flows occurred in 1952, 53, and 54; and again in 1963, 65, and 66; and again in 1969, 70, 71, 73, and 74. However, in the past 17 years, since 1974, such high flows have occurred in only three years, 1982, 83 and probably in 1986, based on the record of the adjoining Navarro River.

Rainfall records are available at the Light House near the mouth of the river beginning in 1902 but they are not continuous. Records were also later kept at other locations in the vicinity of the mouth of the river, but they too were not continuous (Puffer, 1991). These fragmentary records indicate that the average annual rainfall since 1950 has not been markedly different from that in prior years.

**Holes Along the Lower River**

Long time residents referred to a number of good fishing holes along the lower river 40 to 50 years ago. These were described as having depths in the range of 8 to 12 feet, a few as deep as 18 feet, and a few as shallow as 5 to 6 feet. In the early 70's the Bishop and Redwood Holes were 10 to 12 feet deep. Craig Bell, who has fished the river since 1979 and has been a professional fishing guide on the Garcia River since 1984, described the fishing as still good in the early 80's, but by the mid 80's he noticed there had been a change. He said the fish numbers are down ... "This (1991) is the lowest year by far, the fewest fish I've seen."

Mr. Bell noted that several holes had been lost. As to existing holes, he described the Lynch Hole as a wonderful hole, one of the best on the upper Garcia; Indian Hole another good hole; and the Bishop Hole area is coming back good. The fish habitat survey made in the summer of 1991 at low water (10 cfs) indicated that along the lower river there were 12 holes having maximum depths of 6 feet or more. The extent of each was not measured. Understanding that the high winter flows may be expected to scour out the silts which settled in the holes after the preceding high water, their depths may be increased by 1 to 3 feet.

**Channel Depths Generally**

Available data were studied with a view to determining whether there has been any material decrease in the depths of the channel generally, i.e., between the holes, over the past 40 years or so which could have contributed to the reduction in the fish population.

Observations along the lower river in 1991 and study of the 1988 aerial photos support the view that the channel depths have generally not decreased in recent years. If the depths have decreased, it would have been observed that the deeper sections of the channel had filled with sediments and that the low as well as high flows spread over the entire width of the channel. There is practically no such evidence. Rather, the river generally has a well defined low water channel, confined by well defined convex bars, which indicate that the channel depths have not decreased in recent years, not since about 1980.

With respect to a decrease in depths generally prior to 1980: Cross-section surveys were made of the channel of the lower river in the vicinity of the USGS Gauging Station in 1956, again in 1963, and again in 1991 (Jackson, 1991). Comparison of these surveys shows no material change in the elevation of the bed of the channel. Each of the surveys show bankfull depths in the range from 14 to 16 feet. This evidence supports the view that there has not been a material overall change in the depths of the channel since 1956.

Further, photographs were reviewed which showed the clearance under the Highway 1 Bridge across the lower river in 1938 when the bridge was rebuilt, in 1940, 1958, 1968, and in 1979 (Caltrans photos, 1938, 40, 58, 68, 79), and a measurement was made of the clearance in 1992. Although the clearance could only be roughly estimated from the photos, they indicate that there does not appear to have been a large change in the depth of the channel at that location since 1938.

The foregoing findings relating to the depths of holes and the depths generally in the lower river need to be supplemented with the understanding that although there appear no major overall changes in the depths since around 1950, there have been and will continue to be local changes in depths and in alignment incident to changes in the magnitude and frequency of high flows, and the duration of the low flow periods.

**Sediment Load**

The sediment load as referred to here relates only to the bed load which is made up of the coarse sands, gravels, and cobbles which move along the bed of the river, as distinguished from the fine sediments which for the most part are carried in suspension directly to the ocean. Measuring the quantities of bed load carried by the flows into the lower river requires extensive procedures outside the scope of this planning process.

However, the evidence that there has not been a material decrease in the depths of the channel generally along the lower river since 1956 also indicates that there has not been a significant increase in the quantity of sediments brought into the lower river by corresponding flows since that year.

**Water Temperatures**

A record of the daily temperatures of the waters of the lower river was maintained at the gauging station from October, 1963 to December, 1978 (USGS Gauging Station, water temperature data, 1963-78). The record shows no significant changes in that period. However, prior to 1963 there was undoubtedly a significant increase in temperatures in the waters incident to the loss of vegetative cover over the upper river and tributary streams incident to the logging operations.

**Water Quality**

Only sparse records are available of the quality of the water of the lower river. It is understood that there are no industries along the river which could cause pollution. However, it is suggested that a check be made on the effects on the fish life of such fertilizers as may be used on farms adjoining the river and may drain into the river.

**Effects of Logging Operations**

It is understood that the watershed of the Garcia River upstream from the North Fork was heavily logged in the 1950's and early 1960's. The slopes were scarred by roads and trails resulting in much increased erosion and accumulations of sediments and trash which entered into and clogged the upper river and its tributaries. In the upper mainstem logging also occurred throughout the 1980's.

However, as noted above, the observations and data studied indicate that the quantity of sediments carried into the lower river has not materially increased in recent years. Therefore, it appears that the increased accumulations in the upper river have not yet entered the lower river.

**Effects of Gravel Operations**

Since 1986, gravel has been mined from the bars upstream from the highway bridge and from the bars in the area opposite, and downstream from the mouth of the North Fork, known as the Buckridge area. The mining of the bars has caused the river to widen and shallow and to that extent has adversely affected such habitat as existed in the local area. The operations to date do not appear to have adversely affected the channel upstream or downstream from the mined areas.

**Overall Finding**

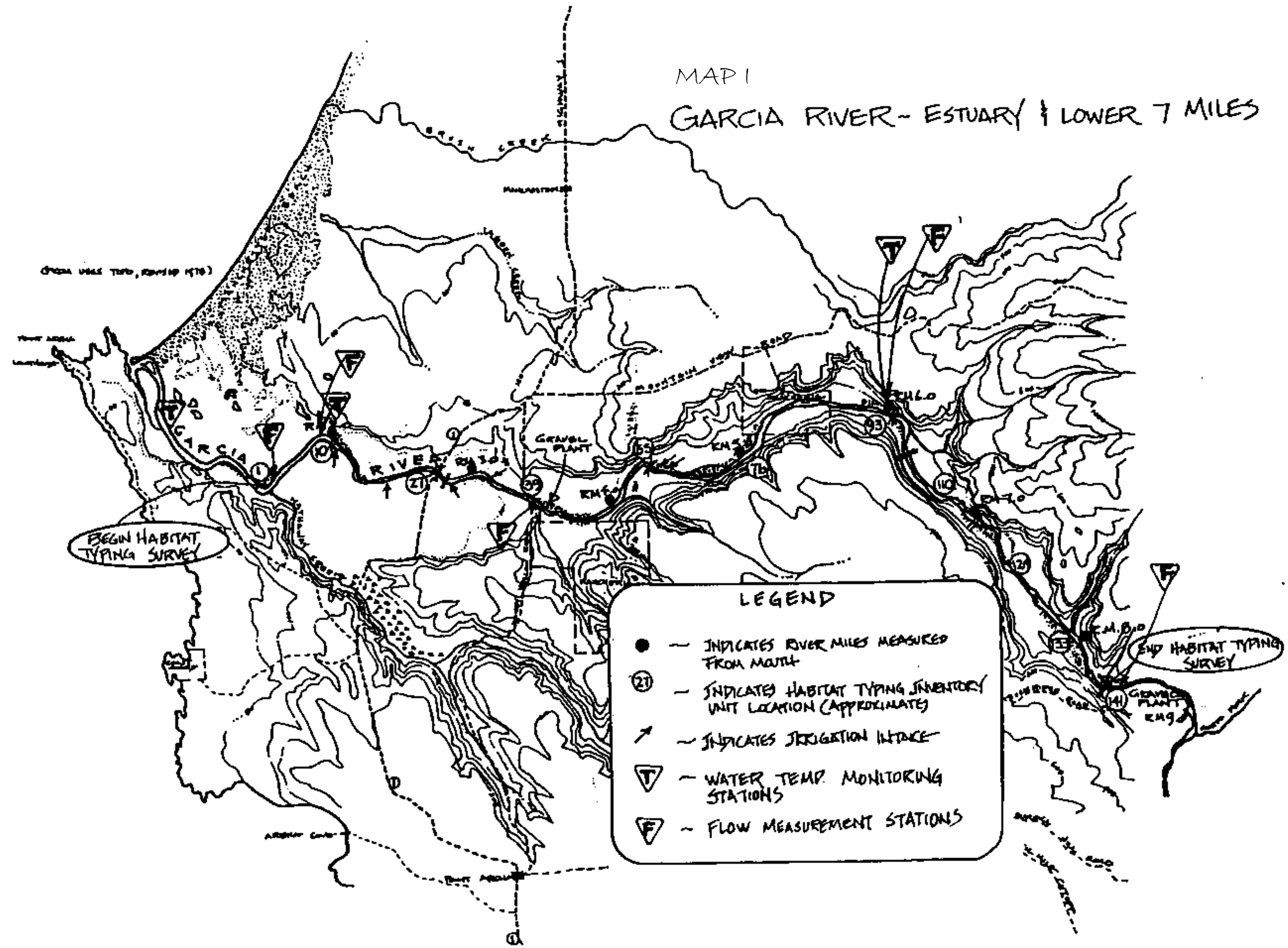
The above observations and findings support the view that there do not appear to have been marked changes in the physical elements of the lower river, i.e., channel depths, water temperatures and channel shape, since the late l950's.

Consulting Fisheries Biologist Patrick Higgins studied available data on the Garcia and used his experience on North Coast streams to analyze the lower river channel and the fisheries resource. Some of his observations follow:

Earliest available aerial photos from 1937 show that the stream channel was wide and open. This could indicate that the river was still in early stages of recovery from the large influx of sediment that occurred as a result of logging and other land use activities near the turn of the century. Transportation of logs utilizing splash dams and log drives took place on the Garcia in the late 1800's (Moungovan, 1968). Similar activities in Oregon watersheds had profound and lasting impacts on stream channels (Seddell, et al, 1988). Conversion of timber land to grazing land, the use of the lower river channel as the main transportation artery between the North Fork and Highway 1, and the breaching of the mill dam just above the North Fork together with the splash dams and log drives combined to produce a very wide and unstable river channel as indicated by the 1937 aerial photos.

Judging from aerial photo sequences from 1937 to 1990, the riparian zone of the lower river has shown trends toward recovery since the mid 1980's. Dramatic changes in channel width and form were not apparent after major flood events, yet upslope activity and floods must have delivered considerable sediment to the lower river. Apparent lack of channel response may be a consequence of the magnitude of original deposition from activities occurring pre-1937. High water events occurring after 1937 may have only added to existing stored material without changing the "footprint" of the river

# MAP I: ESTUARY & LOWER 7-MILE TOPOGRAPHIC MAP



as seen in aerial photos. Since the river terrace was used as a highway for much of the year and grazing must have occurred, revegetation of the lower river riparian zones may have been retarded by human activities. Conversely, recognition by farmers today of the value of a riparian buffer for flood protection has helped allow recovery. Low flow conditions during recent years of low rainfall is also a factor in increasing riparian vegetation.

There is a spatial and temporal lag between impacts on hillslopes, delivery of sediment to waterways during floods, and the response of salmon and steelhead populations. As floods destroy river habitat, two or three year classes of salmon or steelhead may be feeding in the ocean. If only a few of their eggs survive when they return due to decreased spawning gravel quality, each successful emerging fry may survive well due to decreased competition. When cycles of ocean productivity and impacts of fishing are factored in, one can see that direct cause and effect of habitat loss and decreased fish populations may be hard to unmask. Oral history, however, is in keeping with a major decline in salmon and steelhead linked in time with major changes in the river channel related to sediment incursions.

## FISHERIES ANALYSIS

Coastal streams such as the Garcia River have been recently formed in geologic time and therefore, do not harbor a diverse assemblage of fishes (Moyle, 1976). This lack of competition and ideal cold water conditions allowed salmon and steelhead to thrive in the river before its alteration by man. The three species of anadromous salmonids native to the Garcia are Chinook salmon *(Oncorhynchus tshawyschta),* coho salmon *(Oncorhynchus kisutch),* and steelhead trout *(Oncorhynchus mykiss).* It is also possible that chum salmon *(Oncorhynchus keta)* and pink salmon *(Oncorhynchus gorbuscha)* were present historically, but since they are not viewed as retrievable populations at this time, they are not treated in this report.

Habitat inventories and fish population estimation give us a snapshot of the river and the tributaries surveyed in 1991. Combining fish observations today and historical accounts allows a reconstruction of the fish STOCKS or runs that existed in the past and that persist today.

### Stocks of Salmon and Steelhead

Fisheries scientists have recognized that salmon and steelhead have developed sub-populations because of their strong homing instinct to the stream of their birth (Ricker, 1972). These populations that spawn in different rivers or subbasins at different times are known as STOCKS and have evolved special traits necessary to survive in their home stream. Characteristics that can be used to identify stocks include: genetic structure, resistance to disease, body shape and size, run timing, juvenile life history traits, ocean migration patterns, and number and size of eggs (Nicholas and Hankin, 1988).

**King or Chinook Salmon:** Old timers describe large deep bodied kings that returned to the Garcia River in fall and could be readily speared in the estuary. The large size of these adult fish would indicate that they spent three to five years in the ocean. Large body size is associated with high numbers of eggs, which is a selective advantage. Large Chinook salmon are able to nest in large cobble and gravel characteristic of main river channels and are also able to bury their eggs deeper to avoid scour and fill in streambeds during high flows (Frissell and Hrai, 1988). Although most Chinook migrate downstream early after emerging from the gravel, some may spend several months to a year in the stream if appropriate habitat is available (Sullivan, 1989). Extended rearing in the estuary may have been an important life history for juvenile Chinooks similar to streams in Oregon (Reimers, 1973).

Fall Chinook salmon suitable for restoring runs to the Garcia River may still exist in other north coastal California Rivers such as the Mattole, the Eel River, or Little River (Humboldt County). Native runs of these fish from nearby rivers seem to have died out. (See Part 3, Area 4.)

**Silver or Coho Salmon:** Because of the steep gradient of the upper Garcia River and its tributaries, coho salmon were probably able to access much more of the basin than Chinook salmon. Therefore, coho salmon would have been much more abundant than Chinook salmon in the Garcia River in its natural state. The appearance of coho in upper tributaries such as Pardaloe Creek after a migration barrier was removed at River Mile 24 on the Garcia River suggests that coho salmon must have spawned in the mainstem up to the barrier prior to its removal.

A strain of large adult coho was described by numerous people interviewed. Although adult coho spend only two years in the ocean, Garcia River fish are remembered as often exceeding 15 pounds. Ocean productivity along the coast of California is extremely high, so it is likely that Garcia River coho grew large by feeding in areas of upwelling along the Continental Shelf. Introductions of Noyo River Hatchery coho caused a shift toward smaller adult fish in the 1970's and 1980's (Bell, 1992, personal communication). What other changes introductions of non-native coho may have caused in native stock behavior, resistance to disease, or other traits are not known. Almost all coho salmon spend one year in freshwater rearing in pools with large woody elements (Reeves, et al, 1988). This would have been the dominant behavior pattern of juvenile coho in the Garcia River.

Bartly and Gall (1987) found that coho salmon of north coastal California were very similar genetically from one river to another. This genetic similarity could be the result of recent colonization of the region by this species (less than 10,000 years). Another explanation would be that blending of populations may have occurred as coho strayed between rivers when migrations were blocked by splash dams. Such opportunistic straying and recolonization has been documented after the disturbances in the Toutle River in Washington after the eruption of Mt. St. Helens. Discovery of the adult female coho during estuary seining and juvenile coho in a lower tributary in 1992 suggest that some remnant population may still exist. Additional gene resources for recolonization of the Garcia River may exist in streams such as Lagunitas Creek (Marin County), Little River (Mendocino County), or Elk River (Humboldt County).

**Steelhead Trout:** Highly valuable and diverse runs of native steelhead trout remain today in the Garcia River. Large adults are characteristic of the river which may be due in part to repeat spawning (Behnke, 1982). Ocean feeding of coastal stocks of California steelhead has been recorded in areas as far north as Alaska (Light et al., 1988). It is possible that Garcia River steelhead show this extended ocean migration pattern. An adult female steelhead captured in the Gualala River returned the following season and increased three pounds in weight (Bell, 1992, personal communication). Such repeat spawners could also be feeding in a shorter migration pattern along the rich Continental Shelf area.

The timing of peak spawning runs has shown some shift in recent decades. While early steelhead runs in November were once much stronger, late spawning in February and March now seems more predominant (Bell, 1992, personal communication). This change could be the result of lack of early season rainfall, but may also be caused in part by habitat conditions. Cederholm (1984) found that steelhead spawning runs shifted to later dates in western Washington due to spawning on the peak of the last high water were most successful because the streambed remained stable leading to higher survival of their eggs.

Juvenile young of the year Garcia River steelhead rear in all areas of the stream but dominate upper tributary habitat. The most common life history strategy of these fish is to spend one year in smaller upper tributaries, and then an additional year or two in the lower river and upper estuary. Lack of substantial extended rearing in upper tributaries may be due in part to restricted depth and habitat volume due to aggradation.

**Mainstem Garcia**

The lower reach of the Garcia River has fourteen different habitat types with low gradient riffles most abundant (28%). Runs and glides combined totaled 27% of all habitat units. Corner pools often form in valley bottoms as the river meanders and these pools were most abundant in the lower reach comprising 13% of all habitat types. Average mean depth was under five feet for all pool types except for corner pools and less common lateral scour root wad pools. Approximately 18% of all habitat types were pools formed around large woody material.

The vast majority of one and two year old steelhead in the Garcia River reside in the lower river during low flow periods in summer. In corner pools and lateral scour log formed pools, one year old steelhead actually out-numbered young of the year. Two year old steelhead also show greatest preference for corner pools with next highest densities seen in log formed pools. There is definite positive correlation between depth of pools in the lower river and older age steelhead production. Smith (1988) found that survival of juvenile steelhead in Pescadero Creek (San Mateo County) was greatly increased if they attained large size before entering the ocean. The larger juveniles inhabiting the lower river probably make a significant contribution to adult steelhead returns to the Garcia Watershed.

Specific findings of Fisheries Habitat Typing Inventories and Direct Underwater Observation Surveys of this reach follow:

1) Late summer water temperatures at two stations, Snag Hole at River Mile 1.8 and Lower Oz Hole (formerly Lower Lynch Hole) at River Mile 6 ranged from 58 degrees F to 72 degrees F (14.4 Degrees C to 22.2 degrees C) and averaged about 64 degrees F (17.8 Degrees C). These temperatures are adequate for survival of juvenile steelhead but are the major impediment to restoring coho salmon at this time. Getting colder flows in this reach can be achieved by restoring riparian conditions in upper tributaries.

2) Late summer stream flows measured at five stations. Minor Hole (River Mile 0.8), Snag Hole (River Mile 1.8), Windy Hollow Road Crossing (River Mile 3.5), Lower Oz Hole (River Mile 6), and the R & J Summer Crossing (River Mile 8.31), were quite low — less than 10 cubic feet per second (note: these are not official USGS flow measurements). Shallow reaches and low volume of flow in channels exposed to direct sunlight result in high water temperatures.

3) A high percentage of fines was found in stream bed materials. This limits spawning habitat by restricting the amount of oxygen available for eggs. These fine materials may also limit hiding areas for fry and juveniles and destroy habitat for the small aquatic life essential in the salmonid food chain. Research and upslope field surveys indicate large amounts of sediment have been introduced into the Garcia River system by land uses over the last 120 years as well as natural events. Specific known sources of sediment include: a) the natural rock barrier around River Mile 24, which was blown out in 1964 to allow migration of fish upstream and which is still downcutting and contributing sediment today; and b) the removal of numerous logjams in upslope tributaries during the later 1960's through early 1980's to open up previously inaccessible areas to anadromous fish. Because the Garcia's ability to transport sediment is quite low (due to

infrequent high flows capable of moving large amounts of sediment), it is possible that a major wave of sediment from the upper basins has not yet reached the lower 7-mile reach of the river (see discussion above concerning sediment). In addition, there are specific sites along the lower 7 mile reach, as noted on Work Site Map 2.3, where bank erosion is currently occurring and contributing sediment.

4) Adjacent land uses may have some negative impacts on the fisheries. The possible effects of a large variety of adjacent land uses require further study. (See Recommendations 2.4 and 2.5.)

Due to the extended travels of salmon and steelhead during their different life stages, they face many threats. Scientists try to discover those critical bottlenecks in their life cycle that might keep production levels low or even threaten their continued existence. These are know as LIMITING FACTORS. Discussions on findings from habitat typing suggest factors in fresh water, but other threats will be addressed including ocean fishing, in-stream fisheries, including poaching, hatcheries side effects such as disease introduction, and predation in Part 3, Area 4.

While the lower reach of the mainstem Garcia is showing improvement in riparian conditions, high chronic levels of sediment delivery continue to hamper its recovery. The strong relationship between pool depth and steelhead production suggest that as upslope sediment is controlled, increases in steelhead populations can be expected. The estuary volume has greatly diminished over time due to sedimentation. Long term plans to restore Chinook salmon to the Garcia would require a deeper and healthier estuary.

A primary indication of habitat problems in the Garcia Watershed are water temperature increases. California Department of Fish and Game (1966) surveys after flood and early logging damage indicated that suckers dominated much of the Garcia River and impacted tributary areas. Few suckers were found in the main river or in the North Fork but suckers were abundant in lower reaches of Pardaloe Creek in 1991 surveys. Future changes in the balance between salmonids and suckers may be the key indicator of the success of Garcia Watershed restoration efforts. As stated above, stream temperatures in the main lower river are one of the major impediments to restoring Coho salmon at this time.

## Stream Classification

Finally, data collected on the lower 7 mile reach of the Garcia was used to classify this reach by the Rosgen Stream Classification System (see Part 2: Methodology, Map F and Appendix II) as a further means of understanding its behavior, the decline of fish populations, and to determine effective enhancement measures where necessary. It turned out that this section of the Garcia River does not fit easily into the Rosgen System, and that the types of fish habitat improvement structures compatible with or successful in the types of channel in this reach (B-4, C-4, and G-4) are very limited. Rosgen suggests the following guidelines for fish habitat improvement structures in these types of channels:

a) Large, free-floating organic debris structures should not be used unless bedrock or boulders are part of the bank structure where anchoring occurs.

b) Submerged large organic debris structures can be used in straight reaches where gravel is the predominant bed and bank material, if they can be firmly anchored.

c) Boulders or large cobbles placed along banks (not in center channel) can provide resting/feeding stations for fish without destabilizing banks.

d) Bank protection structures as described in the recommendations that follow provide excellent fish habitat. (See Appendix III, Large Debris Revetment Diagrams.)

e) Any structure which contributes to channel constriction is not recommended in this type of channel.

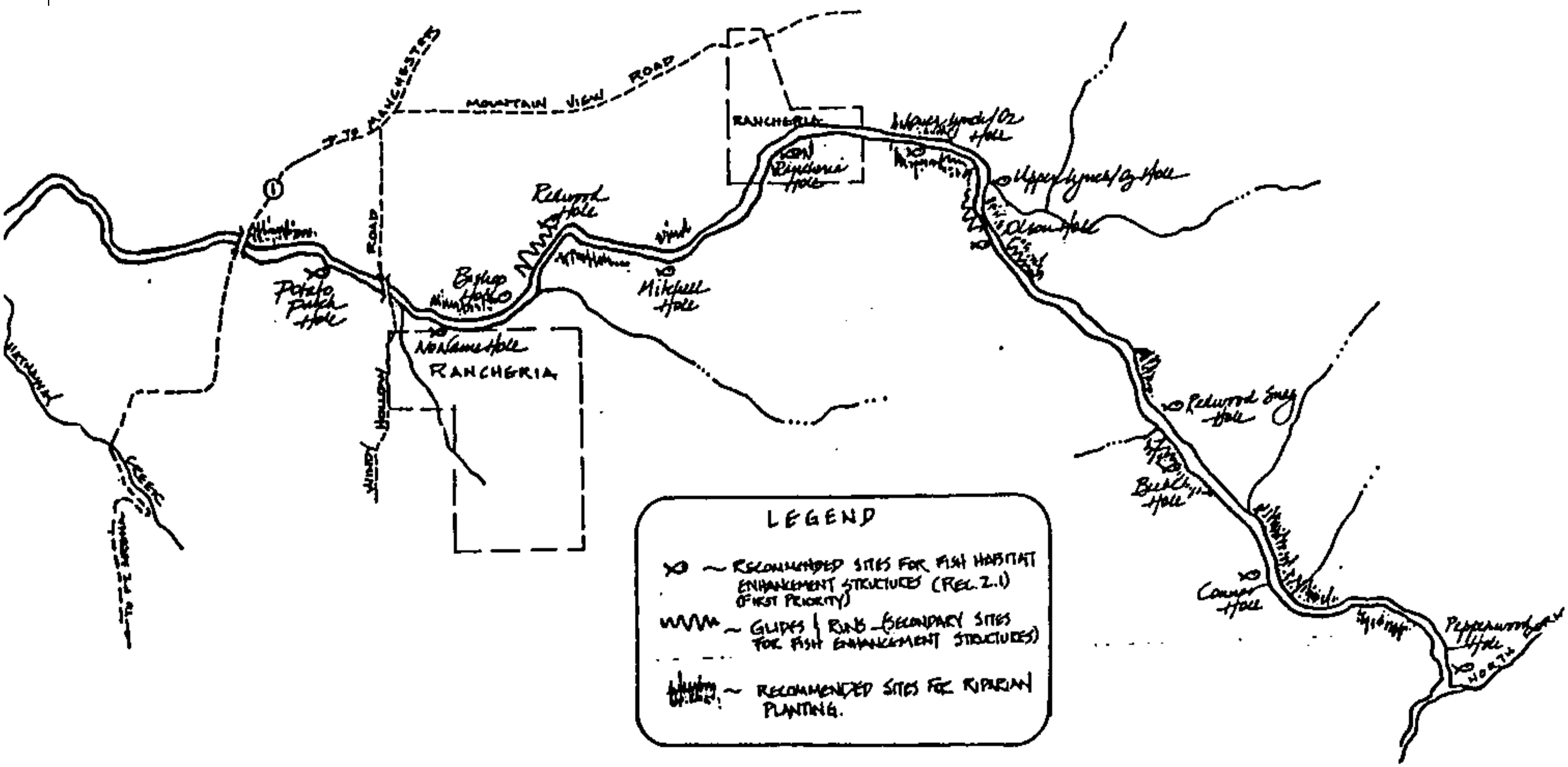
Following are specific recommendations for enhancement of the lower 7 mile reach:

**RECOMMENDATION 2.1: Introduce well-anchored, large organic and inorganic structures into the channel to provide shade and lower water temperatures, cover for protection of fish from predators, scour for pool development, and food for fish at sites indicated on Work Site Map 2.1 and 2.2.**

High priority sites for structure placement are at those pools located between the North Fork confluence and Windy Hollow, where there are secure anchor points. Second priority sites are those long runs and glides where structure would provide diversity. (See Rosgen Guidelines above.) Large Debris Revetment Diagrams. Appendix III, illustrate examples of fish habitat enhancement structures.

**RECOMMENDATION 2.2: Plant and protect riparian vegetation, including Redwood, on the lower 7 mile reach where necessary to provide the following: shade and lower water temperatures, cover, protection for fish, bank protection from erosion, and**

PROPOSED FISH HABITAT ENHANCEMENT AND RIPARIAN PLANTING SITES




GARCIA RIVER ~ LOWER 7 MILES

WORK SITE MAPS 2.1 & 2.2

**large organic debris in the future for habitat. Suggested sites for riparian planting are indicated on Work Site Map 2.1 and 2.2.**

Historically many, if not all, the terraces along the river were conifer forests, most of which were converted to agriculture and grazing. Today riparian tree cover along most of these terraces is limited to a narrow band of willow and alder or is non-existent. It is recommended that a corridor of Redwood and Douglas Fir be planted on the banks and at the edge of the terraces. (See discussion under Recommendation 2.1 above.)

**RECOMMENDATION 2.3: Reduce erosion at sites indicated on Work Site Map 2.3 by: 1) selectively removing willows where they are creating problems in low-flow channel, and 2) protecting banks where needed using live vegetation (large transplanted willow and alder clumps) as well as organic and inorganic revetment. Incorporate fish habitat into bank protection wherever possible.**

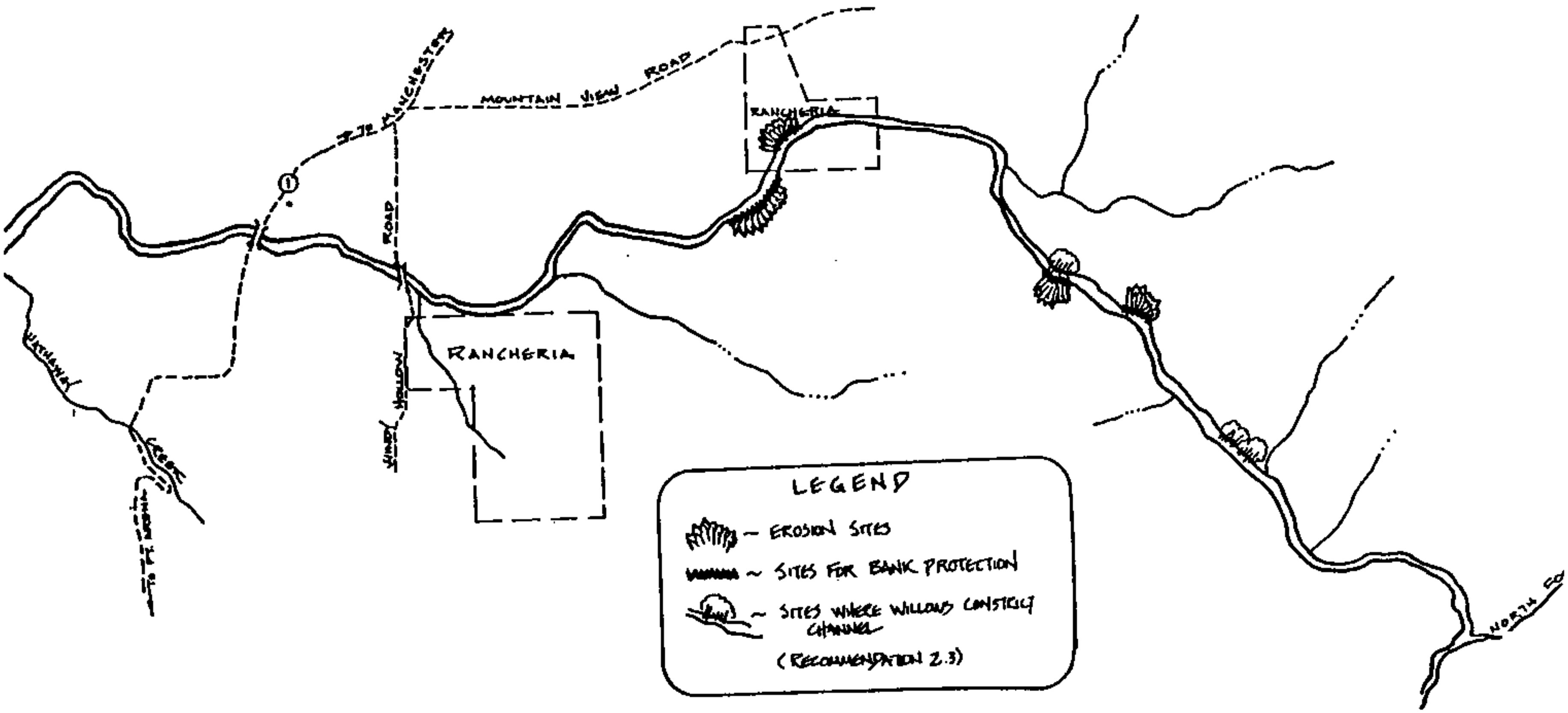
There are reaches of the river where willows have almost completely blocked the low flow channel. Low flows over the past 6 years have allowed this intrusion. Willows and other vegetation act as barriers, slowing flood flows and causing depositions, and can also divert flood flows causing bank failure and other problems. (See Rosgen Guidelines.) Transplanting clusters of willows presently constricting the channel to areas of bank failure will be a very cost-effective method of addressing potential erosion problems on this stretch of river.

Large organic debris should be used for bank protection, as shown in the Large Debris Revetment Diagrams, Appendix III, using native material and incorporating large willow and alder transplants. These treatments would create excellent fish habitat as well as stabilize stream banks.

**RECOMMENDATION 2.4: Limit future land use that could have the effect of further constriction of the river by levee.**

Study of aerial photos from 1952 to the present shows that the active bank-full channel has been reduced 25%-75% over this time period in the reach from approximately 1/3 mile below the Highway 1 bridge (Willow Run) to Bend Hole in the estuary. This change in channel width affects the river's ability to store and process gravel, which certainly has some effect on the estuary below and possibly above the constriction. This recommendation is not intended to prevent maintenance of bank protection by landowners but to prevent further constriction of the channel.

LOWER 7 MILES - PROPOSED BANK PROTECTION SITES |
(INCLUDING SITES OF WILLOW CONSTRICTION) □




GARCIA RIVER ~ LOWER 7 MILES.
WORK SITE MAP 2.3

**RECOMMENDATION 2.5: Conduct further study on possible positive and negative effects of adjacent land uses on fisheries resource. Studies should be conducted on a volunteer basis with the help of adjacent landowners and the Watershed Advisory Group.**

Because no particular limiting factor could be identified based on the field studies conducted for this Plan, the contribution of possible adverse effects and mitigating effects from all land-uses should be considered. Potential areas for further study include:

1) Effects of toxic contamination from Air Force Station.
2) Timber operations occurring adjacent to the river.
3) Effects of agricultural chemical and nutrient runoff: fertilizers, pesticides, fungicides, etc.
4) Irrigation practices — amount of water diverted, timing, intakes, heavy equipment development of systems, runoff, etc.
5) Livestock access to, and crossing of, the river.
6) Gravel operations in or near the river.
7) Conversion of timber or wetland to crop or grazing land.
8) Residential development near the river (septic systems).
9) Sub division developments.
10) Land fills and dump sites.
11) Native American fishing rights and practices.
12) Off-Road-Vehicle use (especially dirt bikes) along the river.
13)

No recommendations will be made regarding gravel extraction until the appropriate EIR's and the Mendocino County Water Agency Gravel Management Plan are computed and reviewed. Appendix V contains the Outline of Tasks Recommended for a Comprehensive Gravel Management Plan for the Garcia River.

# Area 3: The Upper Tributaries

The North Fork of the Garcia River and Pardaloe Creek were selected by the Mendocino County Resource Conservation District (MCRCD) as two representative sub-drainages for this study. The North Fork was selected because over 90% of the North Fork watershed is owned by R & J Timber, Inc. (now Coastal Forestlands, Ltd.). The company was very supportive of this Enhancement Plan — granting access to their property and contributing "in kind" funding to the project. In addition, R & J Timber and the North Coast Regional Water Quality Control Board (NCRWQCB) are currently conducting a water quality monitoring project on the North Fork, which will contribute additional information to this study. Pardaloe Creek was selected because of the land ownership pattern. The Pardaloe Watershed is divided into eight separate parcels (see Appendix V, Land Ownership Map), and land use is varied. (One obstacle encountered in the Pardaloe Watershed was that access to property was granted by only five landowners, which constitutes approximately 60% of the land and 70% of the fish-bearing streams.)

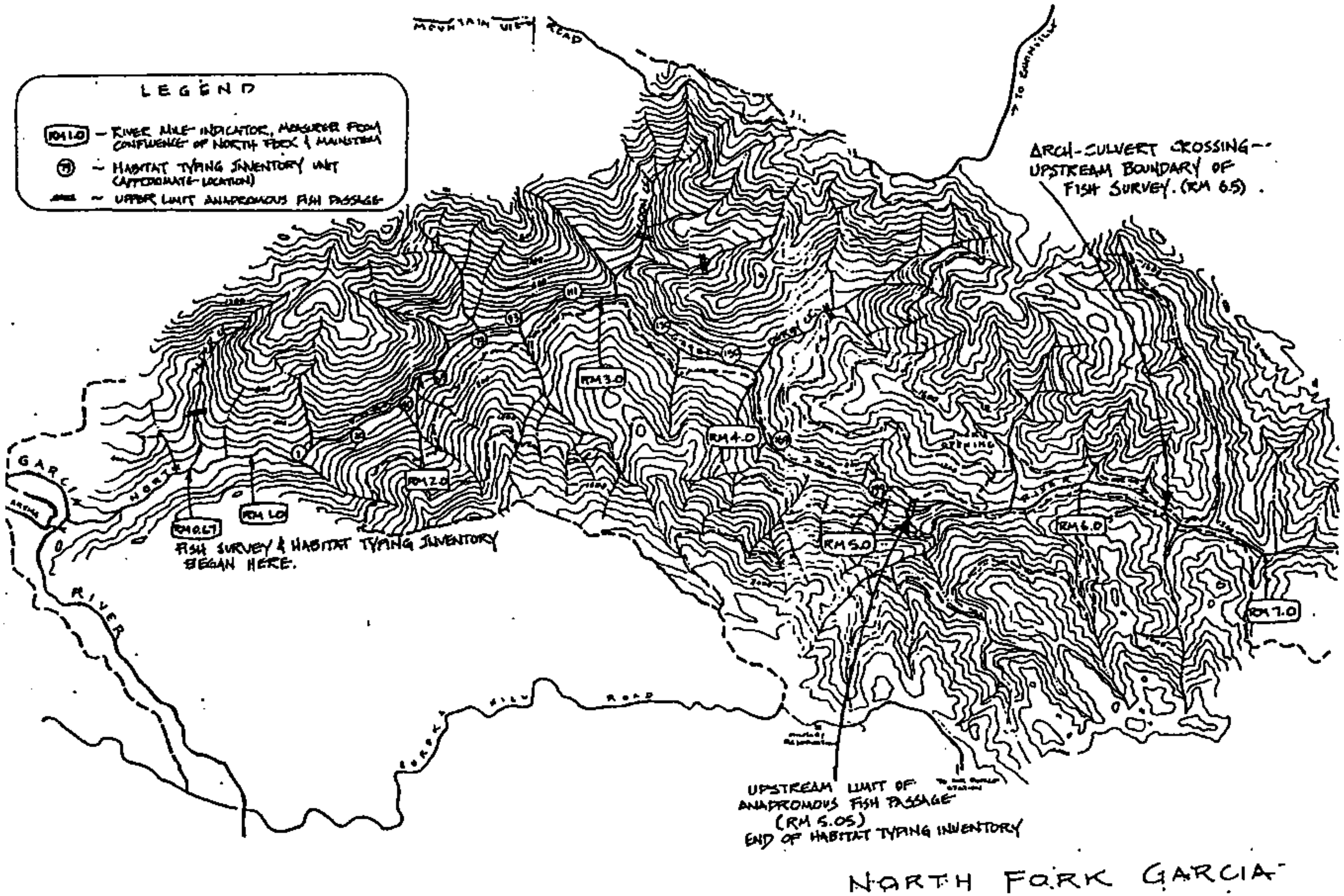
Because tributaries from all areas of the Garcia Basin are in Franciscan Formation geology, information gathered on the North Fork and Pardaloe Creek should be somewhat transferable to other sub-basins (Higgins, 1992).

**THE NORTH FORK GARCIA**

The North Fork of the Garcia (see Map J) is about seven miles long with seven major tributaries and a total drainage of about 12 square miles. The confluence of the North Fork with the mainstem occurs only nine miles upriver from the ocean, so the coastal fog and mild climate have a major effect on this drainage. The lower reaches of the North Fork are predominantly Redwood, with the upper slopes being a mixture of Redwood, Douglas Fir, Sugar Pine, and hardwoods. With the exception of some natural grass lands around Jack's Opening in the upper watershed, the entire drainage is forest land. Around the turn of the century there were attempts to convert forest to grazing land near the confluence, but today no physical evidence of this remains.

Slopes adjacent to the North Fork were logged extensively before the turn of the century, first for lumber logs for the Buckridge Mill, and then for railroad ties. By the 1950's there was a very heavy stand of residual old growth and second growth trees, and the entire drainage was logged again. Those few areas that still had merchantable trees were re-entered during the 1960's and 70's. In the last few years (late 1980's - early 1990's) approximately 85% of the North Fork drainage has been under timber harvest plan, with harvest taking residual old growth and some commercial thinning of second growth

# MAP J: NORTH FORK GARCIA TOPOGRAPHIC MAP



trees. The present owners have repaired many of the old upslope erosion problems, which resulted from logging prior to the 1974 Forest Practice Act, as mitigation for soil disturbance and potential erosion caused by current logging. At this time, much of the North Fork has stable stream banks and supports a healthy riparian cover. Overall, the North Fork appears to be a stream "on the road to recovery."

Although no objective historical data regarding the fisheries resource in the North Fork was found, interviews with long-time residents tell of an abundance of salmon and steelhead. "You just fished wherever there were holes, and it didn't take long to catch all the fish you wanted." Chinook may have used the lowest and flattest reaches of the North Fork.

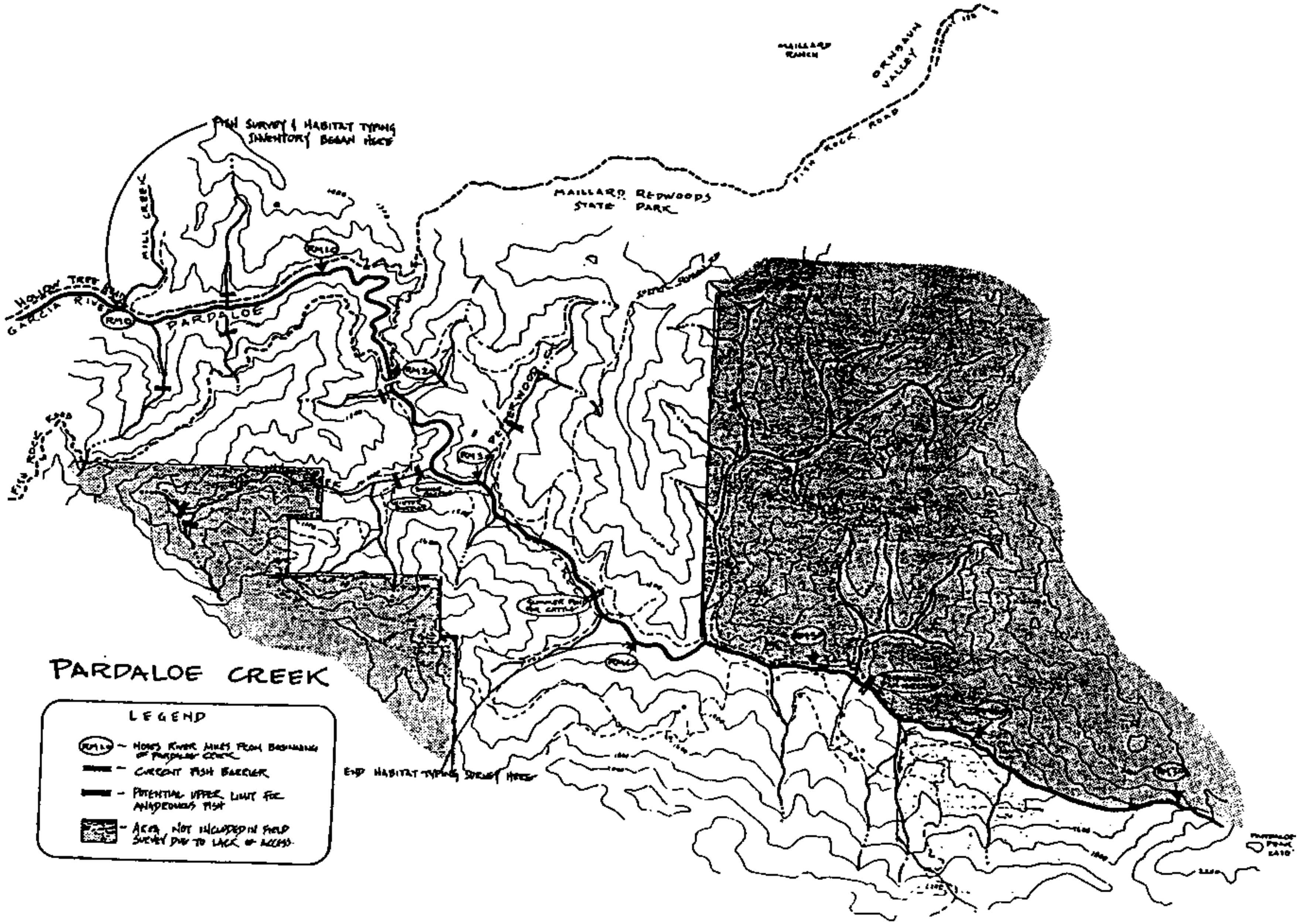
**PARDALOE CREEK**

Pardaloe Creek is the easternmost tributary of the Garcia River, and Pardaloe Peak at 2470' is the highest point in the watershed. At the point where Pardaloe and Mill Creek join (approximately River Mile 30) the stream becomes known as the Garcia River. (See Map K.) There are many characteristics of the Pardaloe Creek Watershed that are quite different from the North Fork. The coastal influence is not as pronounced, with less coastal fog and wind, and higher summer temperatures. Conifer forest land makes up approximately 60% of the watershed with the remainder in meadow, brushfields, and hardwood. Although there are Redwoods, most predominantly along sections of Pardaloe Creek, the percentage of Redwood in the conifer mix and the productive capacity of the land is lower than on the North Fork. Virtually the entire forested acreage in the watershed was logged in the late 1950's and early 1960's. With the exception of three small Timber Harvest Plans, there has been no logging in the watershed since the enactment of the 1974 Forest Practice Act.

Although analysis of current aerial photos shows vegetative recovery in the watershed, field review revealed many erosion and sediment problems dating back to the 1950's-60's. Pardaloe does not, at this time, appear to be a stream "on the road to recovery."

Regarding the fisheries resource, Pardaloe Creek had no anadromous fish prior to 1964, when the California Department of Fish and Game (DFG) removed the natural rock barrier around River Mile 24 to allow migration beyond that point. Interviews with residents tell of an abundance of resident trout before 1964 and of spawning Silver (Coho) Salmon and steelhead after that date.

# MAP K: PARDALOE CREEK TOPOGRAPHIC MAP



## GENERAL FINDINGS ON UPSLOPE TRIBUTARIES

A summary of upslope data collected, analysis of findings, and specific recommendations for enhancement follow:

Historical research on the upslope watersheds disclosed even less objective data than on the lower river. 1937 (UC Berkeley Map Library) and 1952 aerial photos (SCS files, Ukiah) showed forested lands with very little evidence of land use. 1965 aerials (SCS files, Ukiah) showed a sharp contrast, with almost the entire forested area barren and ribboned with roads and skid trails. Roads ran down the middle of or immediately adjacent and parallel to stream beds. Most Class I streams (those that support fish and/or are used as a domestic water source, per California Forest Practice Rules) were completely lacking in riparian or streamside cover. A set of DFG photos of the area, taken in November 1955, document these conditions (DFG photos, 1955). A 1966 DFG Stream Damage Survey rated 84.8% of the 105 mile length of the river as "damaged." Of that amount, 35.2% was rated lightly damaged, 14.4% moderately damaged, and 35.2% severely damaged by "road building, logging, overgrazing, and poor land management practices, aggravated by the 1964 flood." (See Figure 1, page 1-21.)

Study of the 1988 aerial photos shows a strong return of vegetation — most skid trails and many haul roads are unidentifiable, and there is a general return of riparian cover.

Interviews provided some background information: a forester for the Hollow Tree Timber Company (the company that logged much of the Garcia Watershed in the 1950's-60's) remembers the upper tributaries as overgrown and almost impassable, with deep cold pools as deep as 10' in places hiding unseen under layers of fallen trees and debris. (McKenzie, 1991.)

Available timber harvest plans (THPs) and maps of the area were studied, but this information was limited by the fact that the timber harvest planning process did not exist before the Forest Practice Act of 1974. Recent THPs include very detailed descriptions of erosion problems encountered by current timber owners in opening roads and carrying out operations, and noted problem sites were inspected during project field surveys and/or post-harvest reviews. In general, mitigation work by current owners has been very successful in stopping old erosion. In a few areas even more restoration work could be done to return land to pre-1950's logging conditions. These areas will be noted in specific recommendations. (See Recommendation 3.2.)

Jack Monschke, Watershed Management consultant, gathered the information for this project on the upslope areas by extensive field surveys and observations. This included walking the major watercourses, identifying stream characteristics and current or potential erosion problems. In addition, he surveyed existing road networks, identifying unstable road sites and landings for current or future erosion problems. Unstable or problem areas were carefully noted and all relevant information was keyed to topographical maps of the basins. This information was used to develop the work site maps for the recommendations.

In addition, Gary Peterson, the project fisheries biologist, conducted fisheries surveys, habitat typing inventories, and Direct Underwater Observation Surveys on the North Fork from River Mile 0.5 to River Mile 5.9 and on Pardaloe from River Mile 0 to River Mile 4.4. (Land owner access permission and/or the extent of use by anadromous fish was the limiting factor in determining the range of these surveys.) Fish surveys were done during summer and fall, 1991. Maps J and K indicate the extent of fish surveys and identify potential barriers and other fishery related factors.

In an effort to analyze and understand the findings of this field work and to recommend upslope restoration measures to improve the upland tributaries of the Garcia, erosion problems have been separated into two categories:

1) Active or potentially active erosion, which in this case refers to those areas where the land is wearing away or is likely to wear away through the action of moving water. This includes slides, gullies, streambank failure, sheet and rill erosion.

2) In-stream stored sediment, which refers to the large amounts of dirt and rock that have slid and washed into watercourses over the past decades of various land uses by man and natural events, such as floods and earthquakes. Both of these problems must be addressed in order to restore the upper watershed.

**Active or Potentially Active Erosion**

Field survey work done for this project did not identify extensive major active erosion as the primary source of sediment at this time. More current actively eroding sites were found on Pardaloe than on the North Fork. However, it is obvious that major slides and streambank failures, many of which were related to old road systems, have contributed massive loads of sediment to the Garcia in the past. It is also important to note that current observations were made during a three-year period of relatively low rainfall, while slides generally occur during extended wet periods or flooding. Although major current active erosion was not observed, unstable areas where potential problems could occur have been mapped and should be evaluated periodically. Recommendation 3.1 addresses those areas where current active erosion is occurring and likely to result in streambank failure.

As noted above, transportation networks (ranging from paved roads to animal trails and even gopher tunnels) and their cumulative effects are the major cause of past, current, and potential future erosion on the upper watershed. Much upslope erosion (slides and gullies) as well as most stream bank failure results directly or indirectly from roads. Increased erosion and debris resulting from poorly constructed and maintained roads is responsible for a large influx of sediment and organic debris into streams. As this sediment accumulates, the entire stream bed is raised, and obstructions can occur. As a result, high flows are directed against unprotected banks possibly causing bank failure and slides. These in turn introduce more sediment into the system, adding to the problems of scour and obstruction. Because of the cumulative nature of this process, problems often intensify along any given reach.

Correct construction and maintenance of roads OF ALL KINDS (including logging, ranch, farm, subdivision, and county) is crucial to preventing adverse impacts on water quality and fish habitat. In timber harvest areas, land owners must comply with construction and maintenance requirements set forth in the Forest Practice Rules. Consistent application of these practices should be the standard for all logging operations. For other road networks, rural and residential, an option would be to adopt and encourage land owners to follow the guidelines in the California Department of Forestry (CDF) Road Construction and Maintenance Handbook which is currently under development and due for publication in the spring of 1993. Some guidelines for road construction and maintenance are included in Appendix V of the Plan. It is important that the adoption of guidelines includes educational outreach to the Garcia Watershed Community.

Recommendation 3.2 addresses the establishment of road construction and maintenance guidelines.

**In-Stream Stored Sediment**

**It is the finding of field work done in the North Pork and Pardaloe Watersheds that the major problem at this time is the excessive amount of in-stream stored sediment. No matter how much work might be done upslope to control active erosion or, in the lower reaches, to enhance habitat, the magnitude and adverse effects of in-stream stored sediment must be addressed.**

The content of this sediment, which has entered streams during past decades, can be seen in debris slides adjacent to creeks, by stream bed core analysis, and in fresh cuts in streamside terraces. This material is not clean washed and weathered gravels, but dirt and unweathered gravel and cobble, with a very high percentage of fines. In-stream stored sediment deposits up to 8 feet in depth were observed in places, but further data collection is needed to estimate the volume of in-stream stored sediment in designated reaches.

*North Fork Garcia River, DFG photo, 11/22/55, showing debris filled channel caused by PAST logging practices.*

How this sediment affects the stream depends on the following channel characteristics:

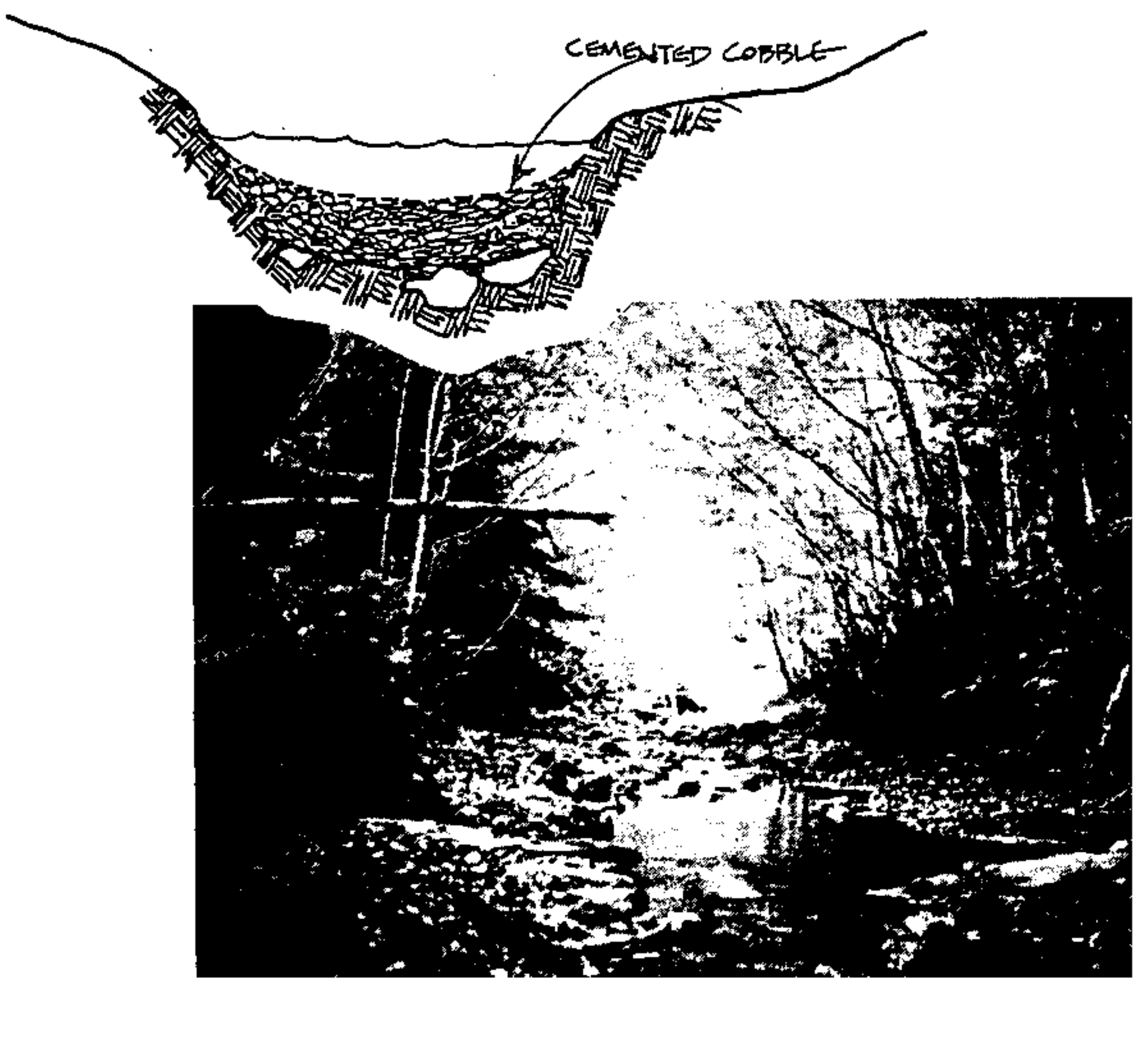
a) In reaches where the gradient is low (not steep), the sediment-filled stream bed becomes wide and flat, with the flow often going under ground in places and then resurfacing. (Examples of this occur in the lower reaches of both the North Fork and Pardaloe Creek.)

b) Where there is some constriction (a narrower channel) and the gradient is steeper, the bed of the channel often becomes "cemented cobble." (Cobble is defined as rock from 2.5" to 10" in diameter (Rosgen 1991).) This means that on the surface of the channel bed it looks like rocks embedded in cement.

Between this layer and the original streambed is a layer of dirt and rocks of varying thickness that has filled in the channel during the past. (See Figure 7.) Cemented cobble channels often appear stable and even beautiful and will often have well-vegetated banks. However, in terms of fisheries habitat, these channels are shallow and sterile, providing little or no hiding places, food sources, spawning gravels, or rearing pools.

A further problem of this sort of channel is that when a knickpoint (source of erosion) is formed or begun, there is this vast amount of fines stored in the actual channel waiting to be washed down the river. Such sites provide a constant source of sediment into the system.

FIGURE 7: DIAGRAM & PHOTO SHOWING STREAM CHANNEL WITH IN-STREAM STORED SEDIMENT AND CEMENTED COBBLE.



c) In steep reaches where bank material is stable (boulder and bedrock), sediment often flushes through with little evidence.

Experts agree that sediment load is crucial:

> An increased sediment load is often the most important adverse effect of forest management activities on streams. Large increases in the amount of sediment delivered to the stream channel can greatly impair, or even eliminate, fish and aquatic invertebrate habitat and alter the structure and width of the streambanks and adjacent riparian zone.
>
> The physical effects of increased sediment load can be equally far-reaching. The amount of sediment can affect channel shape, sinuosity, and the relative balance between pools and riffles. Changes in the sediment load also will affect the bed material size, and this in turn can alter both the quantity and the quality of the habitat for fish and benthic invertebrates. (Benthic invertebrates are fish food sources.)
>
> .... Indirect effects of increased sediment loads may include increased stream temperatures and decreased intergravel dissolved oxygen. (MacDonald, 1991.)

Increased sediment loads upstream will eventually affect the entire downstream reach of a river, all the way to the estuary.

Enhancement Recommendations 3.3, 3.4, 3.5, and 3.6 address the issue of instream stored sediment.

## FISHERIES ANALYSIS ON UPSLOPE TRIBUTARIES

Specific findings of fisheries surveys completed on the North Fork and Pardaloe follow:

### North Fork Garcia

Preliminary fisheries surveys in the lower 5.9 miles of the North Fork (mouth to multi-plate, or arch culvert) were performed in early July 1991. The surveys recorded water temperatures and estimated stream flow in the North Fork and 21 tributary streams. The upstream limit of anadromous salmonid passage was identified around River Mile 5 at a 25 foot high two-step falls, with steep boulder roughs immediately upstream (See Map J.) A small population of resident rainbow trout exists above that barrier.

Fisheries habitat typing inventory was conducted in early September 1991 on the North Fork between River Mile 0.5 and River Mile 4.6 (217 units), and DUO was carried out in a random sample of habitat units. The North Fork supports steelhead in all areas below migration barriers and resident rainbow trout above. Stream temperatures were the lowest of all areas surveyed (57-62 degrees F).

The North Fork had 17 different habitat types present. The North Fork Bar Graph showing Habitat types by Percent Occurrence in Derksen's Report (Appendix II) shows that step runs were the most common habitat type (24%) with high gradient riffles the second most common (10%). Given the steep gradient of this tributary, the frequency of these habitat units is not unexpected. Riffle:Run:Pool ratios for the North Fork were approximately 30:25:45 (Derksen, North Fork Pie Graph, Appendix II).

While pools are relatively abundant, the average depth for most pool types was less than three feet. Only 15% of pools were formed around large woody structure which is probably much lower than historic levels. Step pools (9%) and lateral scour bedrock pools (8%) were the most common pool habitat types. Greatest depth was found in main channel pools but scour around boulders, bedrock, and large woody debris also created some pools deeper than four feet.

All habitat types were used by juvenile steelhead but peak abundance was in run habitats (see North Fork 3-D graph showing Steelhead Densities per Habitat Types, Derksen, Appendix II). Young of the year steelhead used low gradient riffles extensively but showed highest concentrations in runs and had high densities in main channel pools, lateral scour pools around roots, and in boulder formed lateral scour pools. One year old steelhead were far less abundant with highest concentrations in step runs, lateral scour root formed pools, and main channel pools. Two year old steelhead were found only incidentally in step runs and lateral scour log pools. A positive correlation between pool depth and fish densities is evident.

Only two old (1990-91 spawning season) redds were spotted on the North Fork surveys.

The overall observation was that a major limiting factor for salmon on the North Fork is the lack of channel diversity, i.e., the high percentage of long flatwater "step runs" and "glides," that is, where the channel is shallow and bottom is cemented cobble. The general recommendation for restoration of habitat is to diversify the channel by introducing structure to develop pools and provide cover.

In addition, field surveys found four sites where current debris jams partially block the channel and could be potential barriers. These sites require modification and/or annual re-surveying. (See Recommendation 3.9.)

**Pardaloe Creek**

On Pardaloe Creek (see Map K), fisheries habitat typing inventory was conducted in the lower 4.1 miles and in the lowermost reaches of two perennial tributaries, Box Canyon Creek and Pepperwood Creek. No actual or potential barriers were seen in this reach, and lack of access limited further survey.

While steelhead were present in most of the stream reaches surveyed, stream temperatures in Pardaloe Creek ranged from 60-72 degrees F, the highest of any reach of the Garcia River measured. While pools were abundant, mean maximum depth was only just over two feet. Pools where bedrock upcrops or boulders constricted the channel were where maximum depths were achieved. Pools formed around large woody structure comprised approximately 10% of all habitat types. Cover in all habitat units averaged less than 25%, significantly less than cover in the North Fork.

Young of the year were by far the most abundant age class of steelhead rearing in Pardaloe Creek. Steelhead showed almost no use of riffle habitats because they lacked sufficient depth and flow to support fish. Runs and step runs showed low fish densities although young of the year did show some use with occasional one year old steelhead counted. Two year old steelhead were few in number and inhabited lateral scour bedrock pools almost exclusively. Lateral scour bedrock pools showed the highest concentrations of juvenile steelhead. Occasional high quality pools formed around logs or roots had all three year classes of steelhead present. Suckers showed their highest relative abundance of any reach measured in pools in lower Pardaloe Creek.

Habitat typing surveys showed that fish habitat on Pardaloe Creek appears to have greatly diminished as a result of sedimentation and riparian alteration. Lack of flows and decreased depth due to aggradation prevent almost any use of riffles during low flow conditions. Flows often go underground in riffles of this stream. High water temperatures may have prevented use of run and step run units in this stream during fish surveys. Scoured areas around bedrock were the areas supporting the highest concentrations of steelhead juveniles. Pardaloe Creek is only in the early stages of recovery from past sediment incursions and lacks sufficient shade and riparian cover.

Interestingly, 33 old redds (1990-91 spawning season) were noted; however, the quality or gravel and cobble was classified as fair to poor throughout the reach.

Another possible problem in the Pardaloe Watershed, suggested by land owners, is predators, specifically river otter, heron, and mergansers. (DFG has identified mergansers as one of the major predators of fry, or fingerlings.)

Enhancement Recommendations 3.3, 3.4, 3.5, and 3.6, address in-stream stored sediment and are the key to improving fisheries habitat in the upper basins over the long term. However, because of the extent to which the resource has been depleted, other specific restoration measures are recommended to enhance habitat on the short term. See Recommendations 3.7, 3.8, 3.9, 3.10 and 3.11.

Finally, of critical long-range importance is the development of a land use evaluation system to analyze various land uses, their effects on sedimentation and related impact on the fisheries resource. SCS staff has developed a spreadsheet model based on work performed in other watersheds that allows the user to evaluate specific sites in a watershed to estimate the amount of sediment produced by certain types of land use modifications. The model also allows comparisons to be made between various restoration techniques and their costs. The purpose of the model is to provide the user with a sense of which restoration technique would be the most cost effect at a given site, as well as where the most sensitive areas in the watershed can be found (Steffen, 1991). This model would provide an excellent starting point for the development of such an evaluation system for the Garcia River. Watershed landowners should be encouraged to grant access for completion of information gathering surveys. If interest and funding could be generated for such a project, the Garcia River could be a valuable model for resource restoration. See Recommendation 3.12.

Following are specific upslope Enhancement Recommendations:

**RECOMMENDATION 3.1: Armor stream banks at specific active erosion sites, as indicated on Work Site Maps 3.1, designating as highest priority those sites where slides could result from toe erosion.**

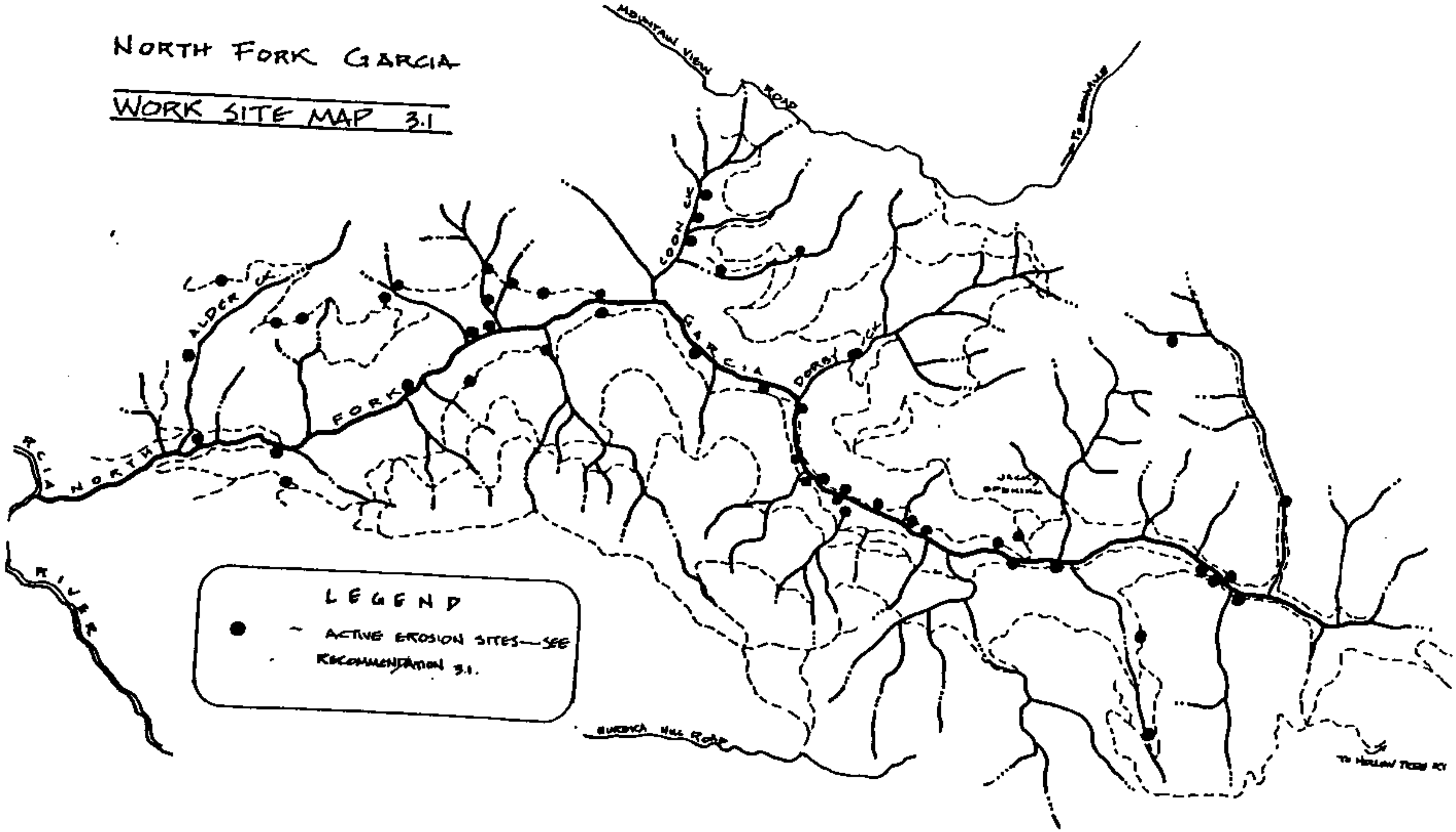
**RECOMMENDATION 3.2: Encourage land owners to follow road construction and maintenance guidelines developed by state and local agencies to limit sediment and adverse effects on fisheries.**

Some road construction and maintenance guidelines are included in the Plan in Appendix V.

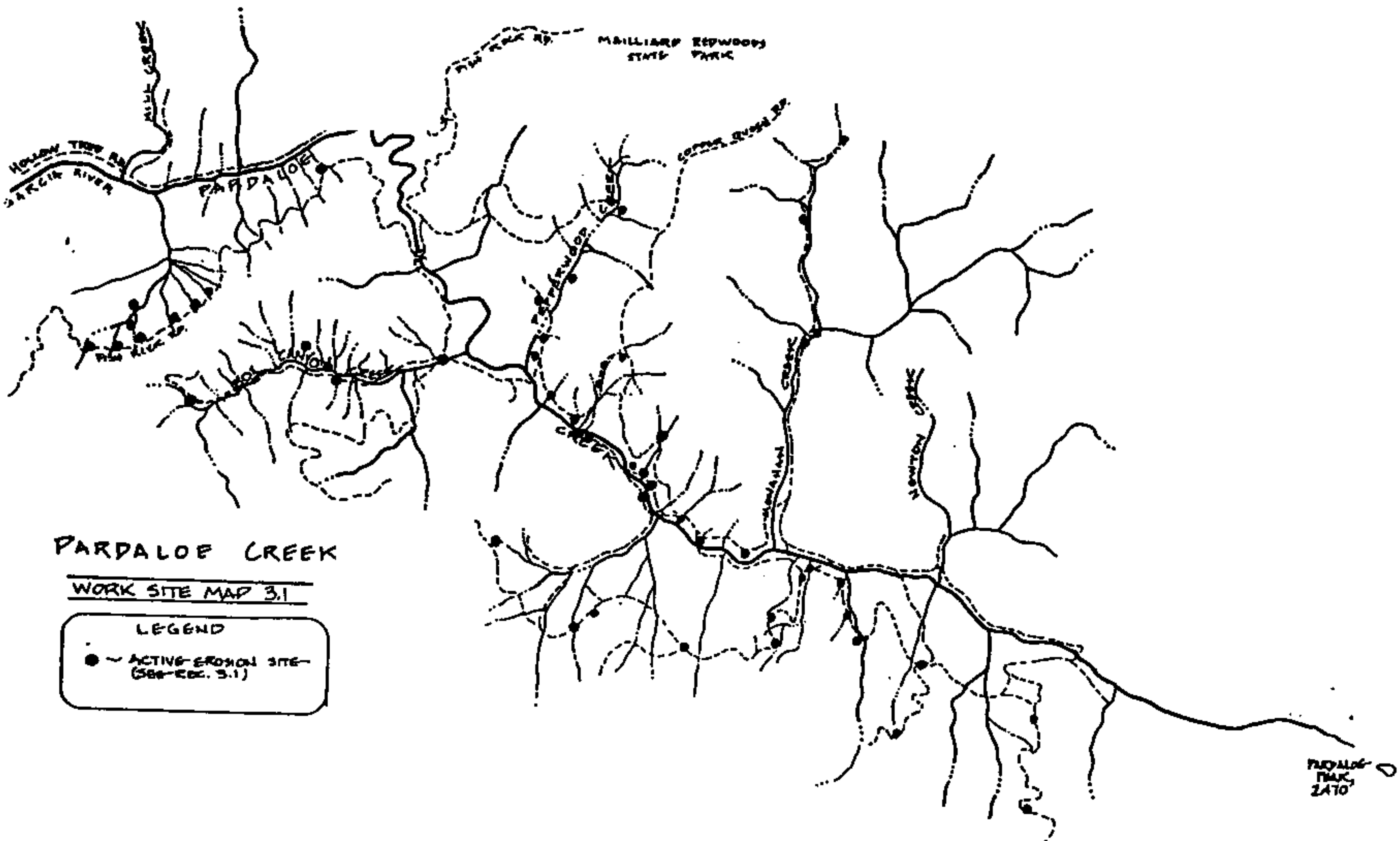
**RECOMMENDATION 3.3: Recontour old in-channel landings and crossings and stabilize channel downstream where necessary.**

Twenty to thirty-five years after logging occurred there are some areas that still have large amounts of sediment stored at old road crossings and instream landings. There are often related stream stability problems immediately downstream from these sites. Specific areas needing this kind of work are indicated on Work Site Maps 3.3, 3.4, 3.5, and 3.6. See Appendix III, Diagram 3.3 for illustrations of general recontouring. It is important to note

ACTIVE EROSION SITES



ACTIVE EROSION SITES



that each site is unique and treatment must be site-specific. Bank protection measures (see Large Debris Revetment Diagrams, Appendix III) can be implemented where needed at recontoured landings or crossings and at problem sites immediately downstream.

**RECOMMENDATION 3.4: Stabilize instream sediment terraces utilizing available native materials and vegetation.**

Many streams in the upper tributaries show evidence of having been filled with from 5-10 feet of sediment along their entire reach. Today most have downcut through this sediment, leaving unstable banks of loose sediment. In many cases nothing protects the newly created terraces from erosion and subsequent bank failure. Specific areas needing this type of work are identified on Work Site Maps 3.3, 3.4, 3.5, and 3.6. Appendix III, Diagram 3.4 illustrates recommended treatment.

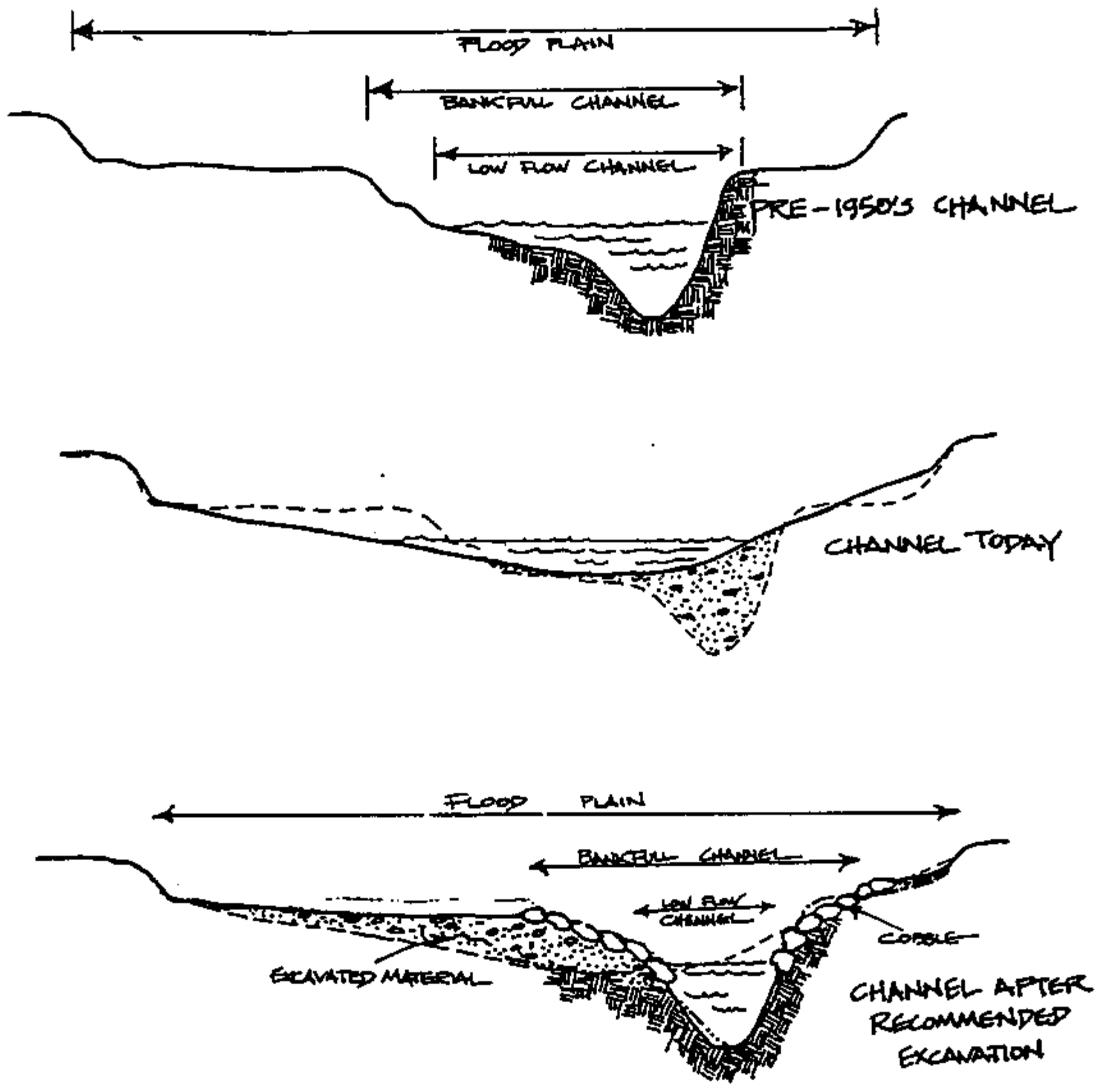
**RECOMMENDATION 3.5: Excavate a well-defined channel on selected sites where stream bed still holds large quantities of stored sediment. Place excavated material above flood stage or create protected flood plain. (See Figure 8.)**

In many reaches of upper streams there is still not a well-incised, clearly defined channel because of excessive sedimentation. These reaches provide poor aquatic habitat and are often sites of bank failure as higher flows with laterally spreading force cut into unprotected banks. Specific areas needing this type of work are identified on Work Site Maps 3.3, 3.4, 3.5, and 3.6.

**RECOMMENDATION 3.6: Stabilize stored sediment behind log jams by stepping streams down through the jam without removing all the structure. (Removal would allow all the sediment to quickly flush downstream.) Also recontour, revet and plant these areas where needed to help stabilize stored sediment.**

Logs and debris should be selectively removed and where appropriate. Excavated debris and logs should be strategically placed and securely anchored to protect eroding adjacent banks and/or redirect stream flow. Woody material not used to stabilize sediment should be placed above the high water zone. Where this is not reasonable or cost effective, material should be piled and burned under permit. Heavy equipment should be used where appropriate in accessible sites.

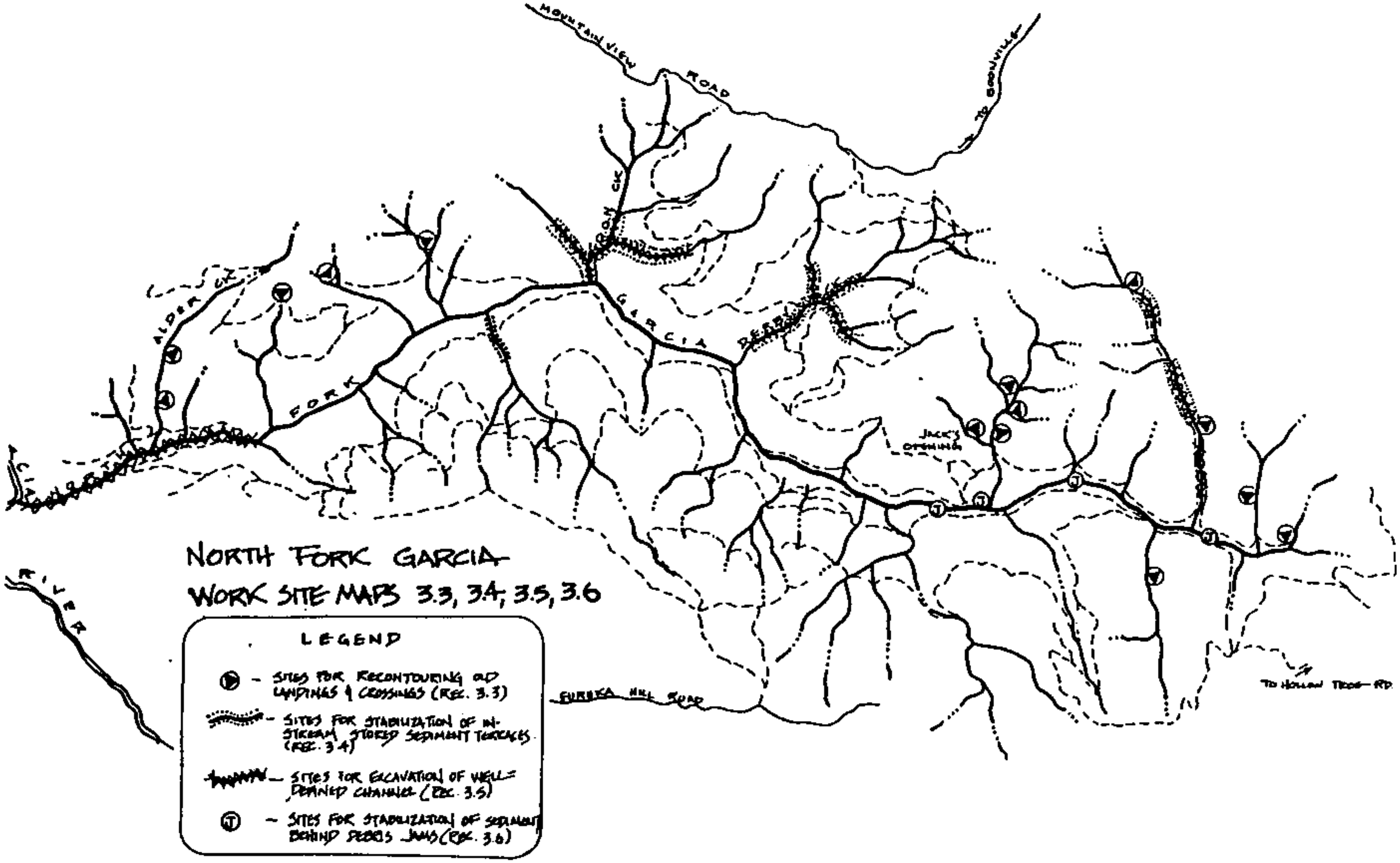
FIGURE 8: DIAGRAM SHOWING EXCAVATION OF A WELL-DEFINED CHANNEL AS RECOMMENDED IN 3.5.



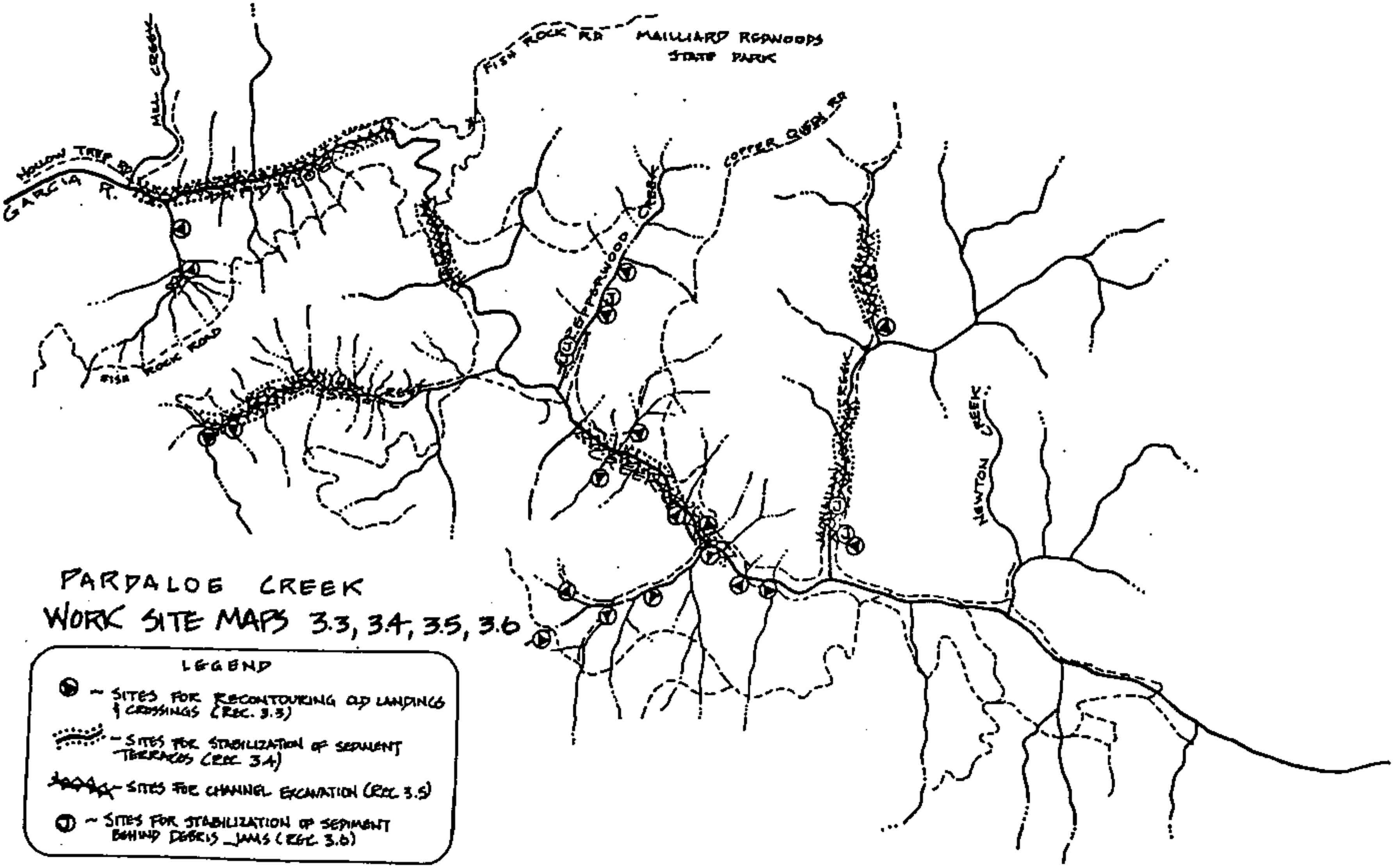

All sound organic material removed by heavy equipment should be stockpiled in an accessible site for future instream structures. On inaccessible sites, hand tools and chainsaws can be used.

The conditions of each debris jam are unique and must be addressed with a site specific workplan. Specific areas needing this type of work are identified on Work Site Maps 3.3, 3.4, 3.5, and 3.6. See Appendix III, Diagram 3.6 for illustration of general treatment of debris jams.

PROPOSED SITES FOR RECONTOURING, STABILIZATION OF SEDIMENT TERRACES, CHANNEL EXCAVATION, AND DEBRIS JAM STABILIZATION



PROPOSED SITES FOR RECONTOURING, STABILIZATION OF SEDIMENT TERRACES, CHANNEL EXCAVATION, AND DEBRIS JAM STABILIZATION



**RECOMMENDATION 3.7: Place large organic debris structures in streams where lacking to scour pools, improve diversity, provide predator protection, clean gravels and support food for fish.**

Work Site Maps 3.7, 3.8 and 3.9 identify specific areas where this enhancement measure is recommended. See Large Debris Revetment Diagrams, Appendix III, for illustrations of fish habitat enhancement structures and guidelines.

**RECOMMENDATION 3.8: Excavate and create stable banks to reestablish a well-defined channel on selected reaches of Class I streams where cemented cobble currently provides poor fisheries habitat. Place excavated material above flood stage or create protected flood plain. Incorporate vortex weirs for grade and alignment control where needed.**

A well-defined channel should provide more scour action and uncover boulders and bedrock for greater diversity for fish habitat. Excavated areas may need large organic structures but, if possible, should be given 1-2 years to adjust to changes before placing structures. Work Site Maps 3.7, 3.8 and 3.9 identify specific areas needing this type of work. See Figure 8 under Recommendation 3.5 in the text for an illustration of this type of excavation. See Appendix III, Diagram 3.8 for an illustration and description of vortex weirs.

**RECOMMENDATION 3.9: Monitor and consider modification of potential fish barriers, as needed, to maintain spawning and rearing habitat for salmonids.**

On many Class I streams debris jams often caused by past logging practices resulted in impassable barriers for anadromous fish, eliminating many miles of productive habitat. Many of these barriers have been removed, but there are still others in place that threaten to block fish passage. Work Site Maps 3.7, 3.8 and 3.9 show locations of debris Jams that need to be monitored to allow passage of anadromous fish. See Appendix III, Diagram 3.6 for illustration of general treatment of debris jams.

**RECOMMENDATION 3.10: Encourage retention of existing riparian vegetation, where it provides stream cover. To the extent possible, leave some mature conifers in these areas to allow for recruitment of large organic debris. Plant riparian vegetation where necessary to provide shade and help provide lower water temperatures and food for fish.**

**RECOMMENDATION 3.11: Where culverts cause migration barriers, modify or replace, if feasible, with bridges or multi-plates (half round culverts with poured cement footings) or other suitable alternative structures.**

Many culverts are impassable for upstream spawning migration because of velocity, gradient, or inaccessible outlet. Bridges and multi-plates allow maintenance of natural stream bottom and gradient. Other crossing structures (including modified culverts) can be used if they can be adapted to these standards. See Appendix III, Diagram 3.11, for an illustration of a multi-plate.

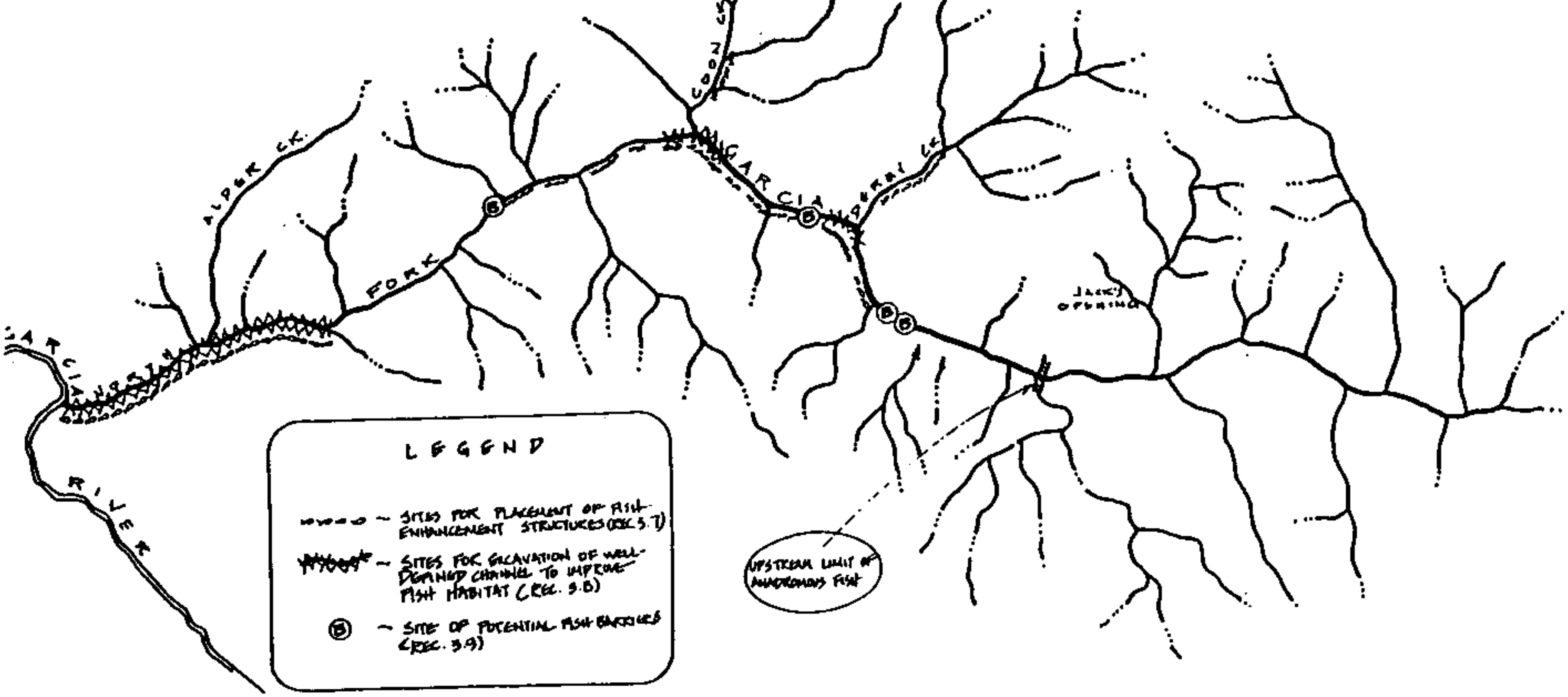
**RECOMMENDATION 3.12: Develop a land use evaluation system that shows the relationship between various land uses, their corresponding sediment yields, and the related effects on fisheries resource.**

This system should include analysis of various land treatments to determine cost-effectiveness in relation to fisheries impact. Spreadsheet models developed by SCS staff that would be useful for the Garcia are on file at the MCRCD (Steffen, 1991) and provide a good starting point.

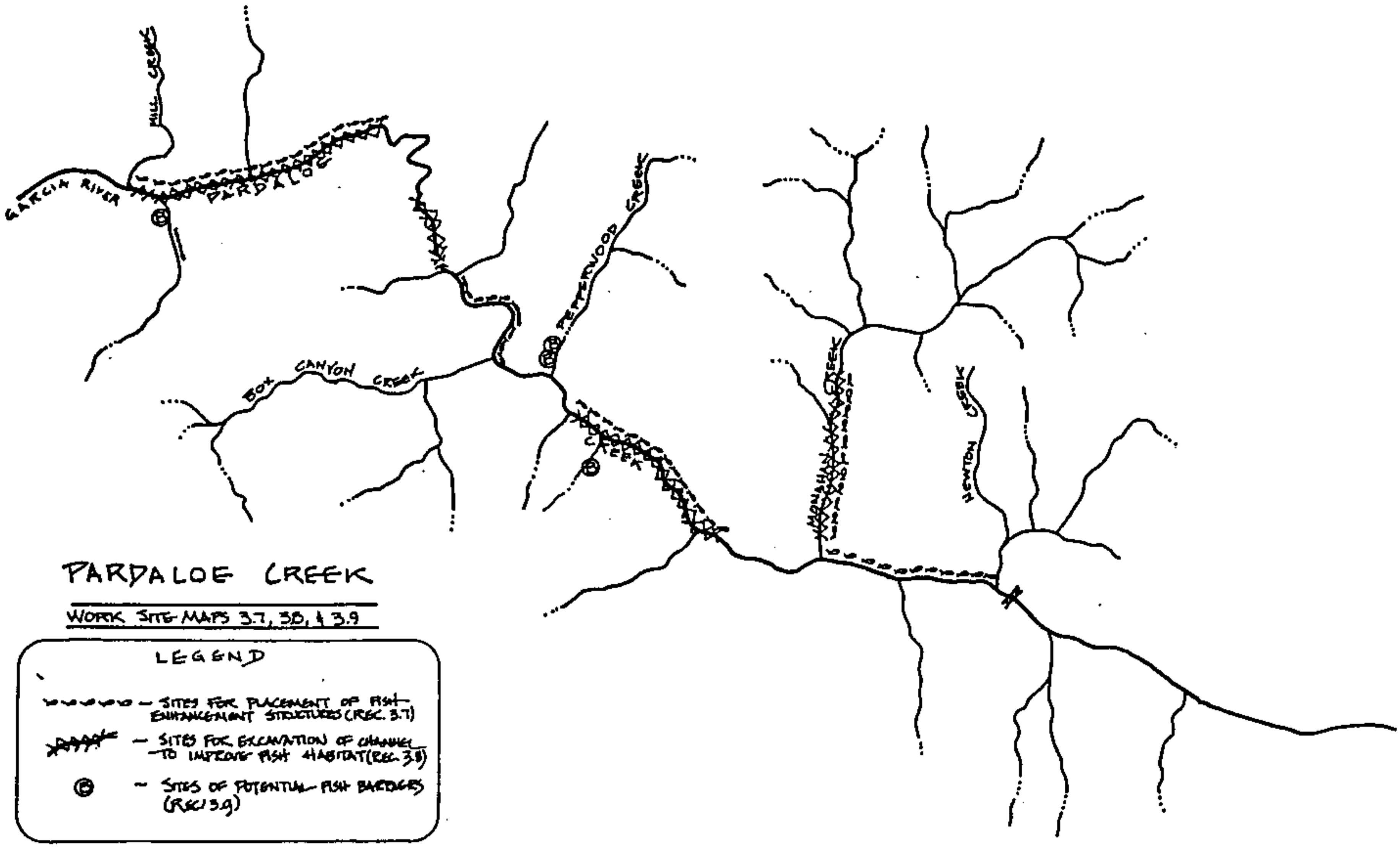
PROPOSED SITES FOR FISH HABITAT ENHANCEMENT MEASURES

## NORTH FORK GARCIA

## WORK SITE MAPS 3.7, 3.8, & 3.9



PROPOSED SITES FOR FISH HABITAT ENHANCEMENT MEASURES



# Area 4: General Recommendations

One of the main objectives of this plan is to lay a foundation for the development of a comprehensive plan for the implementation of fish and wildlife habitat and estuarine restoration and enhancement for the entire watershed.

The following recommendations apply to the Garcia River Watershed as a whole and are aimed towards building the necessary institutional, biological and informational frameworks for the achievement of this larger watershed-wide objective.

**RECOMMENDATION 4.1: Establish a permanent Garcia Watershed Association (possibly an extension and/or expansion of the Watershed Advisory Group) with the objective of continuing the work begun by this plan.**

If the implementation of this plan is to be effective and community-based, there must be continuing leadership and a forum for decision-making within the community. The Watershed Advisory Group has worked hard over the last year to put aside their differing interests to build a consensus regarding the enhancement needs for the watershed. Members of this group should look for ways to establish a permanent Watershed Advisory Group. Some options include: forming a non-profit organization, incorporating into a Community Economic Development Corporation similar to that of the Plumas Corporation, and/or working with agencies under a Coordinated Resource Management and Planning (CRMP) process (CARCD, 1990). This would enable the local group to apply for grant funding (see Appendix IV) and to better work with state and federal agencies as well as private foundations and local sponsors.

This local group would have need to focus on three major objectives:

1) Developing funding sources to implement the recommendations of this Plan;

2) Organizing the personnel needed to carry out projects, similar to the Mattole Restoration Council (MRC 1989); and

3) Undertaking public outreach efforts to expand landowner involvement in the watershed and encouraging individual landowners to develop long range land management plans consistent with goals and objectives of this plan.

**RECOMMENDATION 4.2 Encourage adoption of the following principle as a goal for all watershed land use: where resource use causes significant adverse impacts on the environment, including impacts that become significant when considered cumulatively, such impacts should be mitigated, if it is feasible to do so, by compensating positive action or by limiting negative actions.**

A good example of this is the restoration of areas damaged by past logging practices during current logging activity so that the overall effect of current harvest is positive.

**RECOMMENDATION 4.3: Develop propagation assistance programs for native Garcia River salmonids.**

Artificial propagation (fish culture) can play an important role in restoring Garcia River salmonid populations. It is essential, however, to regard artificial propagation as merely a short-term solution, that is, as an emergency "holding action" to maintain and enhance native stocks. The long-term solution is habitat protection and restoration (as recommended in Areas 1,2, and 3 above), the goal of which is to provide spawning and rearing habitat of sufficient quality and quantity so that wild fish populations become self-sustaining.

The species of highest priority for fish culture efforts on the Garcia are Silver (Coho) and King (Chinook) Salmon. For reasons of genetic integrity and avoidance of disease problems, the importation of stocks from other watersheds should be attempted only after careful screening for disease and adaptability to a shortrun, small stream such as the Garcia. The disease implications of non-native fish introductions are particularly dangerous, as in the case of the Noyo River Coho, which have a history of Bacterial Kidney Disease (BKD) (Pacific Northwest Fish Health Protection Committee, 1989).

The genetic integrity of the Garcia River Coho is in question. There were numerous stockings of Noyo-Mad River strains mixed with several Oregon state river strains in the 1960's through 1980's (Higgins, 1992). Interviews with old-timers reveal that the Garcia Coho was a different-looking, more aggressive, and generally larger fish than the Noyo influenced strain. It is possible that the Garcia Coho, as a distinct adapted strain, maybe at such low levels that supplementation may be necessary for rebuilding. If outside sources of Coho are sought it may be necessary and even desirable to look beyond the convenient Noyo River Hatchery because of the aforementioned BKD problem, genetic impurity, and past poor success in the Garcia despite sizable plantings.

The Mendocino County Salmon and Steelhead Management Plan adopted by the County Board of Supervisors on February 13,1984(Sommarstom 1984), mentions several local streams as having possible "genetic reserves" of Coho minimally affected by hatchery out plantings. The Coho found in Lagunitas Creek (Marin County) have been mentioned as a possible successful strain of Coho for the Garcia.

The once famous Garcia River King Salmon is now in such low numbers that it is only "rumored" to still exist. Some biologists feel transitions in the rainfall pattern (rains occurring later and later each fall), lack of a deep cool estuary, and degradation of suitable spawning gravels have led to the Garcia King's decline. The Garcia River is unique among the small coastal California rivers in its ability to maintain an open flow into the ocean year round. This characteristic may make it possible to re-establish the King Salmon as these smolts migrate to the ocean in the spring shortly after hatching.

If outside King (Chinook) strains are sought for fish culture they would have to be of a "short run" (small stream-short migration distance) and preferably late fall arriving (Dec.-Jan.) type. The Little River (Humboldt County) King is known to have these traits and there is an egg taking station that could provide eggs for hatchbox operations. The Mattole River strain (considered pure) might be appropriate, but it is unlikely to have excess eggs available in the near future.

With the current research being carried out by the DFG (Dr. Bill Cox) to identify and treat fish diseases such as BKD, and infectious hematopoietic necrosis (IHN), etc., it maybe possible to safely introduce successful salmon strains into the Garcia sometime in the future on an experimental basis, when appropriate habitat has been restored.

Diverse gene resources of steelhead trout still exist within the Garcia River Watershed. If small scale culture is attempted to supplement sport fisheries, steps must be taken to prevent loss of genetic diversity. To reduce the risk of genetic "blending" of the river's stock, trapping and rearing should take place in a specific sub-basin. Catching steelhead in the main river that may be heading for specific sub-basins and mixing them as brood stock may have this effect. If adults are trapped and spawned, no marked fish should be used as brood stock to avoid loss of genetic diversity and minimize problems from straying.

Fish should be raised to yearling size and released on site to minimize straying. All fish should be marked and selective harvest of marked fish and release of wild fish should be encouraged. Downstream migrant trapping should take place to monitor movement of juveniles released and to ascertain that competition is not impacting wild fish. "Rescue rearing" of fish that are stranded in side pools when flows drop can be an effective method if rearing habitat is not a limiting factor. Steelhead can fail to emigrate to the ocean, however, and remain in the stream as residents. Evaluation measures to make sure this does not occur must be taken as competition and predation of smaller wild fish from these "residents" can be severe.

**RECOMMENDATION 4.4: Encourage community development of local regulations and educational outreach programs to protect the local fisheries resource.**

Some ideas follow:

1) Organize a community-wide campaign addressing government representatives and agencies requesting a moratorium on specific off-shore fishing practices that may be impacting Garcia (and other North Coast) fisheries until there have been studies to provide the information necessary to implement protective regulation

Because the salmon and steelhead from the Garcia River have different ocean migration patterns, they are vulnerable to different fisheries. California salmon feed in the ocean along the Continental Shelf from Monterey Bay north to the mouth of the Columbia River (PFMC, 1984). Substantial evidence exists that Chinook and Coho salmon stocks were over-fished by the commercial troll fleet as early as the 1930's (McEvoy, 1986). In the 1950's and 1960's hatchery production of Chinook salmon in California increased dramatically. The commercial troll fleet in California rose from fewer than 600 fishermen in 1938 to nearly 4,000 by the 1980's (McEvoy, 1986). Intensified fishing pressure due to the abundance of hatchery stocks could have severely impacted wild salmon populations. Hatchery fish can sustain harvest levels of up to 90% but wild fish returning to healthy habitat have a maximum harvestable surplus of 65%. These MIXED STOCK FISHERIES pose a particular threat to those salmon stocks that return to spawning streams with poor quality habitat (Lichatowich and McIntyre, 1987).

It is very possible that Garcia River steelhead have some degree of risk in the HIGH SEAS DRIFTNET FISHERY. This fishery was established to harvest squid and uses long line monofilament nets. Steelhead from Rowdy Creek Hatchery on the Smith River in northern California showed a significant amount of gill net scars in 1991 (Higgins, et al, 1992). Long line drift netting has recently been banned by the United Nations but enforcement of this ban may be problematic.

In the last decade a hake (or whiting) fishery has developed off the coast of the Pacific Northwest. Ten million pounds of these fish are harvested annually with 250 foot wide mid-water trawl nets. American fishermen operated the catcher boats that supplemented direct take by factory ships. The ships from foreign nations were allowed access under treaties with the United States, but are being replaced by American owned processing ships. Incidental catch of Chinook salmon in recent years has been about 10,000 fish. The hake fishery was shut down off the California coast in 1992 to prevent harvest of depleted Klamath River stocks. Although the impact of this fishery on coho salmon and steelhead is not thought to be significant, the removal of this large biomass of potential prey items for adult salmon could be causing food resource depletion.

2) Develop emergency natural predator control programs, drafted specifically for the Garcia River by the local community to be used if necessary to protect fisheries. It is interesting to note that before European settlement, there were many natural predators that took a lot of fish. Most of these natural predators were trapped for skins or killed to protect livestock, many to or near extinction. Today, however, some of these natural predators are protected, and their numbers are increasing. At the same time good quality fish habitat, including deep pools and structure for cover, has declined, creating an imbalance that favors a large predator take. There has not been a comprehensive assessment of these effects on the resource, but some degree of predator control might play a critical role in the re-establishment of a healthy fishery.

3) Encourage local community outreach and education efforts aimed at creating an understanding of fish needs and life cycles among the fishing community. Further, the community may decide to consider adopting self-imposed regulations to limit fishing for a time to allow for a period of recovery. Adult salmon and steelhead are very vulnerable to human predation as they spawn in shallow stream areas during fall and winter. If salmon and steelhead stocks are to be rebuilt today, instream harvesters will have to use restraint. Examples include adoption of a low flow closure of fishing, and protection of Chinook and Coho through catch and release programs.

**RECOMMENDATION 4.5: Develop an effective monitoring program for analyzing the effects of all enhancement measures implemented.**

A set of monitoring guidelines are set forth in Part 4 of this Plan. Continuing re-evaluation and analysis are critical. The RWQCB monitoring study of the North Fork, discussed above, should assist in understanding the conditions of the upper watersheds. FROG intends to use some private foundation monies to set up two monitoring stations (at Connor Hole and the Highway 1 Bridge) which will be helpful in documenting conditions on the lower 7 Miles of the River. Such efforts are critical. This short one year study of the

Garcia River Watershed has identified a number of interconnected factors which appear to have contributed to the decline in the salmonid fishery. It is only through longer term evaluation of these factors that a definitive understanding of the actions that need to be taken to stem this decline can be achieved. Monitoring and evaluation efforts are critical to assess the effectiveness of any implementation efforts that are undertaken. In the past, heavy impacts were overcome by the sheer numbers of returning spawners. Today we do not have this abundance; even those factors that once might have caused very light impacts on the resources must be analyzed and mitigated if necessary in order to once again build a strong base stock that can thrive despite the many vagaries of man and nature.

# PART 4: Monitoring Needs, Maintenance Requirements, and Possible Adverse Impacts

## Monitoring Needs

Recommendations for monitoring can be separated into two distinct areas:

A. Monitoring to evaluate specific sites and techniques implemented for enhancement, and

B. Monitoring to evaluate long-term changes in the watershed to facilitate analysis of the overall effects of the Garcia River Watershed Enhancement Plan and of natural events.

It is extremely important that all monitoring procedures be standardized as much as possible so that data collected from year to year is compatible and comparison and analysis of changes can occur with a measure of confidence. Where feasible, data should be entered into a computerized database. Certain monitoring techniques, such as habitat typing and direct observations, which involve some subjective interpretation, should if possible be performed by the same person(s) or someone directly trained by that person(s) with the goal of collecting consistent data.

It is recommended that a committee of Garcia landowners be set up (possibly by the Watershed Advisory Group) specifically to administer a monitoring program. This group would determine specific guidelines, sites, time intervals, formats, seek and allot funding, maintain files and records, etc. The importance of a good monitoring system cannot be overemphasized.

Following are general monitoring recommendations to be used as guidelines:

A. Monitoring Specific Sites and Techniques:

1. **Direct Observation**
   At designated work sites monitoring personnel make specific

observations at set intervals and record data on a set form. For example:

| | | |
|---|---|---|
| Site: | X | Date: 15 July 1996 |
| Location: | River Mile 3.42, left bank | |
| Description: | Placement of debris structure to protect eroding left bank and enhance fish habitat. | |
| Observations: | | |
| Bank Stability: | | |
| Vegetation: | | |
| Pool Size and Depth: | | |
| Fish Count: | | |
| Other: | | |

In spite of the subjectivity of such a record, the information proves useful for future comparison and analysis, study of effective techniques, and understanding of the river.

2. **Photo Documentation**
Photo points should be established before any work takes place on a site. Photos should be taken before and during implementation of enhancement measures and at set intervals during direct observation. (See #1 above.)

3. **Cross-sections, Profiles and Sediment Analysis**
These techniques can be useful at sites where the river channel is being directly manipulated to measure the effects of changes. (Example: at sites of gravel extraction and/or recommended measures that alter the streambed.) Cost factors may limit use of these techniques to a few selective sites.

4. **Habitat Typing, Direct Underwater Observation (DUO), and/or Electrofishing**
Habitat typing and DUO were performed on the mainstem Garcia (lower 7 miles), North Fork Garcia, and Pardaloe by Gary Peterson, fisheries biologist, and the data is recorded on forms currently on file at the MCRCD/SCS office in Ukiah as part of the Garcia Baseline Data collected during the summer of 1991. (Electrofishing was not done due to cost limitations.) These methods can be repeated at specific sites (for example, at work sites) to measure the effects of implementation. Here again cost may be a limiting factor, but at least some selected sites can be monitored over time.

5. **Monitor Fish Migration**
Monitor downstream migration of juvenile salmonids for at least 4 consecutive years (March through June) to evaluate the status of Coho and Chinook (if any) in the basin.

6. **Spawning Surveys**
   Initiate wintertime spawning ground surveys to determine the distribution, relative abundance and timing of Coho and Chinook (if any) spawning in the watershed.

B. Monitoring to Evaluate Long-Term Changes in the Watershed:

1. **Gauging Station**
   Re-establish gauging station at site of original USGS Gauging Station (River Mile 8.2) including complete weather station and water temperature recording device.

2. **Photo Points**
   Establish photo points along the length of the river at representative non-work (undisturbed) sites to document changes and provide information for future analysis.

3. **Aerial Photo Review**
   Compare past and future aerial photos, with specific attention to riparian cover and large conifers in riparian zone.

4. **Cross Sections, Profiles and Sediment Analysis**
   Periodically (every 5 years) these measurements should be taken and compared to baseline data collected during the summer of 1991. This information can be used to evaluate changes in the watershed.

5. **Stream Classification**
   Periodically (every 5 years?) perform tasks necessary to classify the river by the Rosgen Method. This will utilize data collected in 4) above as well as other measurements.

6. **Habitat Typing and Direct Underwater Observation (DUO)**
   While these techniques can be useful in evaluation of enhancement measures implemented on specific study sites as mentioned above, it is also very important to get a periodic overview. This can be done by Habitat Typing and DUO on all sites studied in 1991, summarizing this data by computer to compare with summarized 1991 data. (See Appendix 2, Summary of Habitat Types and Biological Inventory, Garcia River, prepared by Jan Derksen, Ph.D., December 10, 1991.)

7. **Stream Monitoring System**
   At present RWQCB and CDF are jointly developing a system for - Measuring the Condition of Cold Water Fish Habitat Relating to Logging and Road Construction." This plan could become the most cost-effective stream monitoring system developed to date, and if this proves true, it should be applied to the Garcia.

8. **Upslope Sediment Monitoring System**
For a watershed-wide monitoring program to be complete it is important that an effective monitoring system that can determine the relationship of on-site erosion to stream sedimentation be implemented. At present the Board of Forestry, CDF and RWQCB are developing (as a complement to #7 above) a plan for monitoring eroding upslope soils in relation to land use. If this plan proves useful, it could be applied to the Garcia. If not, an effective plan needs to be found or developed.

9. **General Overall Direct Observation**
It is suggested that periodic overviews of main watershed areas be conducted by monitoring personnel. For example, every five years the entire reach of the North Fork could be walked, recording general observations. Likewise, periodically a ranch, or a timber harvest plan, or a sub-division could be observed. **It is always important to keep in mind that effective monitoring looks at both the "forest" and the "trees."**

## Maintenance Requirements

**GENERAL MAINTENANCE GUIDELINE;** Most enhancement recommendations in the Garcia River Watershed Enhancement Plan, if implemented correctly, should require little maintenance. However, **as a general rule it is recommended that all work sites be inspected after the first storm of each season and after all major storms.** This review will not only point out necessary maintenance but will also provide information about the effectiveness of the enhancement measures implemented and can be done at the same time as the Direct Observation listed under monitoring techniques on page 4-1 above.

Specific maintenance recommendations follow, corresponding to Enhancement Recommendations as listed in Part 3.

### ESTUARY

**Recommendation 1.1A** Bank protection measures should be carefully monitored at the realignment site. Additional bank protection may be necessary below the realignment as the channel adjusts to changes. Extensive failure is not anticipated, and willow transplants should provide adequate protection if minor bank failure does occur.

**Recommendation 1.1B** The same bank protection measures are recommended for 1.1A and 1.1B. Some maintenance of the bank protection structures may be necessary. Research has not turned up models using this method of bank protection in lower estuaries, and the effects of tidal action and sandy bank materials are not known. Therefore the extent of maintenance cannot be accurately estimated at this time.

**Recommendation 1.2** Insuring the integrity of the sandbar could require some maintenance. It is difficult to estimate the extent of maintenance because there are no similar projects to use as a model.

**Recommendation 1.3** Bank protection measures as recommended have apparently not been used in lower estuaries, so the extent of maintenance cannot be accurately estimated. (See 1.1B.)

**Recommendation 1.4** During the first year after implementation visual inspection is recommended following each large storm event to check on the integrity of the anchoring of the structures. After that, yearly maintenance inspections should be adequate.

**Recommendation 1.5** Implementation and maintenance requirements of this recommendation require further study.

**LOWER 7 MILES**

**Recommendation 2.1** See Recommendation 1.4.

**Recommendation 2.2** In some areas, depending on land use, fencing may be required for adequate maintenance. Fencing should be checked before bud break in the spring and at least once during the summer. In areas where vegetation needs protection from wildlife (not livestock) vexar tubes can be placed on conifers and need to be reset each spring before buds break and again around the first of June. If browse is a problem on willow and alder, remay protectors may be used and must be adjusted at least bi-monthly from bud break in early spring until the fall.

**Recommendation 2.3** There should be no maintenance necessary at willow removal sites unless drought conditions continue, in which case willows causing constriction may need to be removed every 3-5 years.

**Recommendation 2.4** N/A

**Recommendation 2.5** N/A

**UPPER TRIBUTARIES**

**Recommendation 3.1** See General Maintenance Guideline.

**Recommendation 3.2** N/A

**Recommendation 3.3** See General Maintenance Guideline.

**Recommendation 3.4** See General Maintenance Guideline.

**Recommendation 3.5** All channel excavation sites should be re- viewed after the first major storm, and hand work should be done if necessary to insure the integrity of the newly excavated channel. It is anticipated that at some work sites heavy equipment maintenance may be required after the first winter to maintain a well-defined channel and to protect previously excavated stored sediment.

**Recommendation 3.6** See General Maintenance Guideline.

**Recommendation 3.7** See Recommendation 1.4.

**Recommendation 3.8** See General Maintenance Guideline.

**Recommendation 3.9** See General Maintenance Guideline.

**Recommendation 3.10** Some maintenance may be required for browse protection. See Recommendation 2.2.

**Recommendation 3.11** See General Maintenance Guideline.

**Recommendation 3.12** N/A

## Potential Adverse Effects

### ESTUARY

**Recommendation 1.1A** Changes in alignment will involve intense short term adverse impacts on the fish habitat and will also result in some adaptive changes in alignment both up and downstream, which could include bank failure. The exact nature of these changes is difficult to anticipate.

The use of heavy equipment to carry out the project would also have an adverse effect on the animal and plant communities in the surrounding area.

**Recommendation 1.1B** See Recommendation 1.1A.

**Recommendation 1.2** Could cause increased flooding of fields during large storm events.

If erosion cloth or some other material is used to help stabilization, it could have an adverse aesthetic effect and could also have some possible negative effects on the plant and animal communities.

**Recommendation 1.3** Use of heavy equipment will adversely affect the plant and animal communities in the area of construction.

**Recommendation 1.4** These structures could be utilized by non-target species. (Example: a family of otter made their home in a structure constructed in the Mattole Estuary.)

Structures could affect river channel in ways that could have negative effects. (Example: Current logjam at Mud Flat Hole has contributed to right bank failure.)

**Recommendation 1.5** By targeting a specific estuarine habitat for reestablishment — in this case, tidal marsh — other equally valuable but less understood habitats might be reduced or eliminated.

**LOWER 7 MILES**

**Recommendation 2.1** See 1.4.

**Recommendation 2.2** In the future there may be some reduction in hay fields if this recommendation is implemented. The improved stability of banks resulting from a strong riparian corridor, however, could save sections of fields and thereby offset any loss caused by encroachment of riparian vegetation into fields.

Any time there is a change in vegetation, there will be some adverse effect on plant and animal species dependent on the replaced vegetation type.

**Recommendation 2.3** Excavation of willows in the low flow channel area will have a short term adverse effect on the fisheries habitat by removing shade, food source, complex cover and structure that constricts the channel and creates pools.

Protecting banks could have a short term adverse effect on the habitat in the immediate area.

**Recommendation 2.4** There should be no adverse effects from this recommendation in its current form, as it only recommends further study.

**Recommendation 2.5** See Recommendation 2.4.

**UPPER TRIBUTARIES**

**Recommendation 3.1** Protecting banks would probably have a short term adverse effect on the habitat in the immediate area.

There will also be some changes in the stream channel which could result in minor changes both up and downstream.

**Recommendation 3.2** No adverse effects.

**Recommendation 3.3** Depending on the current instability at each site, there exists the possibility of a short term increase in sediment transport after recontouring.

**Recommendation 3.4** Using materials from immediate area could have a short term adverse effect on the stream channel.

**Recommendation 3.5** This recommendation will cause short term increase in sediment transport.

It will also cause the short term destruction of existing aquatic habitat in those reaches where work is carried out.

**Recommendation 3.6** In most situations mechanical manipulation will cause a short term increase in sediment transport.

Another possible adverse effect is the raising of water temperatures. Currently water flows subsurface during low flows at many of these log jams, which results in lower water temperatures where it resurfaces. Modification of these jams and excavation of stored sediment behind jams will probably result in surface flows during low flow periods and could in crease stream temperatures until riparian vegetation provides shade.

The large jams also provide home and food for other species, some of which will be destroyed in the process of modification.

**Recommendation 3.7** See Recommendation 1.4.

**Recommendation 3.8** See Recommendation 3.4.

**Recommendation 3.9** See Recommendation 3.1.

**Recommendation 3.10** No adverse effects foreseen at this time.

**Recommendation 3.11** Replacing a culvert with a bridge or multi-plate could cause a short term increase in erosion.

**Recommendation 3.12** No adverse effects foreseen at this time.

**NOTE: For all above recommendations requiring use of heavy equipment for implementation, possible adverse effects of developing access to work site must be considered**

**GENERAL RECOMMENDATIONS**

Recommendation 4.1 There is the possibility that this would turn into just one more level of bureaucracy or that in-fighting between diverse interest groups within the WAG would limit its effectiveness.

Recommendation 4.2 No adverse effects.

Recommendation 4.3 Propagation technology and policy has had many adverse effects on the North Coast fisheries resource to date, and great care must be taken to protect against further adverse effects.

Recommendation 4.4 No adverse effects foreseen at this time.

Recommendation 4.5 Many monitoring programs have been ineffective at obtaining **USABLE** data and are used as an excuse to continue current practices. It is important to recognize both the limitations as well as the positive aspects of monitoring.

**END**

## References

Accardi. Al. *Fishfinder Map: Garcia River.* c. 1952. (from U.C. Berkeley Map Library.)

Adams. Mark and Ian Whyte. 1990. *Fish Habitat Enhancement A Manual for Freshwater, Estuarine and Marine Habitats.* Department of Fisheries and Oceans. Vancouver, B.C.. Canada.

Bison. P.A., J.C. Nielsen. R.A. Palmason. and L.E. Grove. 1981. "A System of Naming Habitat Types in Small Streams, with Examples of Habitat Utilization by Salmonids during Summer Low Flow," Proceedings of Acquisition of Aquatic Habitat Inventory Information, WDAFS. Portland. Oregon.

Bjornn, T. C. and D. W. Reiser. 1991. "Habitat Requirements of Salmonids in Streams." *American Fisheries Society,* Special Publication 19.

California Association of Resource Conservation Districts (CARCD). 1990. *Coordinated Resource Management and Planning.* (Pamphlet). Coordinated Resource Management and Planning Technical Advisory Council.

California Department of Fish and Game. 1955. Photos of North Fork Garcia taken November 22, 1955, showing damage of past logging practices. (From files of Ted Wooster.)

California Department of Transportation. 1938, 1940. 1958, 1968, 1979. Photos of Highway 1 Bridge Over Garcia River. (Loaned by Mike Moore. Biologist. CalTrans, Eureka. Calif.)

California State Water Resources Control Board. 1990. *1990 Water Quality Assessment* Sacramento, Calif.

Cedarholm, C.J. 1983. *Clearwater River Wild Steelhead Spawn Timing.* Proceedings of Olympic Wild Fish Conference, Peninsula College, Port Angeles, Washington.

Fairbanks, W. W. 1907. "Point Arena: Its Early History, Settlement, and Growth." *The Northern Crown* Ukiah, Calif.

Fisk, Leonard, et al. August 1966. "Stream Damage Surveys." California Department of Fish and Game. *Inland Fisheries Report* No. 66-10.

Flosi. Gary and Forrest L. Reynolds. 1991. *Habitat Typing and Stream Classification Manual* (Preliminary Draft) California Department of Fish and Game. pp. 3.1 - 3.24,3.37 - 3.41.

Frissell, C.A. and T. Hrai. 1988. "Life History Patterns, Habitat Change, and Productivity of Chinook Stocks of Southwest Oregon." Proceedings of 1988 Northeast Pacific Chinook and Coho Workshop. WDAFS.

Green, Charles. 1992. Regional Water Quality Control Board Monitoring on the North Fork. Personal conversation with Debra Caldon 7/14/92.

GRV Enterprises. 1991. Personal Interviews with Garcia Community members. Pt. Arena, Calif.

Hecht. Barry. 1983. "Hydrology of Lower Brush Creek. Mendocino County: Preliminary Assessment." J. H. Kleinfelder and Assoc. Berkeley, Calif.

Higgins, P., S. Dobush and D. Fuller. June 1992. "Factors in Northern California Threatening Stocks with Extinction." *Humboldt Chapter of Amer. Fisheries Soc.*

Hood. Leslie (ed.). 1975. 1976. 1977. *Inventory of California* Natural Areas, Vol. V. California Natural Areas Coordinating Council. Sonoma. Calif.

Howell. David. 1991. Personal correspondence.

Jackson, Dennis. April 16, 1991. "Review of the Garcia River USGS Gaging Station." Unpublished report.

Jackson, Dennis. 1991-92. Unpublished reports and discussions.

Jones, Wendall. 1990-1992. Personal discussions.

King, Nicholas. 1990-1992. Personal discussions, interviews, and rainfall records.

Light. J.T., S. Fowler, and M. Dahlberg. 1988. *High Seas Distribution of North American Steelhead as Evidenced by Recoveries of Marked or Tagged Fish.* Fisheries Research Institute. University of Washington, Seattle, Washington.

MacDonald, Lee. 1991. *Monitoring Guidelines to Evaluate Effects of Forestry Activities* on *Streams in the Pacific Northwest and Alaska.* EPA. Seattle, Wash.

Maxwell. J.C., S.D. Etter. D.M. Fritz. P.R. Gucwa. M.A. Jordan, J.R. Kleist, D.H. Lehman. J.A. Raney and D.M. Worral. 1981. *Geologic Cross Sections, Northern California Coast Ranges to Northern Sierra Nevada and Lake Pillsbury Area to Southern Klamath Mountains.* Geological Society of America.

Menhaden. W. R. editor. 1991. "Influences of Forest and Rangeland Management on Salmon Fisheries and Their Habitats." American *Fisheries Society,* Special Publication 19.

McCain. M., D. Fuller, L. Decker, and K. Overton, 1990. *Stream Habitat Classification and Inventory Procedures,* USDA Forest Service. Pacific Southwest Region, San Francisco. Calif.

McKenzie. Don. 1991. Personal discussion.

Moungovan, Thomas, Julia Moungovan and Nanie Escola. 1968. *Where There's a Will There's a Way: Unusual Logging and Lumbering Methods on the Mendocino Coast* Mendocino County Historical Society. Ft. Bragg. Calif.

Nawa, R., C.A. Frissell, and W.J. Liss. 1991. *Classification of Stream Habitat and Watershed Systems in South Coastal Oregon.* Report for ODFW. Oak Creek Laboratory, Oregon State University. Corvalis, Oregon.

Nelson, W., J. E. William, and J.A. Lichatowich. 1991. "Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington." *Fisheries* 16:(2):4-21.

Nicholas, J.W. and D.G. Hankin. 1988. Chinook Salmon Populations in *Oregon Coastal River Basins.* Oregon State University, Corvalis, Oregon. Funded by ODFW.

North Coast Regional Water Quality Control Board. 1971. *Water Quality Control Plan for the North Coastal Basin.* Sacramento, Calif.

Ott Water Engineers, Inc. 1979. *Multi-Purpose Water Resources Investigation: Manchester-Point Arena Rancheria for Tribal Council and US Bureau of Indian Affairs.* Redding, Calif.

Pacific Northwest Fish Health Protection Committee (PNFHPC). 1989. *Model Comprehensive Fish Health Protection Program.* 1002 N.E. Holiday Street, Portland, Oregon.

Platts. William S. 1990. *Managing Fisheries and Wildlife on Rangelands Grazed by Livestock: A Guidance and Reference* Document for Biologists. Nevada Department of Wildlife, Carson City, Nevada.

Puckett, L.K. 1977. *The Eel River Estuary — Observations on Morphometry, Fishes. Water Quality, and Invertebrates.* California Department of Fish and Game under contract with CDWR

Puffer, Alan. 1991. National Weather Service. Eureka, Calif.

Rau, Haydon, Bordessa, Franz, and Assoc. August 1990. *An Environmental Assessment for Gravel Bar Skimming on the Garcia River, Mendocino County, California.* Ukiah, Calif.

Reeves, G.H., F.H. Everest, and T.E. Nickelson. 1988. *Identification of Physical Habitat Limiting the Production of Coho Salmon in Western Washington and Oregon.* USDA Forest Service, General Technical Report PNW-140, Portland, Oregon.

Reimers, P.E. 1973. *The Length of Residence of Juvenile Chinook Salmon in the Sixes River, Oregon.* ODFW Commission Report 4(2): 1-43. Portland, Oregon.

Reeves. G.H., F.H. Everest. and T.E. Nickelson. 1988. *Identification of Physical Habitat Limiting the Production of Coho Salmon in Western Washington and Oregon.* USDA Forest Service. General Technical Report PNW-140. Portland, Oregon.

Ricker, W.E. 1972. "Heredity and Environmental Factors Effecting Certain Salmonid Populations," Stock *Concept of Pacific Salmonids,* H.R. McMillan Lecture Series, Vancouver, B.C.

Rosgen, Dave. 1991. *A Short Course on Stream Classifications and Applications.* Wildland Hydrology Consultants. Pagosa Springs. Colorado.

Seddell, J.R., P.A. Bisson, F.J. Swanson, and S.V. Gregory. 1988. "What we know about large trees that fall into streams and rivers." From *the Forest to the Sea: A Story of Fallen Trees.* UJSDA Forest Service and USDI BLM. PNW-GTR-229. Portland. Oregon.

Sengletten, Louis A. 1870. *Pt Arena and Vicinity Map. Surveyed February, March, and July 1870.* U. S. Coast Survey.

Steffen. Lyle and Edward Schmidt. July 9, 1991. *Garcia River Watershed Enhancement Plan.* USDA Soil Conservation Service. Hydrologic Unit Planning Assistance.

Sullenberger, Martha. 1980. "Dog Holes and Donkey Engines." Taken from *An Historical Resources Study of the State Park System Units on the Mendocino Coast* (From U. C. Berkeley Bancroft Library, Berkeley, Calif.)

Sullivan. C.M. 1988. *Juvenile Life History of Klamath River Basin Fall Chinook Salmon as Determined by Scale Analysis.* M.S. Thesis. Humboldt State University. Arcata. Calif.

Suppe. J. 1978. Cross *Section of Southern Part of Northern Coast Ranges and Sacramento Valley, California.* Geological Society of America.

US Geological Survey. Gaging station water flow data 1952-56. 1963-1983.

US Geological Survey. Gaging station water temperature data 1964-1979.

Weatherford. Gary. 1979. *Erosion and Sediment in California Watersheds: A Study of Institutional Controls.* John Muir Institute. Inc. Napa. Calif.

## Bibliography

Accardi. Al. *Fishfinder Map: Garcia River, c.* 1952. (from U. C. Berkeley Map Library.)

Adams, Mark and Ian Whyte. 1990. *Fish Habitat Enhancement A Manual for Freshwater. Estuarine and Marine Habitats.* Department of Fisheries and Oceans. Vancouver, B.C., Canada.

Aerial photos. 1937. U. C. Berkeley Map Library. 1952, SCS/MCRCD Office. Ukiah, California. 1965, SCS/MCRCD Office, Ukiah. California. 1988, SCS/MCRCD Office, Ukiah, California.

Bison. P.A., J.C. Nielsen, R.A. Palmason. and L.E. Grove. 1981. "A System of Naming Habitat Types in Small Streams, with Examples of Habitat Utilization by Salmonids during Summer Low Flow," Proceedings of Acquisition of Aquatic Habitat Inventory Information, WDAFS, Portland, Oregon.

Bjornn, T. C. and D. W. Reiser. 1991. "Habitat Requirements of Salmonids in Streams." American Fisheries Society, Special Publication 19.

California Assembly Bill § 2261, preamble.

California Association of Resource Conservation Districts (CARCD). 1990. *Coordinated Resource Management and Planning.* (Pamphlet). Coordinated Resource Management and Planning Technical Advisory Council.

California Department of Fish and Game Code. § 1505.

California Department of Fish and Game. 1992. *Natural Diversity Data Base: Pt Arena Quadrangle Map Overlay and Textual Printout* Natural Heritage Division.

California Department of Fish and Game. 1956. *Illustrations of Logging Operations and Practices Which Protect North Coast Salmon and Spawning Streams — And Those That Don't* California Department of Fish and Game Publication No. 4.

California Department of Fish and Game. 1955. Photos of North Fork Garcia taken November 22, 1955, showing damage of past logging practices. (from files of Ted Wooster.)

California Department of Fish and Game, Water Projects Branch. Contract Services Section. April 1965. "North Coastal Area Investigation. Appendix C: Fish and Wildlife." *California Dept of Water Resources Bulletin.* No. 136.

California Department of Forestry. June 17. 1991. Timber Harvest Plan 1-91-202-MEN. Owners: Ishizaki 1988 Trust. Plan Addendum to Item 15 Silviculture/ History Addendum.

California Department of Forestry. Timber Harvest Plans:
1-88-223-MEN
1-88-530-MEN

1-88-540-MEN
1-88-581-MEN
1-88-680-MEN
1-88-728-MEN
1-88-734-MEN
1-88-740-MEN
1-89-036-MEN
1-89-105-MEN
1-89-395-MEN
1-89-836-MEN
(North Fork Garcia)
1-85-059-MEN
1-87-310-MEN
(Pardaloe Creek)

California Department of Transportation. 1938. 1940. 1958. 1968, 1979. Photos of Highway 1 Bridge Over Garcia River. (Loaned by Mike Moore, Biologist. CalTrans. Eureka. Calif.)

California Protected Waterways Act (1968) and Plan (1971). Chapter 1278 of the Statutes of 1968.

California State Water Resources Control Board. 1990. *1990 Water Quality Assessment* Sacramento, Calif.

Carlson, Jack, Frank Reckendorf, and Wilbur Teruyik. 1991. *Stabilizing Coastal Sand Dunes in the Pacific Northwest* USDA Soil Conservation Service Agricultural Handbook #687.

Cedarholm, C.J. 1983. *Clearwater River Wild Steelhead Spawn Timing.* Proceedings of Olympic Wild Fish Conference. Peninsula College, Port Angeles, Washington.

Everest, F.H., F.B. Lotspeich, and W.R Meehan. 1982. "New Perspectives on Sampling, Analysis, and Interpretation of Spawning Gravel Quality." N.B. Armantrout (ed.) *Acquisition and Utilization of Aquatic Habitat Inventory Information,* pp. 325-333. Western Division AFS. Portland. Oregon.

Fairbanks. W. W. 1907. "Point Arena. Its Early History. Settlement and Growth." *The Northern Crown.* Ukiah, Calif. (From Mendocino County Historical Society, Ukiah, Calif.)

Fisk, Leonard, et al. August 1966. "Stream Damage Surveys." California Department of Fish and Game. *Inland Fisheries Report* No. 66-10.

Flosi. Gary and Forrest L. Reynolds. 1991. *Habitat Typing and Stream Classification Manual.* (Preliminary Draft) California Department of Fish and Game. pp. 3.1 - 3.24, 3.37 - 3.41.

Friedkin. J. F. 1945. "A Laboratory Study of the Meandering of Alluvial Rivers." Army Corps of Engineers.

Friedkin, J. F. 1991-92. Unpublished reports and discussion.

Friends of Old Growth. June 1992. "The Forest Protector." Insert to *EcoNews,* Vol. 1. No. 1. Northcoast Environmental Center. Arcata. Calif.

Frissell. C.A. and T. Hrai. 1988. "Life History Patterns. Habitat Change, and Productivity of Chinook Stocks of Southwest Oregon." Proceedings of 1988 Northeast Pacific Chinook and Coho Workshop. WDAFS.

Fritts, Harold C., and Geoffrey A. Gordon. Annual *Precipitation for California Since 1600 Reconstructed from Western North American Tree Rings.* (From California Water Resources Department, Federal Building, Eureka, Calif.)

Fry, Donald H., Jr., and Dan W. Clancy, compilers and editors. January 15. 1965. "Inventory and Human Requirements for Anadromous Salmonid Resources." Unpublished report. California Department of Fish and Game. (On file at Calif. Water Resources Agency Library, Sacramento, Calif.)

Green, Charles. 1992. Regional Water Quality Control Board Monitoring on the North Fork. Personal conversation with Debra Caldon 7/14/92.

GRV Enterprises. 1991. Personal interviews with Garcia Community members. Pt. Arena. Calif.

Hammond, Jensen, and Wallen. July 1981. *Wheeler Property Map.*

Hammond, Jensen, and Wallen. Dec. 1, 1963. *North Fork Garcia Unit Map.* Hollow Tree Lumber Co.

Hanen, William. c. 1900. "Point Arena." Old newspaper clipping. (From Mendocino County Historical Society. Ukiah. Calif.)

Hecht, Barry. 1983. "Hydrology of Lower Brush Creek, Mendocino County: Preliminary Assessment." J. H. Kleinfelder and Assoc. Berkeley, Calif.

Higgins, P., S. Dobush and D. Fuller. June 1992. "Factors in Northern California Threatening Stocks with Extinction." *Humbled Chapter of Amer. Fisheries Soc.*

Hood, Leslie (ed.). 1975, 1976, 1977. *Inventory of (California Natural Areas,* Vol. V. California Natural Areas Coordinating Council. Sonoma, Calif.

Howell, David. 1991. Unpublished report and personal correspondence.

Jackson, Dennis. April 16, 1991. "Review of the Garcia River USGS Gaging Station." Unpublished report.

Jackson, Dennis. 1991-92. Unpublished reports and discussions.

Jones and Stokes Associates, Inc. October 1981. An Ecological Characterization of the Central and Northern California Coastal Region. Vol. IV: Watersheds and Basins. U.S. Fish and Wildlife Service, Office of Biological Services, and The Bureau of

Land Management, Pacific Outer Continental Shelf Office. FWS/OBS-80/48.1. Washington. D.C..

Jones. Wendall. 1990-1992. Personal discussions.

King, Nicholas. 1990-1992. Personal discussions, interviews, and rainfall records.

Kleinfelder, J.H. and Assoc. 1983. *Hydrology on the Lower Brush Creek Area.*

Levene, Bruce. 1977. *Mendocino County Remembered: An Oral History. Vol II (M-Z).* Mendocino County Historical Society. Ukiah, Calif.

Lichatowich, J.A. and J.D. McIntyre. 1987. *Use of Hatcheries in the Management of Pacific Anadromous Salmonids.* AFS Symposium. 1: 131-136.

Light, J.T., S. Fowler, and M. Dahlberg. 1988. *High Seas Distribution of North American Steelhead as Evidenced by Recoveries of Marked or Tagged Fish.* Fisheries Research Institute, University of Washington. Seattle. Washington.

Lisle. Thomas and Sue Hilton. 1992. *Measuring the Relative Volume of Fine Sediment in Pools.* (From Mendocino County Water Agency.)

Lisle. Thomas and Sue Hilton. 1992. *The Volume of Fine Sediment in Pools: An Index of Sediment Supply in Gravel Bed Streams.* (From Mendocino County Water Agency.)

MacDonald. Lee. 1991. *Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska.* EPA. Seattle, Wash.

Mackin, J. Hoover. May 1948. "Concept of the Graded River." *Bulletin of the Geological Society of America,* Vol. 59. 483-512. (Taken from *River Morphology,* edited by Stanley Schumm, Benchmark Papers In Geology.)

Mattole Restoration Council. 1989. *Elements of Recovery: An Inventory of Upslope Sources of Sedimentation in the Mattole River Watershed.* (Prepared for the California Department of Fish & Game.) Petrolia. Calif.

Mattole Restoration Council. Winter 1991. Newsletter No. 8. Petrolia. Calif.

Maxwell, J.C., S.D. Etter. D.M. Fritz. P.R. Gucwa. M.A. Jordan. J.R. Kleist, D.H. Lehman, J.A. Raney and D.M. Worral. 1981. *Geologic Cross Sections, Northern California Coast Ranges to Northern Siena Nevada, and Lake Pillsbury area to Southern Klamath Mountains.* Geological Society of America.

McCain, M., D. Fuller. L. Decker, and K. Overton. 1990. *Stream Habitat Classification and Inventory Procedures,* USDA Forest Service. Pacific Southwest Region. San Francisco, Calif.

McEvoy, A.F. 1986. *The Fishermens' Problem: Ecology and Law in California Fisheries. 1850-1980.* Cambridge Press. New York, N.Y.

Mendocino County Resource Conservation District. 1983. Tomki Creek Watershed: North Coast Erosion and Sediment Control Pilot Project. Final Report." Ukiah, Calif.

Menhaden, W.R., editor. 1991. "Influences of Forest and Rangeland Management on Salmon Fisheries and Their Habitats." American Fisheries Society. Special Publication 19.

Moungovan, Thomas, Julia Moungovan and Nanie Escola. 1968. *Where There's a Will There's a Way: Unusual Logging and Lumbering Methods on the Mendocino Coast* Mendocino County Historical Society. Ft. Bragg. Calif.

Nawa, R., C.A. Frissell, and W.J. Liss. 1991. *Classification of Stream Habitat and Watershed Systems in South Coastal Oregon.* Report for ODFW, Oak Creek Laboratory, Oregon State University, Corvalis, Oregon.

Nelson. W., J. E. William, and J. A. Lichatowich. 1991. "Pacific Salmon at the - Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington." *Fisheries* 16:(2):4-21.

Nicholas, J.W. and D.G. Hankin. 1988. *Chinook Salmon Populations in Oregon Coastal River Basins.* Oregon State University, Corvalis. Oregon. Funded by ODFW.

Nielsen. J.L. Anadromous *Salmonid Resources of Mendocino Coastal and Inland Rivers.* 1989-1990.

North Coast Regional Water Quality Control Board. 1971. *Water Quality Control Plan for the North Coastal Basin.* Sacramento. Calif.

North Coast Regional Water Quality Control Board in cooperation with the California Department of Forestry. April 16. 1992. *Draft Monitoring Plan: Measuring the Condition of Cold Water Fish Habitat Relating to Logging and Road Construction.* Santa Rosa. Calif.

North Coast Regional Water Quality Control Board. Northern Coast Region. November 27, 1989. "Interoffice Communication: Stream Survey. No. Fork Garcia." Santa Rosa, Calif.

Ott Water Engineers, Inc. 1979. *Multi-Purpose Water Resources Investigation: Manchester-Point Arena Rancheria for Tribal Council and US Bureau of Indian Affairs.* Redding. Calif.

Pacific Fisheries Management Council. 1984. *Pre-Season Report Stock Abundance Analysis for 1984 Ocean Salmon Fisheries.* PFMC, Portland, Oregon.

Pacific Northwest Fish Health Protection Committee (PNFHPC). 1989. *Model Comprehensive Fish Health Protection Program.* 1002 N.E. Holiday Street, Portland, Oregon.

"Palmer Drought Severity Index, North Coast from 1895 to 1990 and 1970 to 1990." (From Dennis Jackson, Mendocino County Water Agency, Ukaih, Calif.)

Parks. Annette White. 1980. Qh-AWA-LA-Li *Water Comes Down Place.* Fresh Cut Press. California.

Platts, William S. 1990. *Managing Fisheries and Wildlife on Rangelands Grazed by Livestock: A Guidance and Reference Document for Biologists.* Nevada Department of Wildlife, Carson City, Nevada.

Puffer, Alan. 1991. National Weather Service. Eureka, Calif.

Puckett, L.K. 1977. *The Eel River Estuary — Observations on Morphometry, Fishes, Water Quality, and Invertebrates,* California Department of Fish and Game under contract with CDWR.

Rau, Haydon. Bordessa, Franz, and Assoc. August 1990. *An Environmental Assessment for Gravel Bar Skimming on the Garcia River, Mendocino County, California.* Ukiah, Calif.

Reeves. G.H., F.H. Everest. and T.E. Nickelson. 1988. *Identification of Physical Habitat Limiting the Production of Coho Salmon in Western Washington and Oregon.* USDA Forest Service. General Technical Report PNW-140. Portland. Oregon.

Reimers. P.E. 1973. *The Length of Residence of Juvenile Chinook Salmon in the Sixes River, Oregon.* ODFW Commission Report 4(2): 1-43. Portland, Oregon.

Rice, Raymond. Forest Tilley, Patricia A. Datzman. August 1979. "A Watershed's Response to Logging and Roads: South Fork of Caspar Creek, Calif., 1967-1976." *Pacific Southwest Forest and Range Experiment Station.* Berkeley, Calif.

Ricker. W.E. 1972. "Heredity and Environmental Factors Effecting Certain Salmonid Populations," Stock *Concept of Pacific Salmonids,* H.R McMillan Lecture Series. Vancouver. B.C.

Rosgen, Dave. 1991. *A Short Course on Stream Classifications and Applications.* Wildland Hydrology Consultants. Pagosa Springs. Colorado.

Salmon and Steelhead Trout Advisory Committee. 1990. Central Valley Salmon and Steelhead Restoration and Enhancement Plan. April 1, 1990.

Salmon and Steelhead Trout Advisory Committee. Restoring the Balance. Annual Reports.

Seddell, J.R. P.A. Bisson, F.J. Swanson, and S.V. Gregory. 1988. "What We know about Large Trees that Fall into Streams and Rivers." *From the Forest to the Sea: A Story of Fallen Trees.* UJSDA Forest Service and USDI BLM. PNW-GTR-229. Portland, Oregon.

Sengletten, Louis A. 1881. *Point Arena Lighthouse Reservation: Mendocino County, Calif.* (From U. C. Berkeley Bancroft Library, Berkeley. Calif.)

Sengletten, Louis A. 1870. *PL Arena and Vicinity Map, Surveyed February, March, and July 1870.* U. S. Coast Survey.

Smith. Emil J., Jr., Donald H. Fry. Jr.. Herbert W. Frey. John Speth, Alvin Rutsch. and Leonard Fisk. June 1, 1976. Coastal *County Fish and Wildlife Resources and Their Utilization.* Revised edition. University of California Sea Grant Marine Advisory Program in cooperation with the California Department of Fish and Game.

Smith, J. 1988. *Use of the Pescadero Creek Estuary (San Mateo County) by Juvenile Steelhead Trout* Report for California Department of Fish and Game.

Sommerstrom, Sari. February 1984. "Mendocino County Salmon and Steelhead Management Plan." Unpublished report. Mendocino County Fish and Game Advisory Committee. Ukiah, Calif.

Stalder, Walter. 1941. *Geologic Check on Manchester, Mendocino County, Calif., Anticline.* San Francisco, Calif., (from Mendocino County Historical Society. Ukiah, Calif.)

Steffen, Lyle and Edward Schmidt. July 9, 1991. *Garcia River Watershed Enhancement Plan.* USDA Soil Conservation Service, Hydrologic Unit Planning Assistance.

Strange. T. 1990. Comparison *of Aquatic Invertebrates in Disturbed and Undisturbed Watersheds.* Masters Thesis. Humboldt State University, Arcata, Calif.

Sullenberger, Martha. 1980. "Dog Holes and Donkey Engines." Taken from An *Historical Resources Study of the State Park System Units on the Mendocino Coast* (From U. C. Berkeley Bancroft Library, Berkeley, Calif.)

Sullivan, C.M. 1988. *Juvenile Life History of Klamath River Basin Fall Chinook Salmon as Determined by Scale Analysis.* M.S. Thesis. Humboldt State University. Arcata. Calif.

Suppe. J. 1978. Cross *Section of Southern Part of Northern Coast Ranges and Sacramento Valley, California.* Geological Society of America.

US Army Corps of Engineers. 1915. PL *Arena Quadrangle Map.*

US Coast and Geodetic Survey. 1885. *Map: Pacific Coast from San Francisco to Point Arena.*

US Coast and Geodetic Survey. 1883 and 1929. *Point Arena California Topographic and Hydrographic Maps with Field Notes.*

US Coast and Geodetic Survey. 1991. Data re changes in relationship of sea level to land surface. National Oceanic and Atmospheric Administration. Tidal Datum Section. (From correspondence with Dennis Jackson, Mendocino County Water Agency. Ukiah. Calif.)

US Fish and Wildlife Service. 1991. *Long Range Plan for the Klamath River Basin Conservation Area Fisheries Program.* USFWS Klamath Field Office, Yreka. California.

US Geological Survey. Gaging station water flow data 1952-56, 1963-1983.

US Geological Survey. Gaging station water temperature data 1964-1979.

US Geological Survey. 1942. *Pt Arena Quadrangle Topographical Map.*

US Geological Survey. Current topographical maps.

USDA Soil Conservation Service and Eel River Resource Conservation District. 1989. Salt *River Watershed Workplan.* Eureka, Calif.

Vayder, Jerry D., and Donald J. Finlayson. January 1966. "Report on a Study for Improvement of Small Coastal Stream Fisheries." Unpublished report. California Department of Water Resources.

Wagner, D.L. and E. J. Bortogno, compilers. 1982. *Geologic Map of the Santa Rosa Quadrangle.* California Department of Conservation. Division of Mines and Geology.

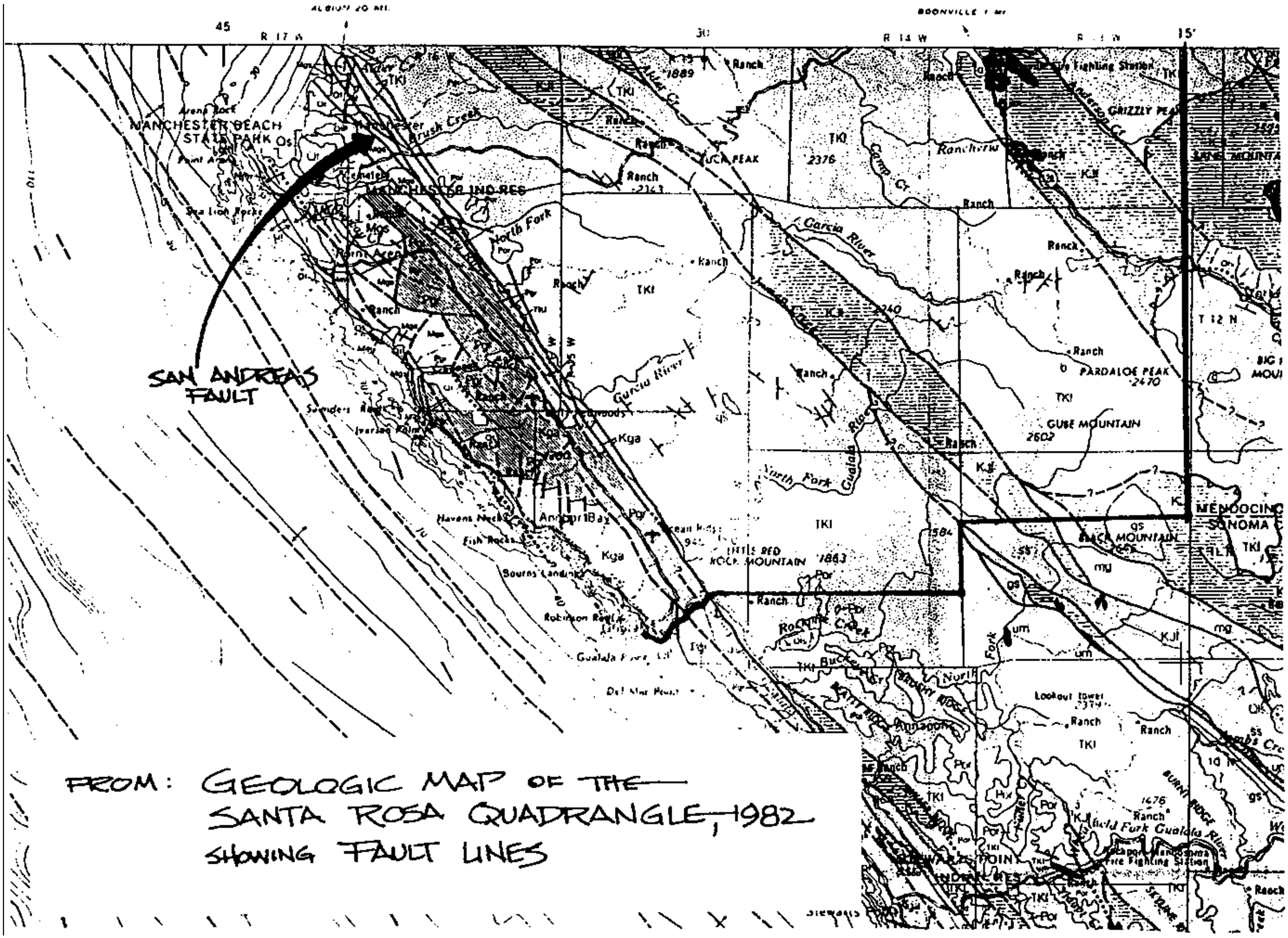
Weatherford. Gary. 1979. *Erosion and Sediment in California Watersheds: A Study of Institutional Controls.* John Muir Institute, Inc. Napa, Calif.

Wells. Rob. 1985. "River Power," *Ridge Review.* Vol. 2. No. 43.

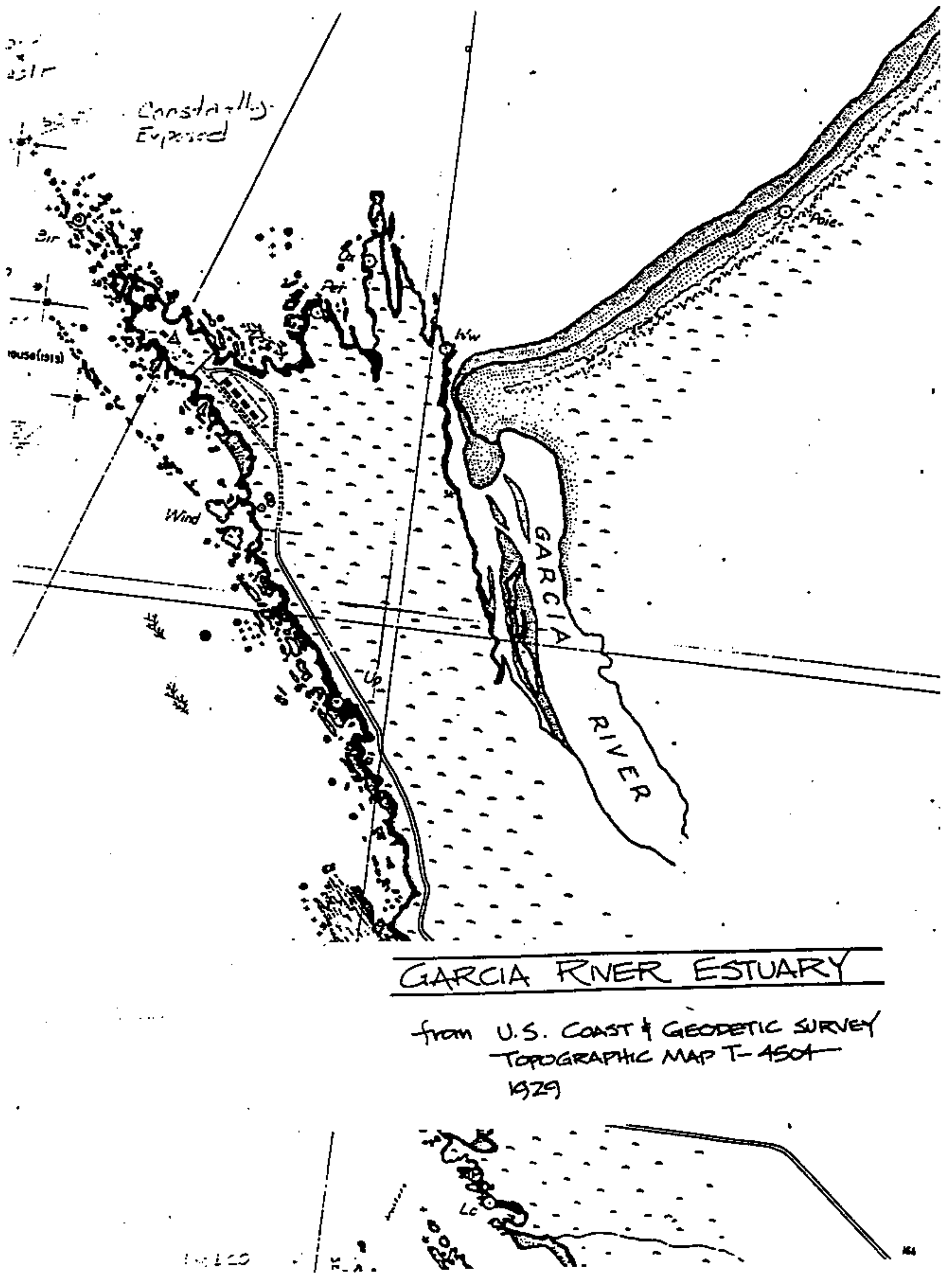
# Appendix 1

# Supporting Documents for Stream Channel Data

# I-1: Geologic Map

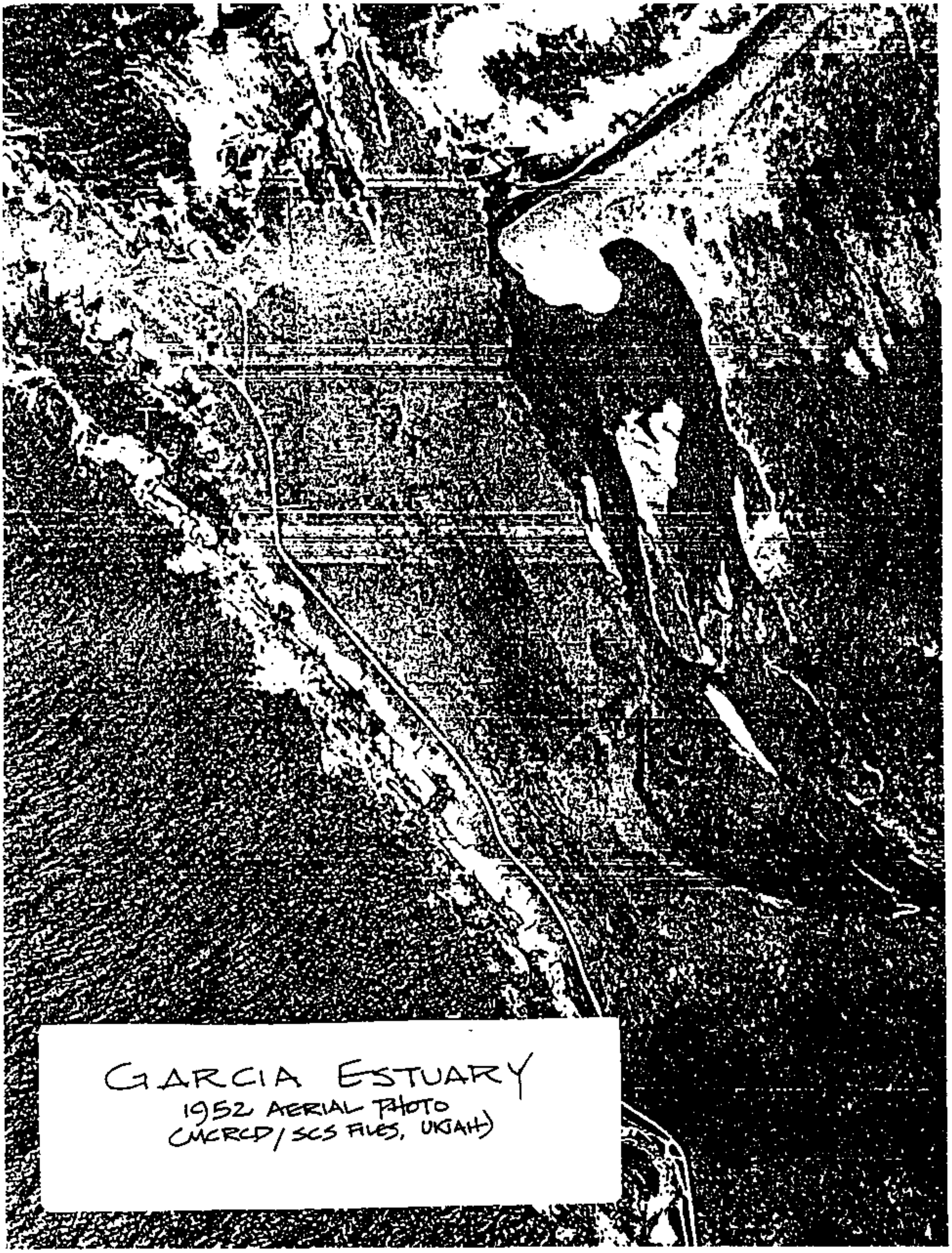


# I-2: Garcia Estuary — 1929 (US Coast and Geodetic Survey



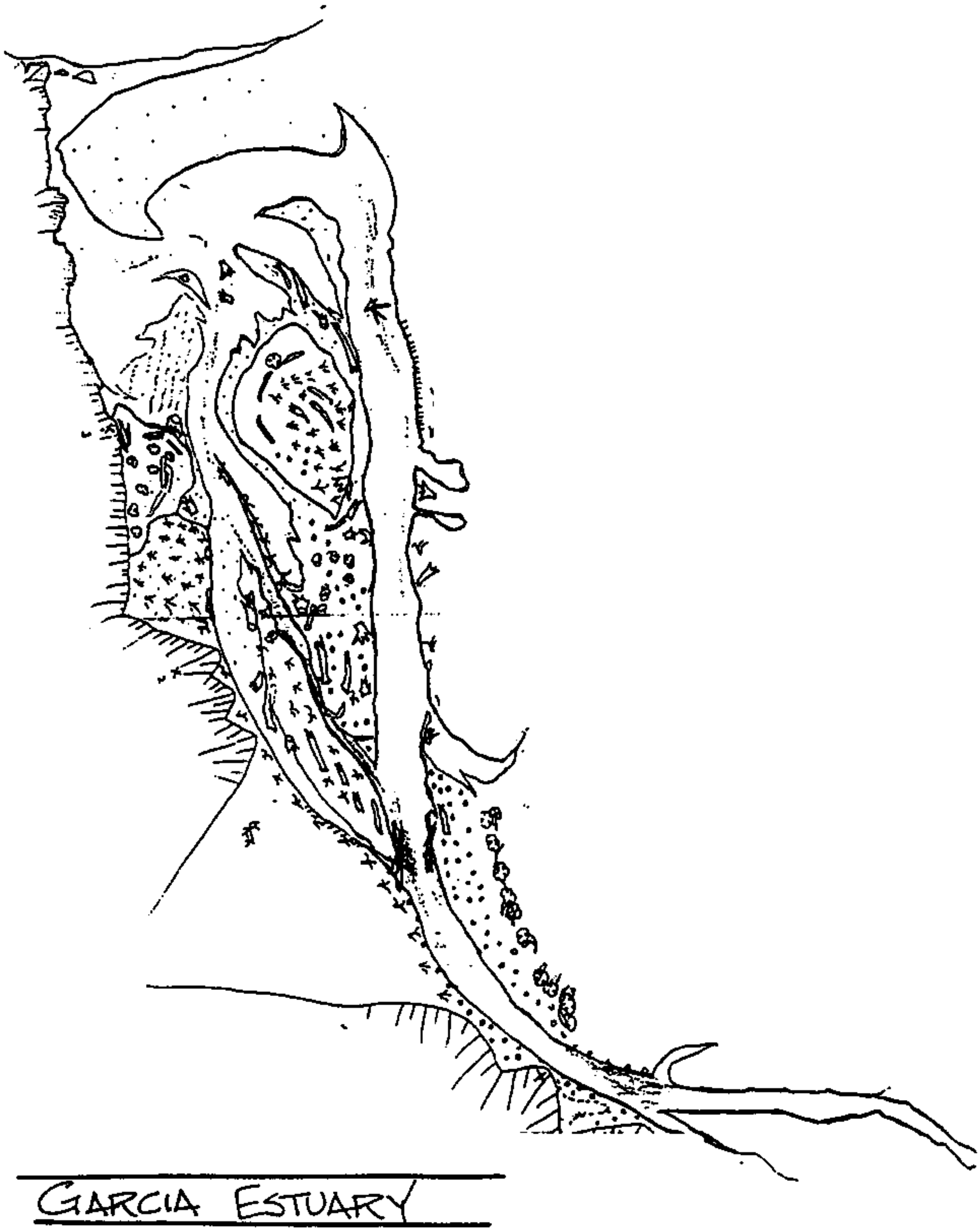
## I-3: Garcia Estuary and Lower River — 1937 Aerial Photo

# I-4: Garcia Estuary — 1952 Aerial Photo



## I-5: Garcia Estuary — 1991 Drawing

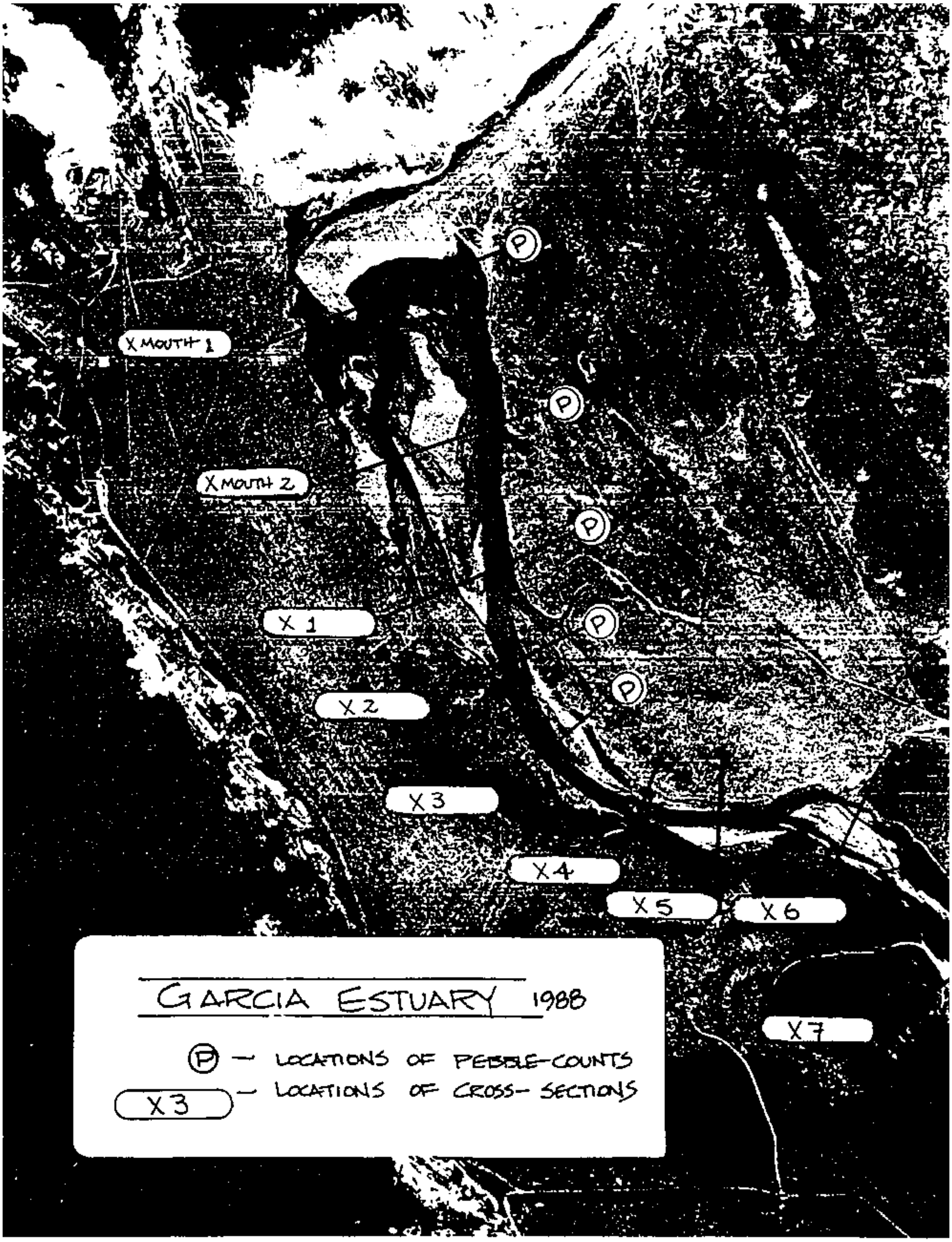
9/23/91: 1430-1620 hrs.



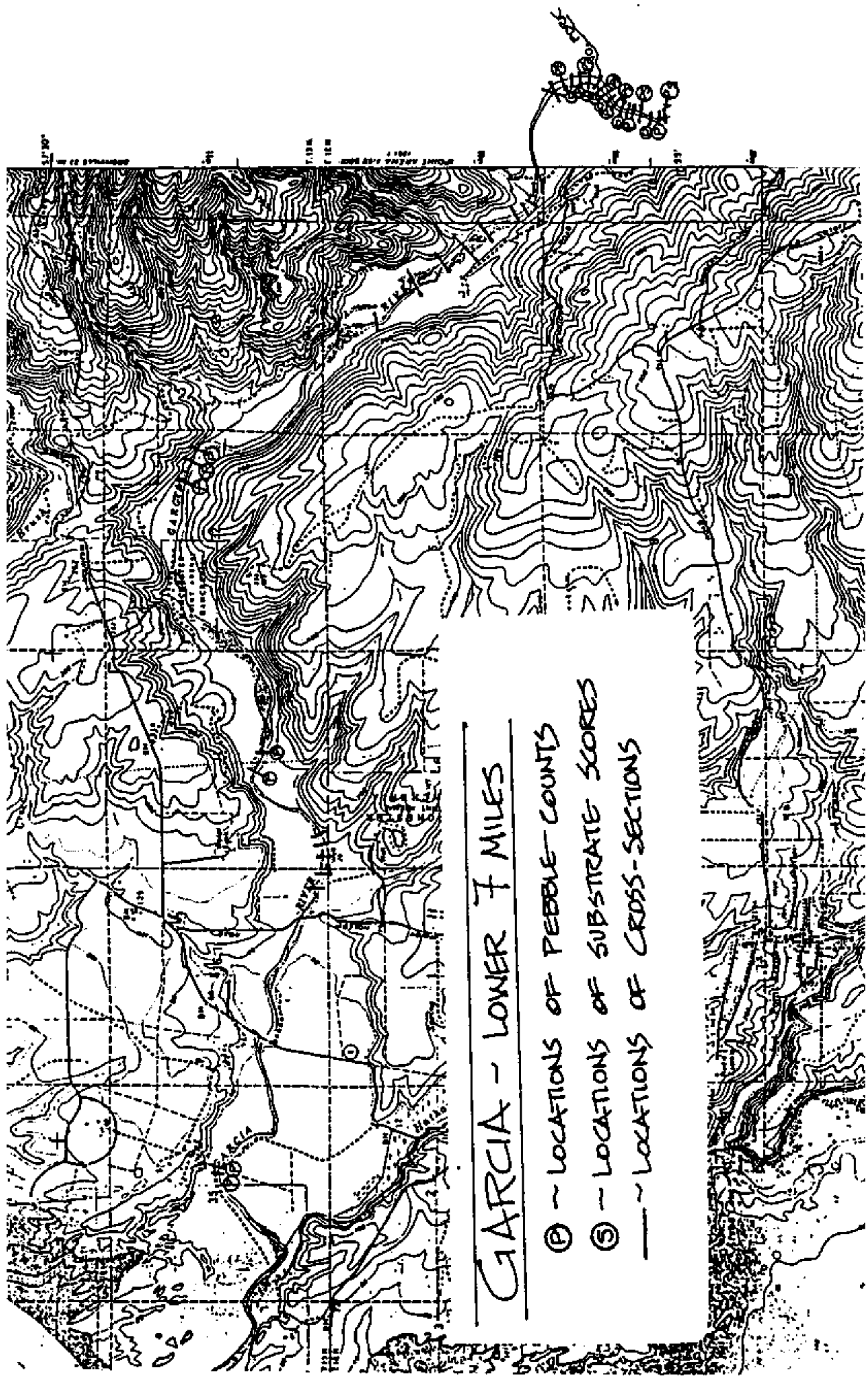
GARCIA ESTUARY

DRAWN BY MAUREEN ROCHE
SEPTEMBER 23, 1991: 1430-1620 HRS.

# I-6: Garcia Estuary — 1988 Aerial Photo Showing Sites of Cross Sections and Pebble Counts



## I-7: Lower 7 Mile Reach Topo Showing Sites of Cross Sections and Pebble Counts



# Appendix II

# Supporting Documents for Fisheries Data

# II-1: DFG Habitat Typing Manual (excerpts)

(FLOSI & REYNOLDS, 1991)

## D. HABITAT TYPING

The habitat typing procedure presented is a standardized (as described in the American Fishery Society's Glossary of stream habitat terms), replicable methodology that physically describes 100% of the wetted channel. It is a composite of systems principally developed or modified by other investigators and compiled by Trinity Fisheries Consulting on contract to the DFG.

Habitat types are described according to location, orientation, and water flow. The attributes distinguishing the various habitat types include over-all channel gradient, velocity, depth, substrate, and the channel features responsible for the unit's formation.

A basin level habitat inventory is designed to produce a thorough description of the physical fish habitat. Basin level habitat classification is on the scale of a stream's naturally occurring pool-riffle-run units. The length of a habitat unit depends on stream size and order. For basin level habitat inventory homogeneous areas of habitat that are equal or greater in length than one wetted channel width are recognized as distinct habitat units.

The information provided by habitat typing, channel typing, and the biological information collected during adult spawning surveys and/or juvenile rearing surveys gives baseline data in which to determine if critical habitat needs of a target species are lacking, and if there are areas where improvements can be made.

Four levels of classification exist when describing fish habitat from a physical viewpoint (Figure 10). Level I habitat types are separated into riffle or pool habitats. Level II separates the riffles into riffle or flatwater habitat types, thus creating three categories. These three level II types are further differentiated at Level III using the following criteria: Riffle types are defined on the basis of water surface gradient (riffle or cascade); Pool types are defined according to their location in the stream channel (main channel, scour, or backwater). Flatwater types are not further subdivided at level III, but at level IV they are differentiated on the basis of depth and velocity. Level IV pools are categorized by the cause of the scour (obstruction, blockage, constriction, or merging flows); riffles are defined by gradient, and cascades by gradient and substrate type. Each of the six level III habitat types are ultimately divided into the 24 habitat types listed below. The level employed in a survey is determined by the objective of the inventory.

Prior to initiation of an inventory, the level of data collection necessary to meet the needs of the investigation should be established. Habitat typing at level IV will provide the greatest detail and the most complete description of existing habitat. This data can later be aggregated into broader levels of habitat classification if detail is found to be excessive.

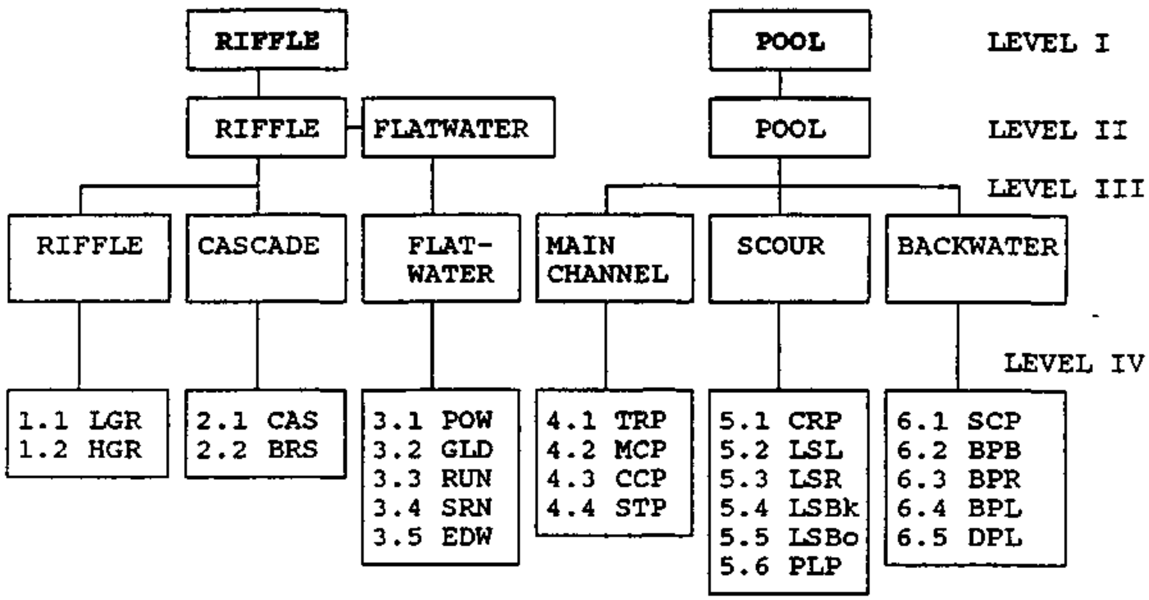



Figure 10. Habitat types hierarchy.

Generally a stream will not contain all 24 habitat types. The mix of habitat types will be reflective of the over-all channel gradient, flow regime, cross-sectional profile, and substrate particle size. Basins that exhibit a wide range in channel gradient will also have a broad mix of habitat types. Stratifying a basin by channel types helps to predict the location of certain habitat types.

For a more detailed habitat analysis, or project level habitat typing, the units can be smaller. Project level habitat typing is used to evaluate and quantify changes in habitat as the result of fish habitat restoration/enhancement projects. It will provide insight on the relationship between channel features and habitat development. The project level habitat size depends on the nature and objective of the particular study. Both levels use the same habitat types.

Application

Habitat typing is intended to yield detailed information that can be used for fisheries management. Basin wide habitat typing can provide a variety of data. Some important applications are:

a. Physically describe 100% of the habitat in a basin.

b. Provide baseline data to evaluate habitat responses to restoration efforts.

c. Facilitate restoration planning and fisheries management.

d. Determine transect locations for Instream Flow Increment Methodology modeling based on habitat availability and accessibility.

The following list of habitat types and their hierarchy has been adapted from the original system developed by Bisson, et al (1981), modified by Decker, Overton (1985), Sullivan (1988), and Snider (1990).

LEVEL I
HABITAT TYPES:
1. RIFFLE: ........................................ [RIF]
(Riffle, Cascade, Flatwater)
2. POOL: .......................................... [POL]
(Main Channel Pool, Scour Pool, Backwater Pool)

LEVEL II
HABITAT TYPES:
1. RIFFLE: ........................................ [RIF]
(Low Gradient Riffle, High Gradient Riffle, Cascade, Bedrock Sheet)
2 . FLATWATER: .................................... [FLT]
(Pocket Water, Run, Step Run, Glide, Edgewater)
3. POOL: .......................................... [POL]
(Plunge Pool, Mid-Channel Pool, Dammed Pool, Step Pool, Channel Confluence Pool, Trench Pool, Lateral Scour Pool Root Wad Enhanced, Boulder Formed, Bedrock Formed, and Log Enhanced, Corner Pool, Secondary Channel Pool, Backwater Pool Boulder Formed, Root Wad Formed, and Log Formed)

| LEVEL III and LEVEL IV HABITAT TYPES: | | LETTER | NUMBER |
|---|---|---|---|
| 1. | **RIFFLE** | | |
| | Low Gradient Riffle: | [LGR] | 1.1 |
| | High Gradient Riffle: | [HGR] | 1.2 |
| 2. | **CASCADE** | | |
| | Cascade: | [CAS] | 2.1 |
| | Bedrock Sheet: | [BRS] | 2.2 |
| 3. | **FLATWATER** | | |
| | Pocket Water: | [POW] | 3.1 |
| | Glide: | [GLD] | 3.2 |
| | Run: | [RUN] | 3.3 |
| | Step Run: | [SRN] | 3.4 |
| | Edgewater: | [EDW] | 3.5 |
| 4. | **MAIN CHANNEL POOL** | | |
| | Trench Pool: | [TRP] | 4.1 |
| | Mid-Channel Pool: | [MCP] | 4.2 |
| | Channel Confluence Pool: | [CCP] | 4.3 |
| | Step Pool: | [STP] | 4.4 |
| 5. | **SCOUR POOL** | | |
| | Corner Pool: | [CRP] | 5.1 |
| | L. Scour Pool - Log Enhanced: | [LSL] | 5.2 |
| | L. Scour Pool - Root Wad Enhanced: | [LSR] | 5.3 |
| | L. Scour Pool - Bedrock Formed: | [LSBk] | 5.4 |
| | L. Scour Pool - Boulder Formed: | [LSBo] | 5.5 |
| | Plunge Pool: | [PLP] | 5.6 |
| 6. | **BACKWATER POOLS** | | |
| | Secondary Channel Pool: | [SCP] | 6.1 |
| | Backwater Pool - Boulder Formed: | [BPB] | 6.2 |
| | Backwater Pool - Root Wad Formed: | [BPR] | 6.3 |
| | Backwater Pool - Log Formed: | [BPL] | 6.4 |
| | Dammed Pool: | [DPL] | 6.5 |

Level IV Habitat Type Descriptions

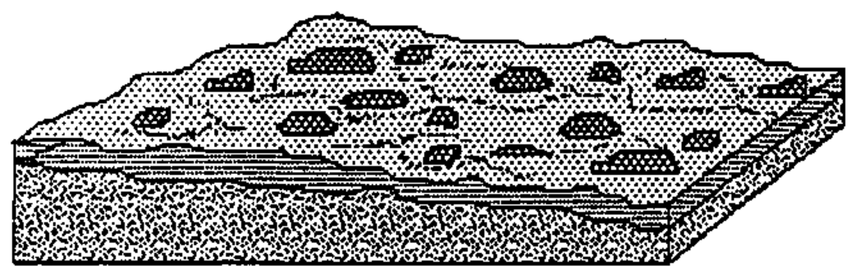
* The three or four letter abbreviations in the (***) are the standardized abbreviations adopted by DFG.

* The three digit numbers in the [*.*] are the standardized numbers adopted by DFG.

* The numbers in the {**} are the numbers listed in the Pacific Southwest Region Habitat Typing Field Guide USDA-USFS.

THE FOLLOWING HABITAT TYPE DESCRIPTIONS ARE TAKEN FROM THE PACIFIC SOUTHWEST REGION HABITAT TYPING FIELD GUIDE USDA-USFS.

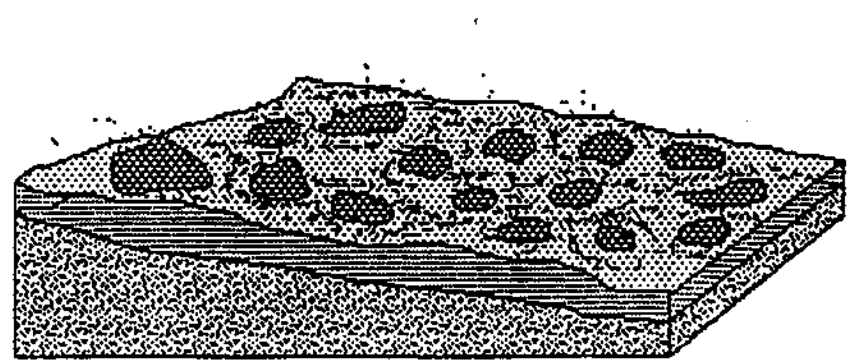
**LOW GRADIENT RIFFLE (LGR) [1.1] {1}**



**LOW GRADIENT RIFFLES - "LGR"**

Shallow reaches with swiftly flowing, turbulent water with some partially exposed substrate. Gradient < 4%, substrate is usually cobble dominated.

**HIGH GRADIENT RIFFLE (HGR) [1.2] {2}**



**HIGH GRADIENT RIFFLE - "HGR"**

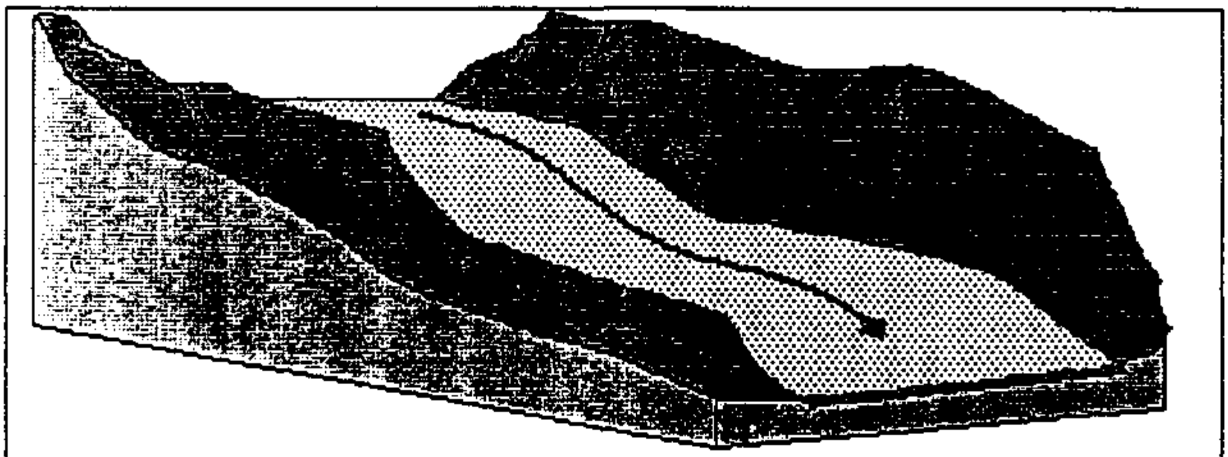
Steep reaches of moderately deep, swift, and very turbulent water. Amount of exposed substrate is relatively high. Gradient is > 4%, and substrate is boulder dominated.

**CASCADE (CAS) [2.1] {3}**

CASCADE - "CAS"

The steepest riffle habitat, consisting of alternating small waterfalls and shallow pools. Substrate is usually bedrock and boulders.

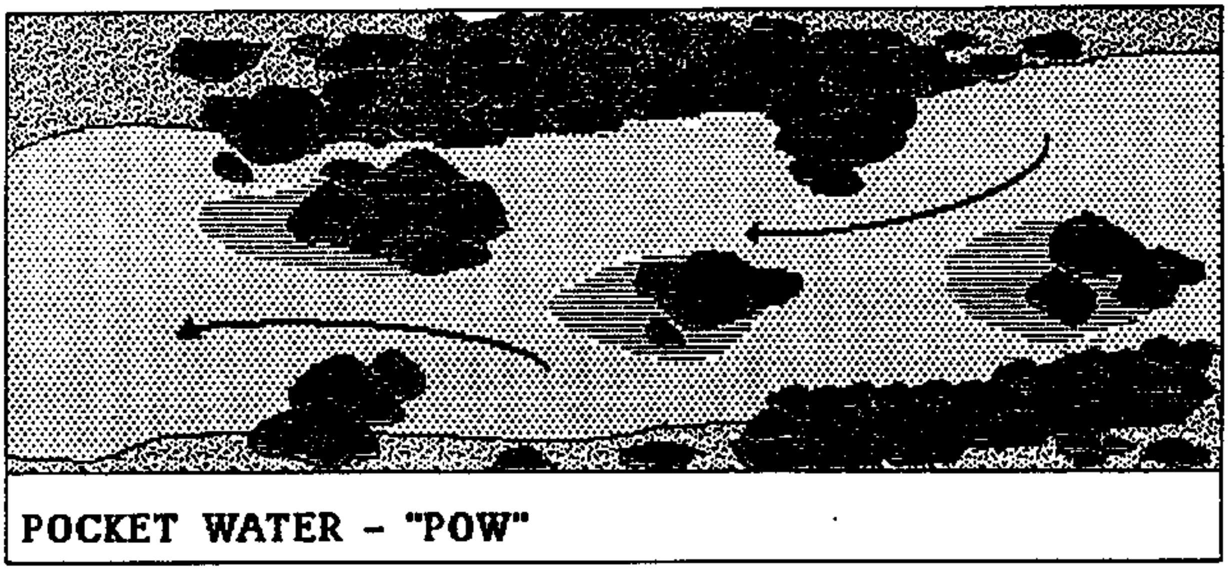
**BEDROCK SHEET (BRS) [2.2] {24}**



BEDROCK SHEET - "BRS"

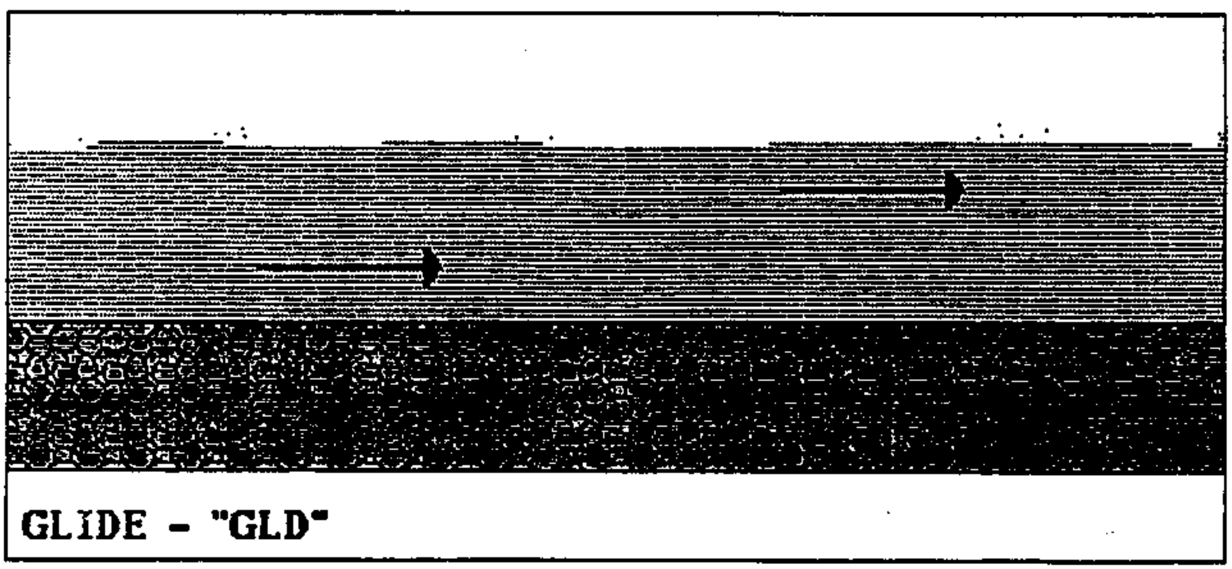
A thin sheet of water flowing over a smooth bedrock surface. Gradients are highly variable.

**POCKET WATER (POW) [3.1] {21}**



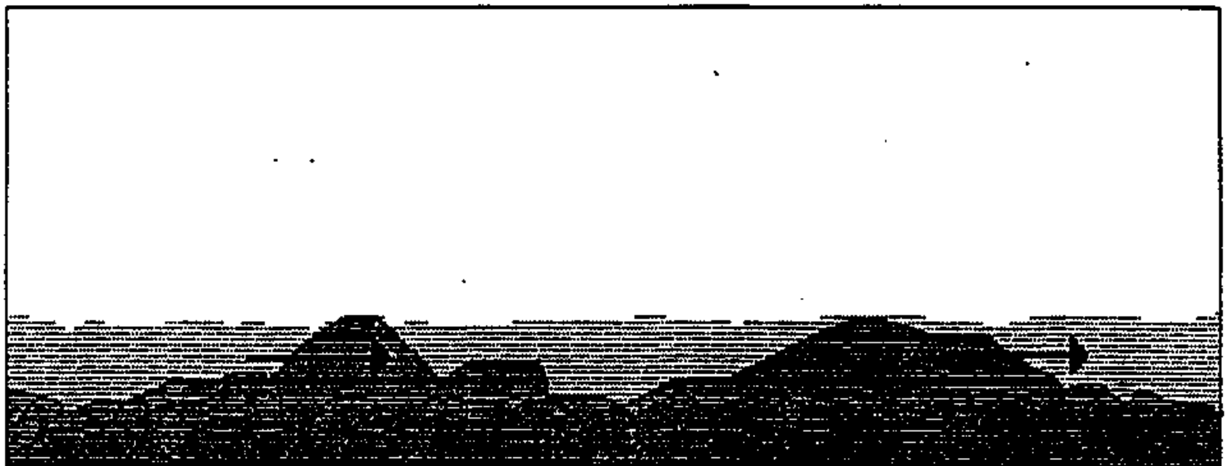

A section of swift flowing stream containing numerous boulders or other large obstructions which create eddies or scour holes (pockets) behind the obstructions.

**GLIDE (GLD) [3.2] {14}**




A wide uniform channel bottom. Flow with low to moderate velocities, lacking pronounced turbulence. Substrate usually consists of cobble, gravel, and sand.

**RUN (RUN) [3.3] {15}**



RUN - "RUN"

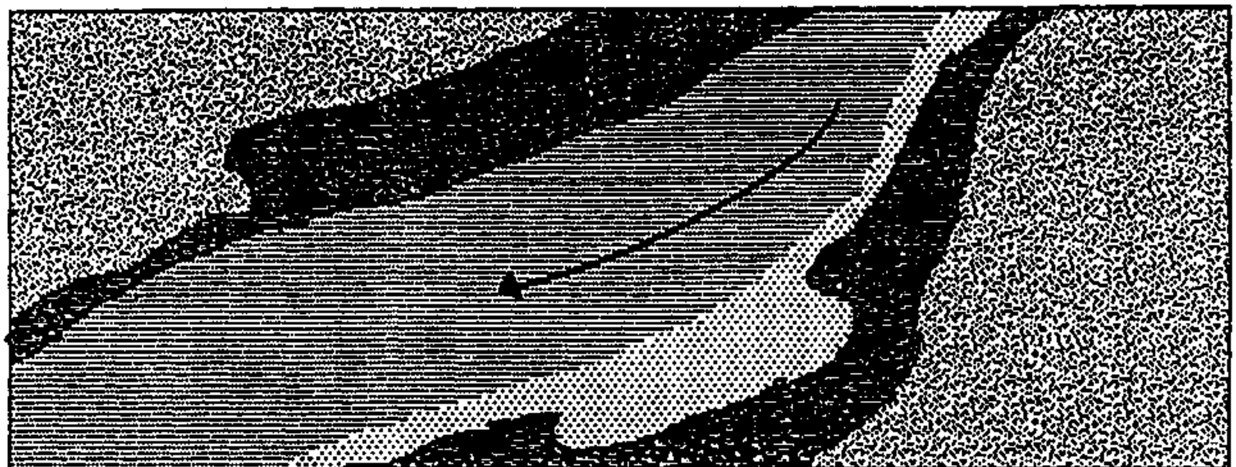
Swiftly flowing reaches with little surface agitation and no major flow obstructions. Often appears as flooded riffles. Typical substrate consists of gravel, cobble, and boulders.

**STEP RUN (SRN) [3.4] {16}**

STEP RUN - "SRN"

A sequence of runs separated by short riffle steps. Substrate is usually cobble and boulder dominated.

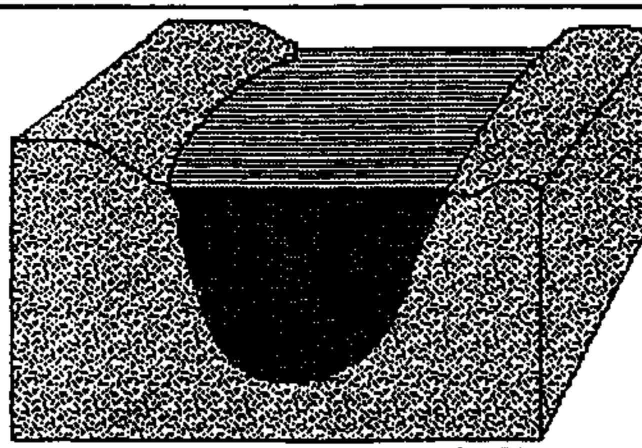
**EDGEWATER (EDW) [3.5] (18)**



**EDGEWATER - "EDW"**

Quiet, shallow area found along the margins of the stream, typically associated with riffles. Water velocity is low and sometimes lacking. Substrate varies from cobbles to boulders.

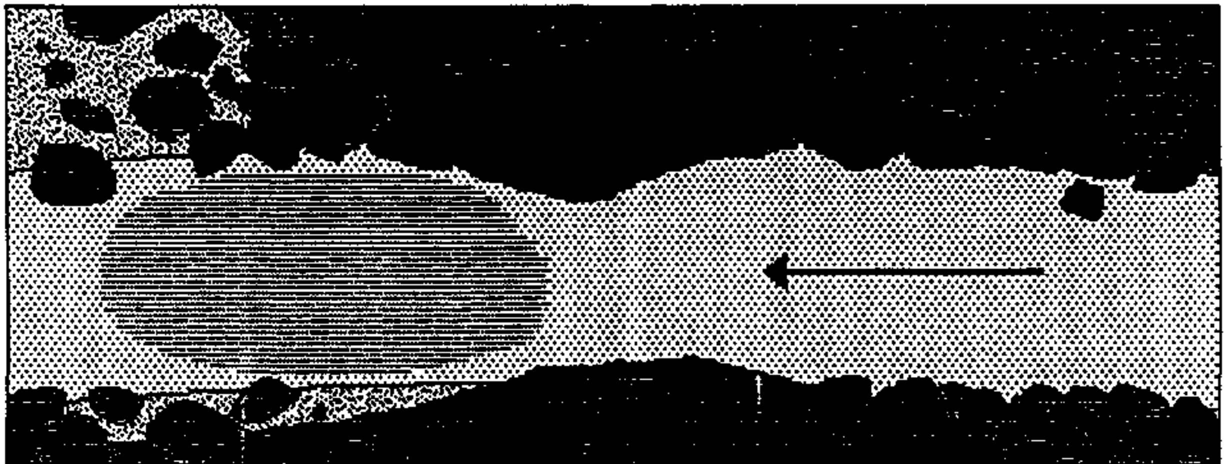
**TRENCH POOLS (TRP) [4.1] {8}**



**TRENCH/CHUTE - "TRP"**

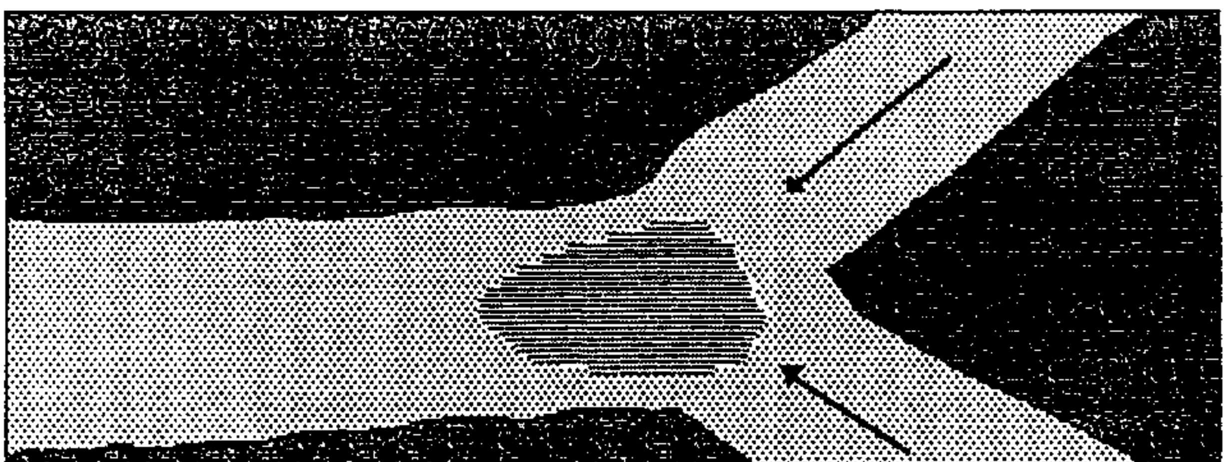
Channel cross sections typically U-shaped with bedrock or coarse grained bottom flanked by bedrock walls. Current velocities are swift and the direction of flow is uniform.

**MID-CHANNEL POOL (MCP) [4.2] {17}**



MID-CHANNEL POOL - "MCP"

Large pools formed by mid-channel scour. The scour hole encompasses more than 60% of the wetted channel. Water velocity is slow, and the substrate is highly variable.



CHANNEL CONFLUENCE POOL - "CCP"

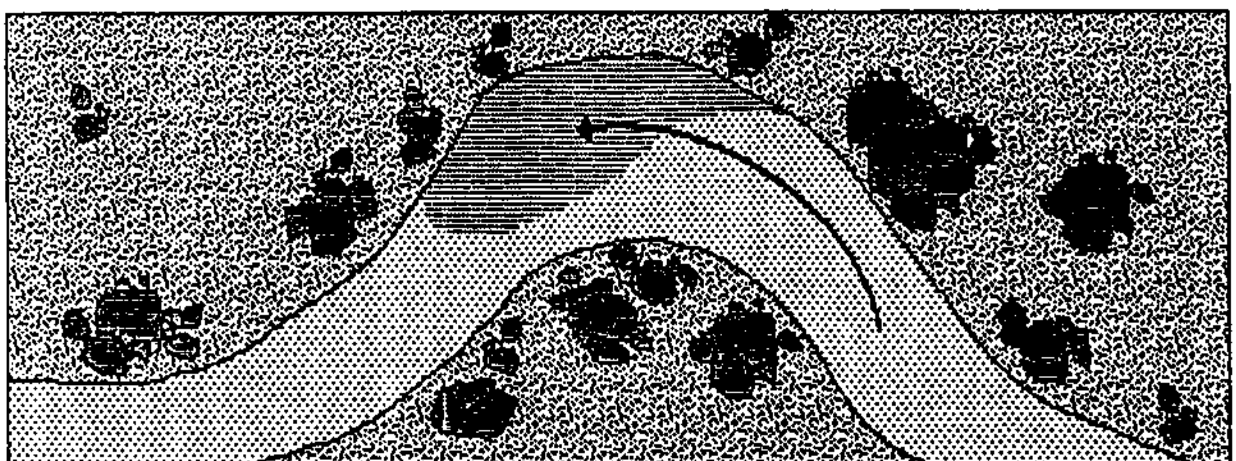
Large pools formed at the confluence of two or more channels. Scour can be due to plunges, lateral obstructions or scour at the channel intersections. Velocity and turbulence are usually greater than those in other pool types.

**STEP POOL (STP) [4.4] {23}**

**STEP POOL - "STP"**

A series of pools separated by short riffles or cascades. Generally found in high gradient, confined mountain streams dominated by boulder substrate.

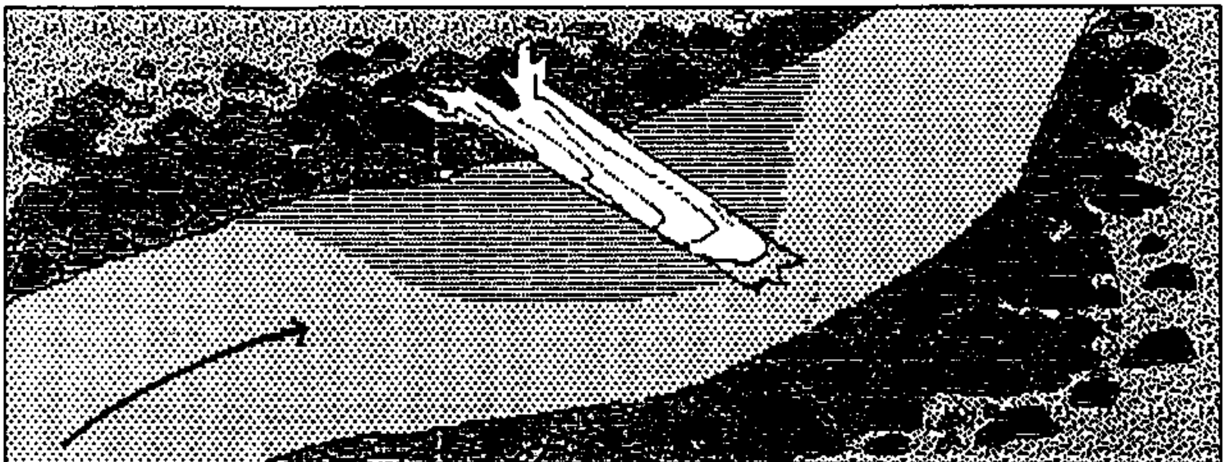
**CORNER POOL (CRP) [5.1] {22}**



**CORNER POOL - "CRP"**

Lateral scour pools formed at a bend in the channel. These pools are common in lowland valley bottoms where stream banks consist of alluvium and lack hard obstructions.

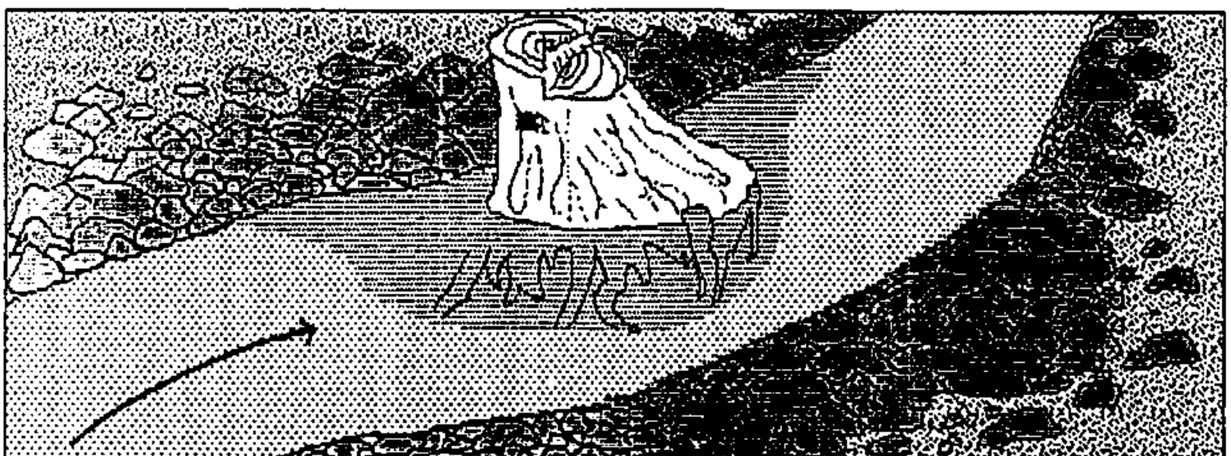
**LATERAL SCOUR POOL - LOG ENHANCED (LSL) [5.2] {10}**



LATERAL SCOUR POOL - "LSL" LOG ENHANCED

Formed by flow impinging against a partial channel obstruction consisting of large woody debris. The associated scour is generally confined to < 60% of the wetted channel width.

**LATERAL SCOUR POOL ROOT WAD ENHANCED (LSR) [5.3] {11}**



LATERAL SCOUR POOL - "LSR" ROOT WAD ENHANCED

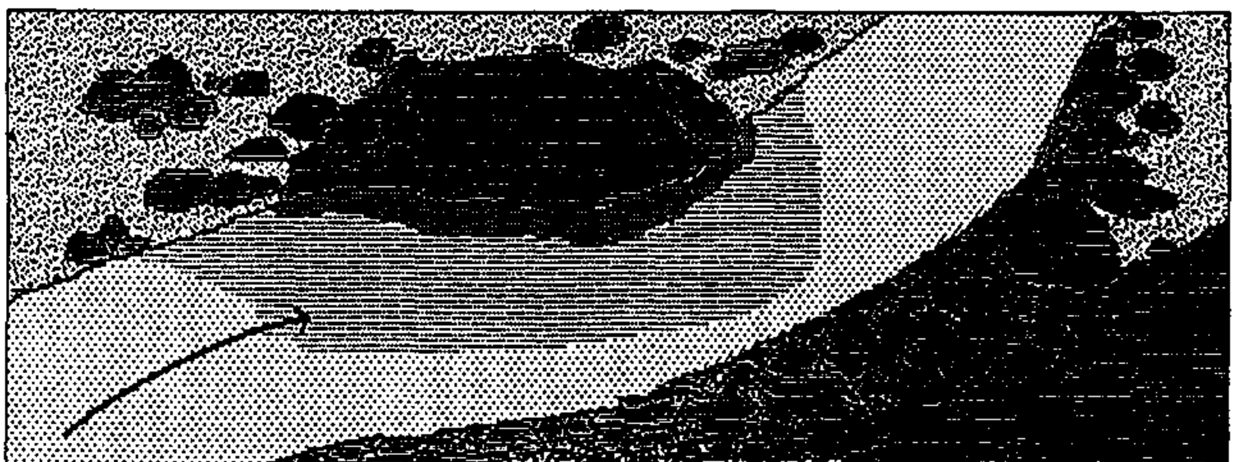
Formed by flow impinging against a partial channel obstruction consisting of a root wad. The associated scour is generally confined to < 60% of the wetted channel width.

**LATERAL SCOUR POOL - BEDROCK FORMED (LSBk) [5.4] {12}**

LATERAL SCOUR POOL - "LSBk" BEDROCK FORMED

Formed by flow impinging against a bedrock stream bank. The associated scour is generally confined to < 60% of the wetted channel width.

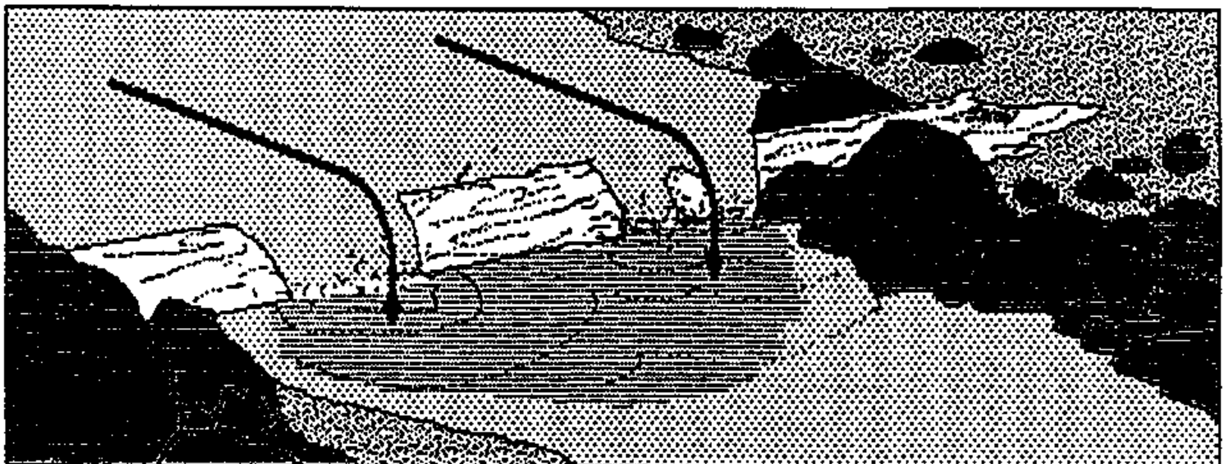
**LATERAL SCOUR POOL - BOULDER FORMED (LSBo) [5.5] {20}**



LATERAL SCOUR POOL - "LSBo" BOULDER FORMED

Formed by flow impinging against a partial channel obstruction consisting of a boulder. The associated scour is generally confined to < 60% of the wetted channel width.

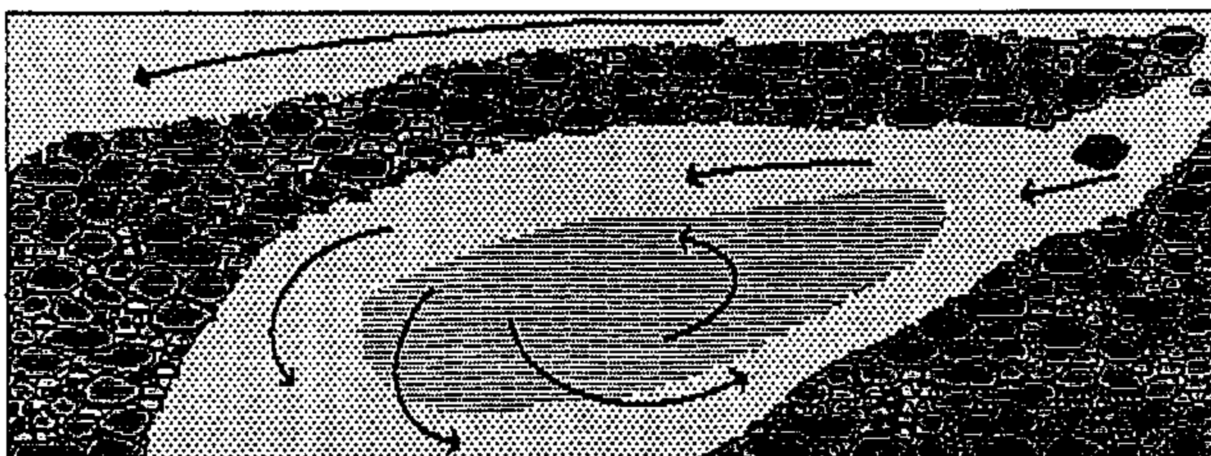
**PLUNGE POOL (PLP) [5.6] {9}**



PLUNGE POOL - "PLP"

Found where the stream passes over a complete or nearly complete channel obstruction and drops steeply into the stream bed below, scouring out a depression; often large and deep. Substrate size is highly variable.

**SECONDARY CHANNEL POOL (SCP) [6.1] {4}**



SECONDARY CHANNEL POOL - "SCP"

(sic)
summer, these pools will dry up or have very little flow. Mainly associated with gravel bars and may contain sand and silt substrate.

**BACKWATER POOL - BOULDER FORMED (BPB) [6.2] {5}**

BACKWATER POOL - "BPB" BOULDER FORMED

Found along channel margins and caused by eddies around a boulder obstruction. These pools are usually shallow and are dominated by fine-grain substrate. Current velocities are quite low.

**BACKWATER POOL - ROOT WAD FORMED (BPR) [6.3] (6)**

BACKWATER POOL - "BPR" ROOT WAD FORMED

Found along channel margins, and caused by eddies around a root wad obstruction. These pools are usually shallow and are dominated by fine-grained substrate. Current velocities are quite low.

**BACKWATER POOL - LOG FORMED (BPL) [6.4] {7}**

BACKWATER POOL - "BPL" LOG FORMED

Found along channel margins and caused by eddies around a large woody debris obstruction. These pools are usually shallow and are dominated by fine-grained substrate. Current velocities are quite low.

**DAMMED POOLS (DPL) [6.5] {13}**

DAMMED POOL - "DPL"

Water impounded from a complete or nearly complete channel blockage (debris jams, rock landslides or beaver dams). Substrate tend toward smaller gravel and sand.

B.

# II-2: Rosgen Classification System Summary

(FLOSI & REYNOLDS, DFG, 1991)

STREAM CLASSIFICATION

Numerous stream classification systems have been developed for a myriad of purposes. This manual uses the stream classification system developed by Dave Rosgen which categorizes various stream types by morphological characteristics. Delineation criteria are soil/landform features, valley confinement, stream gradient (measured as energy slope of the water surface), channel materials or substrate, entrenchment or width/depth ratio, and sinuosity.

The Rosgen system of stream classification can provide a variety of data. Some important applications of -this data are:

a. Determine the suitability of habitat restoration structures.

b. Describe the specific reaches by channel type, and their sequence within the basin.

c. Provide baseline data from which to anticipate and measure channel responses to:

   1) upslope management activities affecting sediment input rates or water discharge timing;
   2) major flood events (to assist in determining the stage and form of channel recovery);
   3) controlled or reduced flows resulting from water diversion;
   4) installation of instream habitat structures;
   5) sediment storage or transport capabilities.

d. Provide information on the potential effects from restoration and enhancement of the riparian corridor.

Definitions and Delineation Criteria

a. Bankfull discharge: The discharge corresponding to the stage at which the flood plain of a particular stream reach begins to be flooded. The point at which over bank flow begins. This level is delineated by deposits of fine sediments such as sand or silt at the active scour mark, break in stream bank slope, and or perennial vegetation limit (Figure 5).

b. Flood plain: Any flat, or nearly flat lowland that borders a stream and is covered by its waters at flood stage (Figure 5).

c. General Description: A general description of the channel.

d. Landform/Soils: A general description of the slopes, bank stability, and soil composition.

e. Water Slope/Gradient (measured as energy slope of the water surface):

   1) The general slope, or rate of change in elevation per unit of horizontal distance, as defined by the bankfull discharge demarcations.
   2) The rate of change in elevation of any characteristic per unit of horizontal distance.

f. Dominant Particle Size of Channel Materials: The mineral and/or organic material that forms the bed of the stream.

| **PARTICLE SIZE:** | **INCHES** | **METRIC** |
|---|---|---|
| Large Boulder | 40-160" | 102.4-409.6 cm |
| Medium Boulder | 20-40" | 51.2-102.4 cm |
| Small Boulder | 10-20" | 25.6-51.2 cm |
| Large Cobble | 5-10" | 12.8-25.6 cm |
| Small Cobble | 2.5-5" | 6.4-12.8 cm |
| Gravel | 0.08-2.5" | 2.0-64.0 mm |
| Sand | <0.08" | 0.062-2.0 mm |
| Silt/Clay | N/A | <0.062 mm |
| Bedrock | N/A | N/A |

g. Channel Entrenchment: The ratio of the average width to the average depth during bankfull discharge (width/depth ratio). The categories are:
   1) Deeply entrenched <10
   2) Moderately entrenched 10 to 15
   3) Shallow entrenchment >15

h. Sinuosity
   1) The ratio of channel length between two points on a channel to the straight line distance between the same two points.
   2) The ratio of stream length to down valley length (Figure 6).

i. Valley Confinement: The ratio of active flood plain width over bankfull width (Figure 7). The categories are:
   1) Well confined (FP/BF width <1.5)
   2) Moderately confined (FP/BF width 1.5 to 2.5)
   3) Slightly confined (FP/BF width >2.5)
   4) Braided

Stream gradient (water slope/energy gradient), entrenchment or the width/depth ratio, dominant substrate, and confinement are all determined from measurements taken in the field. Sinuosity can be determined from a 7 1/2 minute topographic map by measuring the lengths of the valley and the stream.  Each measurement will be discussed later in Part III.

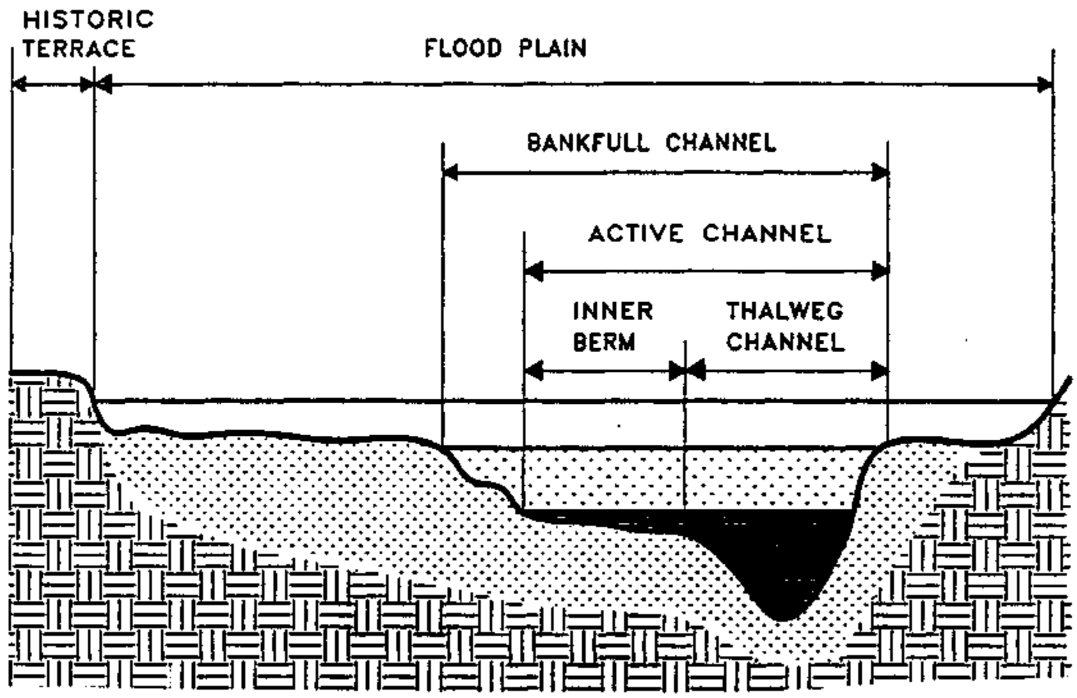



**Figure 5. Channel cross section.**

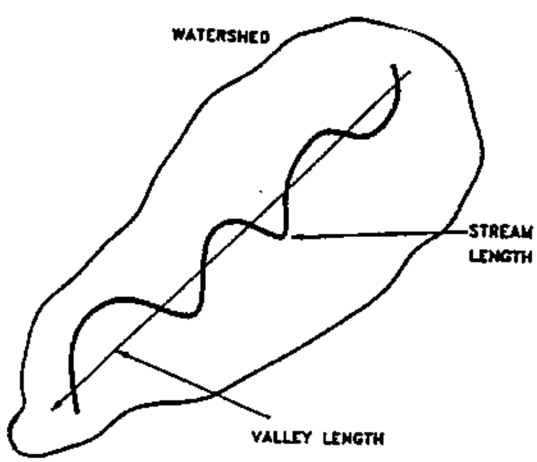



**Figure 6. Sinuosity.**

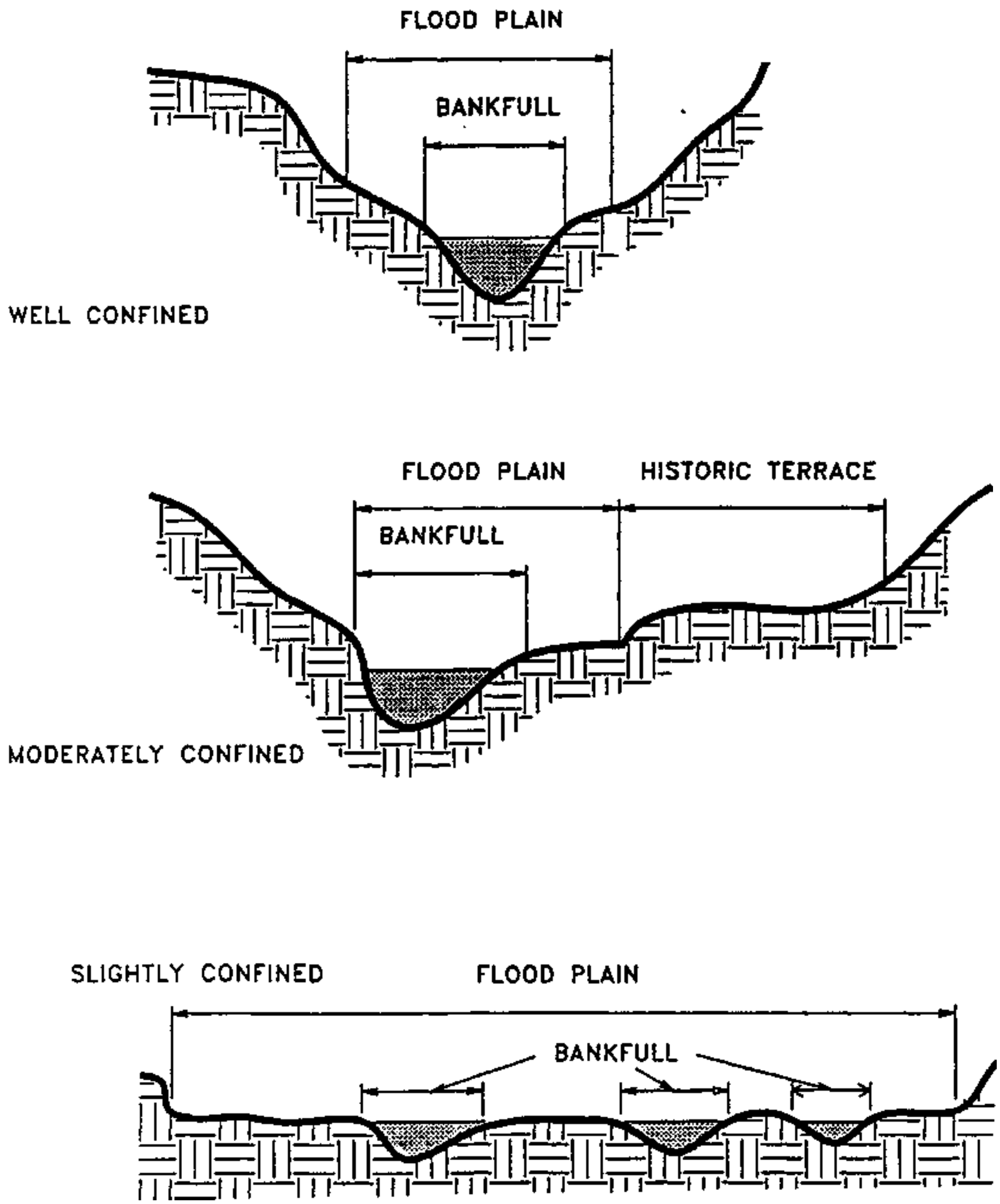
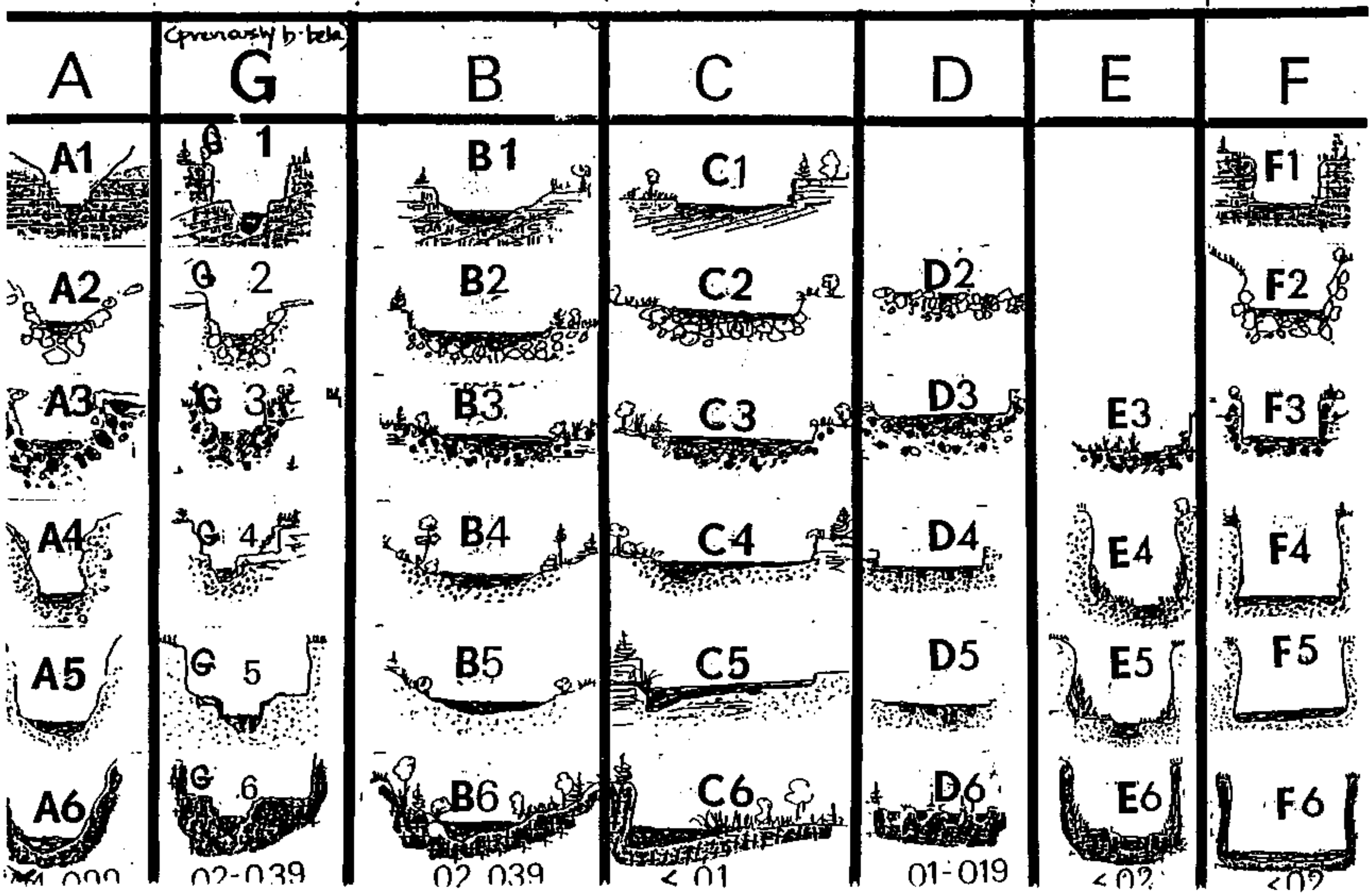



Figure 7. Confinement.

GENERALIZED VISUAL DELINEATION OF
MAJOR STREAM TYPES
(CROSGEN, 1991)



## II-3: McNeil Scores, 1988-91, North Fork Garcia Monitoring Project

McNeil Scores, 1989-1991, sites 1-5, North Fork Garcia River (sic) (NCWQCB & R&J TIMBER< INC., 1989-91)

| | | | Raw Scores | | | | | | | Percent Totals | | | | | | | Cumulative Percent Totals | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Site | Sample | 75 | 25.4 | 12.5 | 4.75 | 2.37 | 1 | <1 | 75% | 25.4 % | 12.5% | 4.75% | 2.37% | 1% | <1% | <2.37% | <4.75% | <12.5% | <25.4% | <75% | Total% |
| 89 | 1 | 1 | 0 | 725 | 330 | 355 | 295 | 540 | 550 | 0 | 26 | 12 | 13 | 11 | 19 | 20 | 39 | 50 | 62 | 74 | 100 | 100 |
| 89 | 1 | 2 | 0 | 535 | 550 | 490 | 265 | 290 | 455 | 0 | 21 | 21 | 19 | 10 | 11 | 18 | 29 | 39 | 58 | 79 | 100 | 100 |
| 89 | 1 | 3 | 0 | 540 | 290 | 710 | 540 | 340 | 416 | 0 | 19 | 10 | 25 | 19 | 12 | 15 | 27 | 46 | 71 | 81 | 100 | 100 |
| 89 | 1 | 4 | 0 | 985 | 360 | 410 | 220 | 270 | 385 | 0 | 37 | 14 | 16 | 8 | 10 | 15 | 25 | 33 | 49 | 63 | 100 | 100 |
| 89 | 1 | 5 | 0 | 570 | 420 | 515 | 205 | 190 | 440 | 0 | 24 | 18 | 22 | 9 | 8 | 19 | 27 | 36 | 58 | 76 | 100 | 100 |
| 89 | 1 | 6 | 340 | 465 | 360 | 340 | 275 | 560 | 370 | 12.5 | 17 | 13 | 13 | 10 | 21 | 14 | 34 | 44 | 57 | 70 | 87 | 100 |
| 89 | 1 | 7 | 0 | 600 | 500 | 450 | 135 | 155 | 470 | 0 | 26 | 22 | 19 | 6 | 7 | 20 | 27 | 33 | 52 | 74 | 100 | 100 |
| 89 | 1 | 8 | 0 | 600 | 420 | 375 | 270 | 490 | 405 | 0 | 23 | 16 | 15 | 11 | 19 | 16 | 35 | 46 | 60 | 77 | 100 | 100 |
| 89 | 1 | 9 | 0 | 595 | 300 | 390 | 265 | 330 | 390 | 0 | 26 | 13 | 17 | 12 | 15 | 17 | 32 | 43 | 61 | 74 | 100 | 100 |
| 89 | 1 | 10 | 0 | 550 | 480 | 485 | 180 | 180 | 475 | 0 | 23 | 20 | 21 | 6 | 8 | 20 | 28 | 36 | 56 | 77 | 100 | 100 |
| 89 | 2 | 1 | 0 | 540 | 560 | 260 | 65 | 60 | 171 | 0 | 33 | 34 | 16 | 4 | 4 | 10 | 14 | 18 | 34 | 67 | 100 | 100 |
| 89 | 2 | 2 | 0 | 660 | 640 | 380 | 90 | 120 | 252 | 0 | 31 | 30 | 18 | 4 | 6 | 12 | 17 | 22 | 39 | 69 | 100 | 100 |
| 89 | 2 | 3 | 0 | 90 | 490 | 650 | 260 | 210 | 276 | 0 | 5 | 25 | 33 | 13 | 11 | 14 | 25 | 36 | 71 | 95 | 100 | 100 |
| 89 | 2 | 4 | 0 | 470 | 745 | 380 | 40 | 25 | 102 | 0 | 27 | 42 | 22 | 2 | 1 | 6 | 7 | 9 | 31 | 73 | 100 | 100 |
| 89 | 2 | 5 | 0 | 1280 | 320 | 100 | 30 | 70 | 257 | 0 | 62 | 16 | 5 | 1 | 3 | 12 | 16 | 17 | 22 | 38 | 100 | 100 |
| 89 | 2 | 6 | 0 | 424 | 820 | 460 | 10 | 90 | 374 | 0 | 19 | 37 | 22 | 0 | 4 | 17 | 21 | 22 | 43 | 81 | 100 | 100 |
| 89 | 2 | 7 | 0 | 695 | 305 | 400 | 335 | 380 | 859 | 0 | 23 | 10 | 13 | 11 | 13 | 29 | 42 | 53 | 66 | 77 | 100 | 100 |
| 89 | 2 | 8 | 0 | 830 | 560 | 480 | 270 | 320 | 306 | 0 | 30 | 20 | 17 | 10 | 12 | 11 | 23 | 32 | 50 | 70 | 100 | 100 |
| 89 | 2 | 9 | 0 | 610 | 430 | 440 | 200 | 230 | 285 | 0 | 28 | 20 | 20 | 9 | 10 | 13 | 23 | 33 | 53 | 72 | 100 | 100 |
| 89 | 2 | 10 | 470 | 740 | 630 | 530 | 265 | 300 | 263 | 14.7 | 23 | 20 | 17 | 8 | 9 | 8 | 18 | 26 | 42 | 62 | 85 | 100 |
| 89 | 3 | 1 | 0 | 610 | 335 | 610 | 110 | 26 | 740 | 0 | 25 | 14 | 25 | 5 | 1 | 30 | 32 | 36 | 61 | 75 | 100 | 100 |
| 89 | 3 | 2 | 0 | 690 | 415 | 530 | 225 | 250 | 800 | 0 | 24 | 14 | 18 | 8 | 9 | 27 | 36 | 44 | 62 | 76 | 100 | 100 |
| 89 | 3 | 3 | 395 | 250 | 450 | 630 | 285 | 215 | 615 | 13.9 | 9 | 16 | 22 | 10 | 8 | 22 | 29 | 39 | 61 | 77 | 86 | 100 |
| 89 | 3 | 4 | 0 | 725 | 335 | 400 | 175 | 95 | 560 | 0 | 32 | 15 | 17 | 8 | 4 | 24 | 29 | 36 | 54 | 68 | 100 | 100 |
| 89 | 3 | 5 | 285 | 560 | 515 | 350 | 94 | 92 | 660 | 11.2 | 22 | 20 | 14 | 4 | 4 | 26 | 29 | 33 | 47 | 67 | 89 | 100 |
| 89 | 3 | 6 | 0 | 570 | 570 | 480 | 210 | 140 | 655 | 0 | 22 | 22 | 18 | 8 | 5 | 25 | 30 | 38 | 57 | 78 | 100 | 100 |
| 89 | 3 | 7 | 0 | 620 | 450 | 500 | 275 | 260 | 940 | 0 | 20 | 15 | 16 | 9 | 9 | 31 | 39 | 48 | 65 | 80 | 100 | 100 |
| 89 | 3 | 8 | 530 | 430 | 350 | 240 | 60 | 40 | 425 | 25.5 | 21 | 17 | 12 | 3 | 2 | 20 | 22 | 25 | 37 | 54 | 74 | 100 |
| 89 | 3 | 9 | 1150 | 135 | 350 | 230 | 45 | 25 | 400 | 49.3 | 6 | 15 | 10 | 2 | 1 | 17 | 18 | 20 | 30 | 45 | 51 | 100 |
| 89 | 3 | 10 | 320 | 590 | 320 | 490 | 140 | 60 | 630 | 11.6 | 21 | 12 | 18 | S | 2 | 30 | 32 | 37 | 55 | 67 | 88 | 100 |
| 89 | 4 | 1 | 0 | 600 | 310 | 405 | 165 | 215 | 485 | 0 | 28 | 14 | 19 | 6 | 10 | 22 | 32 | 40 | 58 | 72 | 100 | 100 |
| 89 | 4 | 2 | 0 | 385 | 400 | 455 | 170 | 160 | 480 | 0 | 19 | 20 | 22 | 8 | 8 | 23 | 31 | 40 | 62 | 81 | 100 | 100 |

McNeil Scores, 1989-1991, sites 1 - 5, North Fork Garcia River

| | | | --------- Raw Scores --------------------------------- | | | | | | | ----------- Percent Totals ------------------------------ | | | | | | | -------- Cumulative Percent Totals --------- | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Site | Sample | 75 | 25.4 | 12.5 | 4.75 | 2.37 | 1 | <1 | 75% | 25.4% | 12.5% | 4.75% | 2.37% | 1% | <1% | <2.37% | <4.75% | <12.5% | <25.4% | <75% | Total% |
| 89 | 4 | 3 | 0 | 670 | 250 | 385 | 245 | 365 | 562 | 0 | 27 | 10 | 16 | 10 | 15 | 23 | 37 | 47 | 63 | 73 | 100 | 100 |
| 89 | 4 | 4 | 0 | 810 | 240 | 330 | 200 | 200 | 565 | 0 | 35 | 10 | 14 | 9 | 9 | 24 | 33 | 41 | 55 | 65 | 100 | 100 |
| 89 | 4 | 5 | 0 | 1150 | 350 | 320 | 220 | 285 | 635 | 0 | 39 | 12 | 11 | 7 | 10 | 21 | 31 | 39 | 49 | 61 | 100 | 100 |
| 89 | 4 | 6 | 0 | 180 | 550 | 510 | 125 | 140 | 630 | 0 | 6 | 26 | 24 | 6 | 7 | 30 | 36 | 42 | 66 | 92 | 100 | 100 |
| 83 | 4 | 7 | 0 | 250 | 465 | 560 | 190 | 240 | 1085 | 0 | 9 | 17 | 20 | 7 | 9 | 39 | 47 | 54 | 74 | 91 | 100 | 100 |
| 89 | 4 | 8 | 270 | 670 | 350 | 370 | 170 | 285 | 465 | 10.5 | 26 | 14 | 14 | 7 | 11 | 18 | 29 | 36 | 50 | 64 | 90 | 100 |
| 89 | 4 | 9 | 0 | 330 | 450 | 430 | 190 | 215 | 560 | 0 | 15 | 21 | 20 | 9 | 10 | 26 | 36 | 45 | 64 | 85 | 100 | 100 |
| 89 | 4 | 10 | 0 | 310 | 265 | 500 | 280 | 320 | 785 | 0 | 13 | 11 | 20 | 11 | 13 | 32 | 45 | 56 | 77 | 87 | 100 | 100 |
| 89 | 5 | 1 | 0 | 480 | 520 | 520 | 205 | 280 | 490 | 0 | 19 | 21 | 21 | 8 | 11 | 20 | 31 | 39 | 60 | 81 | 100 | 100 |
| 89 | 5 | 2 | 0 | 470 | 320 | 380 | 210 | 250 | 675 | 0 | 20 | 14 | 16 | 9 | 11 | 29 | 40 | 49 | 66 | 80 | 100 | 100 |
| 89 | 5 | 3 | 0 | 280 | 320 | 460 | 270 | 330 | 930 | 0 | 11 | 12 | 18 | 10 | 13 | 36 | 49 | 59 | 77 | 89 | 100 | 100 |
| 89 | 5 | 4 | 0 | 575 | 450 | 430 | 160 | 200 | 700 | 0 | 23 | 18 | 17 | 6 | 8 | 28 | 36 | 42 | 59 | 77 | 100 | 100 |
| 89 | S | 5 | 0 | 520 | 410 | 460 | 225 | 260 | 800 | 0 | 19 | 15 | 17 | 8 | 10 | 30 | 40 | 48 | 65 | 81 | 100 | 100 |
| 89 | 5 | 6 | 0 | 285 | 280 | 585 | 305 | 390 | 1100 | 0 | 15 | 15 | 32 | 17 | 21 | 0 | 21 | 38 | 69 | 85 | 100 | 100 |
| 89 | 5 | 7 | 0 | 650 | 510 | 490 | 205 | 160 | 710 | 0 | 24 | 19 | 18 | 8 | 6 | 26 | 32 | 39 | 57 | 76 | 100 | 100 |
| 89 | S | 8 | 0 | 170 | 510 | 430 | 165 | 200 | 607 | 0 | 8 | 24 | 21 | 8 | 10 | 29 | 39 | 47 | 67 | 92 | 100 | 100 |
| 89 | 5 | 9 | 0 | 530 | 410 | 480 | 260 | 310 | 685 | 0 | 20 | 15 | 18 | 10 | 12 | 26 | 37 | 47 | 65 | 80 | 100 | 100 |
| 89 | 5 | 10 | g | 370 | 370 | 520 | 240 | 325 | 1210 | 0 | 12 | 12 | 17 | 8 | 11 | 40 | 51 | 58 | 76 | 88 | 100 | 100 |
| 90 | 1 | 1 | 0 | 320 | 440 | 570 | 290 | 410 | 5S5 | 0 | 12 | 17 | 22 | 11 | 16 | 22 | 38 | 49 | 71 | 63 | 100 | 100 |
| 90 | 1 | 2 | 390 | 640 | 450 | 530 | 300 | 290 | 590 | 12.2 | 20 | 14 | 17 | 9 | 9 | 18 | 28 | 37 | 54 | 68 | 88 | 100 |
| 90 | 1 | 3 | 0 | 390 | 650 | 630 | 290 | 430 | 630 | 0 | 13 | 22 | 21 | 10 | 14 | 21 | 35 | 45 | 66 | 87 | 100 | 100 |
| 90 | 1 | 4 | 0 | 630 | 520 | 390 | 240 | 180 | 400 | 0 | 27 | 22 | 17 | 10 | 8 | 17 | 25 | 35 | 51 | 73 | 100 | 100 |
| 90 | 1 | 5 | 380 | 270 | 260 | 330 | 210 | 260 | 330 | 18.6 | 13 | 13 | 16 | 10 | 13 | 16 | 29 | 39 | 55 | 68 | 81 | 100 |
| 90 | 1 | 6 | 0 | 280 | 430 | 480 | 300 | 420 | 565 | 0 | 11 | 17 | 19 | 12 | 17 | 23 | 40 | 52 | 71 | 89 | 100 | 100 |
| 90 | 1 | 7 | 0 | 720 | 240 | 310 | 200 | 230 | 430 | 0 | 34 | 11 | 15 | 9 | 11 | 20 | 31 | 40 | 55 | 66 | 100 | 100 |
| 90 | 1 | 8 | 0 | 400 | 310 | 620 | 540 | 940 | 830 | 0 | 11 | 9 | 17 | 15 | 26 | 23 | 49 | 63 | 80 | 89 | 100 | 100 |
| 90 | 1 | 9 | 0 | 120 | 410 | 430 | 400 | 420 | 670 | 0 | 5 | 17 | 18 | 16 | 17 | 27 | 44 | 61 | 78 | 95 | 100 | 100 |
| 90 | 1 | 10 | 0 | 270 | 470 | 630 | 480 | 620 | 665 | 0 | 9 | 15 | 20 | 15 | 20 | 21 | 41 | 56 | 76 | 91 | 100 | 100 |
| 90 | 2 | 1 | 0 | 240 | 450 | 570 | 115 | 390 | 300 | 0 | 12 | 22 | 28 | 6 | 19 | 15 | 33 | 39 | 67 | 86 | 100 | 100 |
| 90 | 2 | 2 | 0 | 445 | 475 | 535 | 200 | 170 | 315 | 0 | 21 | 22 | 25 | 9 | 8 | 15 | 23 | 32 | 57 | 79 | 100 | 100 |
| 90 | 2 | 3 | 0 | 60 | 380 | 750 | 470 | 370 | 490 | 0 | 2 | 15 | 30 | 19 | 15 | 19 | 34 | 53 | 83 | 98 | 100 | 100 |
| 90 | 2 | 4 | 715 | 350 | 170 | 290 | 130 | 260 | 475 | 29.9 | 15 | 7 | 12 | 5 | 11 | 20 | 31 | 36 | 48 | 55 | 70 | 100 |

McNeil Scores, 1989-1991, sites 1-5, North Fork Garcia River

| | | | ----- Raw Scores --------- | | | | | | | --------- Percent Totals ----- | | | | | | | --------- Cumulative Percent Totals | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Site | Sample | 75 | 25.4 | 12.5 | 4.75 | 2.37 | 1 | <1 | 75% | 25.4% | 12.5% | 4.75% | 2.37% | 1% | <1% | <2.37% | <4.75% | <12.5% | <25.4% | <75% | Total% |
| 90 | 2 | 5 | 0 | 310 | 480 | 560 | 490 | 600 | 505 | 0 | 11 | 16 | 19 | 17 | 20 | 17 | 38 | 54 | 73 | 89 | 100 | 100 |
| 90 | 2 | - 6 | 0 | 700 | 470 | 245 | 120 | 90 | 240 | 0 | 38 | 25 | 13 | 6 | 5 | 13 | 18 | 24 | 37 | 62 | 100 | 100 |
| 90 | 2 | 7 | 0 | 460 | 290 | 530 | 270 | 190 | 260 | 0 | 23 | 15 | 27 | 14 | 10 | 13 | 23 | 36 | 63 | 77 | 100 | 100 |
| 90 | 2 | 8 | 0 | 525 | 425 | 535 | 330 | 390 | 332 | 0 | 21 | 17 | 21 | 13 | 15 | 13 | 28 | 41 | 63 | 79 | 100 | 100 |
| 90 | 2 | 9 | 0 | 900 | 510 | 380 | 150 | 150 | 250 | 0 | 38 | 22 | 16 | 6 | 6 | 11 | 17 | 24 | 40 | 62 | 100 | 100 |
| 90 | 2 | 10 | 0 | 240 | 450 | 460 | 310 | 480 | 440 | 0 | 10 | 19 | 19 | 13 | 20 | 18 | 39 | 52 | 71 | 90 | 100 | 100 |
| 90 | 3 | 1 | 0 | 60 | 410 | 790 | 310 | 75 | 492 | 0 | 3 | 19 | 37 | 15 | 4 | 23 | 27 | 41 | 78 | 97 | 100 | 100 |
| 90 | 3 | 2 | 0 | 450 | 520 | 590 | 230 | 110 | 275 | 0 | 21 | 24 | 27 | 11 | S | 13 | 18 | 28 | 55 | 79 | 100 | 100 |
| 90 | 3 | 3 | 0 | 240 | 300 | 520 | 270 | 180 | 413 | 0 | 12 | 16 | 27 | 14 | 9 | 21 | 31 | 45 | 72 | 86 | 100 | 100 |
| 90 | 3 | 4 | 0 | 990 | 400 | 250 | 70 | 95 | 335 | 0 | 46 | 19 | 12 | 3 | 4 | 16 | 20 | 23 | 35 | 54 | 100 | 100 |
| 90 | 3 | 5 | 0 | 530 | 340 | 375 | 215 | 415 | 495 | 0 | 22 | 14 | 16 | 9 | 18 | 21 | 38 | 47 | 63 | 78 | 100 | 100 |
| 90 | 3 | 6 | 0 | 645 | 395 | 285 | 90 | 55 | 410 | 0 | 34 | 21 | 15 | S | 3 | 22 | 25 | 30 | 45 | 66 | 100 | 100 |
| 90 | 3 | 7 | 400 | 435 | 200 | 200 | 70 | 50 | 250 | 24.9 | 27 | 12 | 12 | 4 | 3 | 16 | 19 | 23 | 36 | 48 | 75 | 100 |
| 90 | 3 | 8 | 240 | 400 | 590 | 290 | 50 | 22 | 183 | 13.5 | 23 | 33 | 16 | 3 | 1 | 10 | 12 | 14 | 31 | 64 | 86 | 100 |
| 90 | 3 | 9 | 0 | 380 | 770 | 656 | 60 | 25 | 305 | 0 | 17 | 35 | 30 | 4 | 1 | 14 | 15 | 19 | 48 | 83 | 100 | 100 |
| 90 | 3 | 10 | 0 | 370 | 310 | 435 | 200 | 180 | 415 | 0 | 19 | 16 | 23 | 10 | 9 | 22 | 31 | 42 | 64 | 81 | 100 | 100 |
| 90 | 4 | 1 | 0 | 320 | 390 | 560 | 270 | 360 | 670 | 0 | 12 | 15 | 22 | 11 | 14 | 26 | 40 | 51 | 72 | 88 | 100 | 100 |
| 90 | 4 | 2 | 0 | 290 | 410 | 620 | 330 | 450 | 605 | 0 | 11 | 15 | 23 | 12 | 17 | 22 | 39 | 51 | 74 | 89 | 100 | 100 |
| 90 | 4 | 3 | 235 | 420 | 330 | 450 | 750 | 450 | 860 | 6.72 | 12 | 9 | 13 | 21 | 13 | 25 | 37 | 59 | 72 | 81 | 93 | 100 |
| 90 | 4 | 4 | 0 | 60 | 100 | 210 | 10 | 110 | 590 | 0 | 6 | 9 | 19 | 1 | 10 | 55 | 65 | 66 | 85 | 94 | 100 | 100 |
| 90 | 4 | 5 | 0 | 725 | 390 | 620 | 260 | 320 | 500 | 0 | 26 | 14 | 22 | 9 | 11 | 18 | 29 | 36 | 60 | 74 | 100 | 100 |
| 90 | 4 | 6 | 0 | 460 | 470 | 470 | 140 | 270 | 410 | 0 | 21 | 21 | 21 | 6 | 12 | 18 | 31 | 37 | 58 | 79 | 100 | 100 |
| 90 | 4 | 7 | 0 | 30 | 400 | 770 | 410 | 260 | 625 | 0 | 1 | 16 | 31 | 16 | 10 | 25 | 35 | 52 | 83 | 99 | 100 | 100 |
| 90 | 4 | 8 | 0 | 390 | 260 | 380 | 150 | 260 | 520 | 0 | 20 | 13 | 19 | 8 | 13 | 27 | 40 | 47 | 67 | 80 | 100 | 100 |
| 90 | 4 | 9 | 780 | 370 | 340 | 400 | 200 | 170 | 410 | 29.2 | 14 | 13 | 15 | 7 | 6 | 15 | 22 | 29 | 44 | 57 | 71 | 100 |
| 90 | 4 | 10 | 0 | 300 | 320 | 370 | 260 | 290 | 551 | 0 | 14 | 15 | 18 | 12 | 14 | 26 | 40 | 53 | 70 | 66 | 100 | 100 |
| 90 | 5 | 1 | 0 | 460 | 425 | 470 | 170 | 210 | 440 | 0 | 21 | 20 | 22 | 8 | 10 | 20 | 30 | 36 | 59 | 79 | 100 | 100 |
| 90 | 5 | 2 | 0 | 590 | 460 | 480 | 230 | 240 | 764 | 0 | 21 | 17 | 17 | 8 | 9 | 28 | 37 | 45 | 62 | 79 | 100 | 100 |
| 90 | 5 | 3 | 230 | 310 | 350 | 425 | 340 | 520 | 875 | 7.54 | 10 | 11 | 14 | 11 | 17 | 29 | 46 | 57 | 71 | 82 | 92 | 100 |
| 90 | 5 | 4 | 450 | 175 | 440 | 520 | 175 | 170 | 635 | 17.5 | 7 | 17 | 20 | 7 | 7 | 25 | 31 | 38 | 58 | 76 | 82 | 100 |
| 90 | 5 | 5 | 0 | 360 | 820 | 520 | 110 | 60 | 700 | 0 | 14 | 32 | 20 | 4 | 3 | 27 | 30 | 34 | 54 | 86 | 100 | 100 |
| 90 | 5 | 6 | 0 | 360 | 440 | 470 | 260 | 350 | 735 | 0 | 14 | 17 | 18 | 10 | 13 | 28 | 41 | 51 | 69 | 86 | 100 | 100 |

McNeil Scores, 1989-1991, sites 1-5, North Fork Garcia River

| | | | Raw Scores | | | | | | | Percent Totals | | | | | | | Cumulative Percent Totals | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Site | Sample | 75 | 25.4 | 12.5 | 4.75 | 2.37 | 1 | <1 | 75% | 25.4% | 12.5% | 4.75% | 2.37% | 1% | <1% | <2.37% | <4.75% | <12.5% | <25.4% | <75% | Total% |
| 90 | 5 | 7 | 0 | 70 | 310 | 670 | 410 | 475 | 758 | 0 | 3 | 12 | 25 | 15 | 18 | 28 | 46 | 61 | 86 | 97 | 100 | 100 |
| 90 | 5 | 8 | 0 | 580 | 620 | 462 | 170 | 130 | 605 | 0 | 23 | 24 | 18 | 7 | 6 | 24 | 29 | 35 | 53 | 77 | 100 | 100 |
| 90. | 5 | 9 | 0 | 240 | 510 | 520 | 260 | 210 | 800 | 0 | 9 | 20 | 20 | 10 | 8 | 31 | 40 | 50 | 70 | 91 | 100 | 100 |
| 90 | 5 | 10 | 0 | 200 | 480 | 580 | 325 | 445 | 910 | 0 | 7 | 16 | 20 | 11 | 15 | 31 | 46 | 57 | 77 | 93 | 100 | 100 |
| 91 | 1 | 1 | 0 | 150 | 380 | 535 | 290 | 395 | 303 | 0 | 7 | 19 | 26 | 14 | 19 | 15 | 34 | 48 | 74 | 93 | 100 | 100 |
| 91 | 1 | 2 | 0 | 870 | 400 | 310 | 100 | 110 | 300 | 0 | 42 | 19 | 15 | 5 | 5 | 14 | 20 | 24 | 39 | 58 | 100 | 100 |
| 91 | 1 | 3 | 0 | 1000 | 490 | 410 | 150 | 180 | 252 | 0 | 40 | 20 | 17 | 6 | 7 | 10 | 17 | 23 | 40 | 60 | 100 | 100 |
| 91 | 1 | 4 | 0 | 430 | 390 | 420 | 230 | 310 | 350 | 0 | 20 | 18 | 20 | 11 | 15 | 16 | 31 | 42 | 62 | 80 | 100 | 100 |
| 91 | 1 | 5 | 0 | 860 | 620 | 500 | 210 | 100 | 410 | 0 | 32 | 23 | 19 | 8 | 4 | 15 | 19 | 27 | 45 | 68 | 100 | 100 |
| 91 | 1 | 6 | 0 | 940 | 460 | 370 | 150 | 190 | 341 | 0 | 38 | 19 | 15 | 6 | *B* | 14 | 22 | 28 | 43 | 62 | 100 | 100 |
| 91 | 1 | 7 | 0 | 810 | 520 | 420 | 150 | 110 | 328 | 0 | 35 | 22 | 18 | 6 | *5* | 14 | 19 | 25 | 43 | 65 | 100 | 100 |
| 91 | 1 | 8 | 0 | 720 | 360 | 390 | 190 | 100 | 357 | 0 | 34 | 17 | 18 | 9 | *5* | 17 | 22 | 31 | 49 | 66 | 100 | 100 |
| 91 | 1 | 9 | 0 | 570 | 440 | 530 | 260 | 250 | 248 | 0 | 25 | 19 | 23 | 11 | 11 | 11 | 22 | 33 | 56 | 75 | 100 | 100 |
| 91 | 1 | 10 | 570 | 580 | 490 | 330 | 110 | 80 | 366 | 22.6 | 23 | 19 | 13 | 4 | 3 | 14 | 18 | 22 | 35 | 54 | 77 | 100 |
| 91 | 2 | 1 | 0 | 590 | 730 | 710 | 300 | 65 | 155 | 0 | 23 | 29 | 28 | 12 | 3 | 6 | 9 | 20 | 48 | 77 | 100 | 100 |
| 91 | 2 | 2 | 0 | 560 | 600 | 470 | 140 | 80 | 325 | 0 | 26 | 28 | 22 | 6 | 4 | 15 | 19 | 25 | 47 | 74 | 100 | 100 |
| 91 | 2 | 3 | 0 | 290 | 410 | 340 | 50 | 495 | 365 | 0 | 15 | 21 | 17 | 3 | 25 | 19 | 44 | 47 | 64 | 85 | 100 | 100 |
| 91 | 2 | 4 | 500 | 560 | 380 | 380 | 100 | 55 | 300 | 22 | 25 | 17 | 17 | 4 | 2 | 13 | 16 | 20 | 37 | 53 | 78 | 100 |
| 91 | 2 | 5 | 2060 | 320 | 330 | 390 | 260 | 520 | 725 | 44.7 | 7 | 7 | 8 | 6 | 11 | 16 | 27 | 33 | 41 | 48 | 55 | 100 |
| 91 | 2 | 6 | 430 | 0 | 380 | 530 | 210 | 240 | 420 | 19.5 | 0 | 17 | 24 | 10 | 11 | 19 | 30 | 39 | 63 | 81 | 81 | 100 |
| 91 | 2 | 7 | 250 | 390 | 410 | 210 | 280 | 640 | 345 | 9.9 | 15 | 16 | 8 | 11 | 25 | 14 | 39 | 50 | 58 | 75 | 90 | 100 |
| 91 | 2 | 8 | 500 | 210 | 260 | 150 | 110 | 265 | 390 | 26.5 | 11 | 14 | 8 | 6 | 14 | 21 | 35 | 41 | 49 | 62 | 73 | 100 |
| 91 | 2 | 9 | 480 | 650 | 300 | 330 | 210 | 340 | 295 | 18.4 | 25 | 12 | 13 | 8 | 13 | 11 | 24 | 32 | 45 | 57 | 82 | 100 |
| 91 | 2 | 10 | 0 | 430 | 330 | 380 | 320 | 420 | 415 | 0 | 19 | 14 | 17 | 14 | 18 | 18 | 36 | 50 | 67 | 81 | 100 | 100 |
| 91 | 3 | 1 | 0 | 150 | 310 | 530 | 330 | 440 | 575 | 0 | 6 | 13 | 23 | 14 | 19 | 25 | 43 | 58 | 80 | 94 | 100 | . 100 |
| 91 | 3 | 2 | 280 | 640 | 490 | 330 | 90 | 70 | 550 | 11.4 | 26 | 20 | 13 | 4 | 3 | 22 | 25 | 29 | 42 | 62 | 89 | 100 |
| 91 | 3 | 3 | 550 | 1100 | 190 | 180 | 80 | 45 | 410 | 21.5 | 43 | 7 | 7 | 3 | 2 | 16 | 18 | 21 | 28 | 35 | 78 | 100 |
| 91 | 3 | 4 | 0 | 250 | 690 | 630 | 210 | 100 | 285 | 0 | 12 | 32 | 29 | 10 | 5 | 13 | 16 | 27 | 57 | 88 | 100 | 100 |
| 91 | 3 | S | 0 | 250 | 245 | 460 | 230 | 260 | 430 | 0 | 13 | 13 | 25 | 12 | 14 | 23 | 37 | 49 | 74 | 87 | 100 | 100 |
| 91 | 3 | 6 | 0 | 0 | 260 | 1010 | 340 | 105 | 320 | 0 | 0 | 13 | 50 | 17 | 5 | 16 | 21 | 38 | 87 | 100 | 100 | 100 |
| 91 | 3 | 7 | 0 | 540 | 430 | 480 | 250 | 305 | 680 | 0 | 20 | 16 | 18 | 9 | 11 | 25 | 37 | 46 | 64 | 80 | 100 | 100 |
| 91 | 3 | 8 | 0 | 340 | 330 | 430 | 185 | 205 | 475 | 0 | 17 | 17 | 22 | 9 | 10 | 24 | 35 | 44 | 66 | 83 | 100 | 100 |

McNeil Scores, 1989-1991, sites 1-5, North Fork Garcia River

| | | | ----------- Raw Scores -------------------------- | | | | | | | ----- Percent Totals -------------------------------- | | | | | | | ------- Cumulative Percent Totals | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Site | Sample | 75 | 254 | 12.5 | 4.75 | 2.37 | 1 | <1 | 75% | 25.4% | 12.5% | 4.75% | 2.37% | 1% | <1% | <2.37% | <4.75% | <12.5% | <25.4% | <75% | Total% |
| 91 | 3 | 9 | 0 | 780 | 270 | 350 | 250 | 310 | 600 | 0 | 30 | 11 | 14 | 10 | 12 | 23 | 36 | 45 | 59 | 70 | 100 | 100 |
| 91 | 3 | 10 | 0 | 0 | 105 | 690 | 860 | 90 | 389 | 0 | 0 | 5 | 32 | 40 | 4 | 18 | 22 | 63 | 95 | 100 | 100 | 100 |
| 91 | 4 | 1 | 550 | 500 | 300 | 340 | 210 | 330 | 900 | 17.6 | 16 | 10 | 11 | 7 | 11 | 29 | 39 | 46 | 57 | 66 | 82 | 100 |
| 91 | 4 | 2 | • 0 | 400 | 310 | 550 | 215 | 302 | 425 | 0 | 18 | 14 | 25 | 10 | 14 | 19 | 33 | 43 | 68 | 82 | 100 | 100 |
| 91 | 4 | 3 | 360 | 370 | 330 | 425 | 185 | 290 | 975 | 12.3 | 13 | 11 | 14 | 6 | 10 | 33 | 43 | 49 | 64 | 75 | 88 | 100 |
| 91 | 4 | 4 | 0 | 110 | 340 | 420 | 180 | 205 | 400 | 0 | 7 | 21 | 25 | 11 | 12 | 24 | 37 | 47 | 73 | 93 | 100 | 100 |
| 91 | 4 | 5 | 480 | 220 | 220 | 330 | 170 | 185 | 495 | 22.9 | 10 | 10 | 16 | 8 | 9 | 24 | 32 | 40 | 56 | 67 | 77 | 100 |
| 91 | 4 | 6 | 470 | 640 | 230 | 220 | 146 | 180 | 398 | 20.6 | 28 | 10 | 10 | 6 | 8 | 17 | 25 | 32 | 41 | 51 | 79 | 100 |
| 91 | 4 | 7 | 0 | 290 | 280 | 330 | 180 | 160 | 775 | 0 | 14 | 14 | 16 | 9 | 8 | 38 | 46 | 55 | 72 | 86 | 100 | 100 |
| 91 | 4 | 8 | 0 | 230 | 330 | 370 | 200 | 240 | 520 | 0 | 12 | 17 | 20 | 11 | 13 | 28 | 40 | 51 | 70 | 88 | 100 | 100 |
| 91 | 4 | 9 | 0 | 180 | 320 | 420 | 240 | 350 | 60S | 0 | 9 | 15 | 20 | 11 | 17 | 29 | 45 | 57 | 76 | 91 | 100 | 100 |
| 91 | 4 | 10 | 300 | 540 | 340 | 410 | 210 | 260 | 825 | 10.4 | 19 | 12 | 14 | 7 | 9 | 29 | 38 | 45 | 59 | 71 | 90 | 100 |
| 91 | 5 | 1 | 0 | 390 | 440 | 430 | 210 | 230 | 810 | 0 | 16 | 18 | 17 | 8 | 9 | 32 | 41 | 50 | 67 | 84 | 100 | 100 |
| 91 | S | 2 | 0 | 330 | 450 | 550 | 380 | 600 | 1075 | 0 | 10 | 13 | 16 | 11 | 18 | 32 | 49 | 61 | 77 | 90 | 100 | 100 |
| 91 | 5 | 3 | 0 | 550 | 605 | 500 | 230 | 185 | 730 | 0 | 20 | 22 | 18 | 8 | 7 | 26 | 33 | 41 | 59 | 80 | 100 | 100 |
| 91 | 5 | 4 | 0 | 565 | 635 | 565 | 100 | 95 | 775 | 0 | 20 | 25 | 20 | 4 | 3 | 28 | 31 | 35 | 55 | 80 | 100 | 100 |
| 91 | S | 5 | 0 | 420 | 460 | 545 | 230 | 335 | 820 | 0 | 15 | 16 | 19 | 8 | 12 | 29 | 41 | 49 | 69 | 85 | 100 | 100 |
| 91 | S | 6 | 0 | 710 | 480 | 460 | 270 | 375 | 785 | 0 | 23 | 18 | 15 | 9 | 12 | 25 | 38 | 46 | 61 | 77 | 100 | 100 |
| 91 | S | 7 | 0 | 80 | 290 | 320 | 190 | 300 | 725 | 0 | 4 | 15 | 17 | 10 | 16 | 38 | 54 | 64 | 81 | 96 | 100 | 100 |
| 91 | S | 8 | 0 | 110 | 430 | 680 | 275 | 410 | 850 | 0 | 4 | 16 | 25 | 10 | 15 | 31 | 46 | 56 | 80 | 96 | 100 | 100 |
| 91 | S | 9 | 0 | 120 | 430 | 610 | 460 | 495 | 1170 | 0 | 4 | 13 | 19 | 14 | 15 | 36 | 51 | 65 | 83 | 96 | 100 | 100 |
| 91 | 5 | 10 | 0 | 220 | 450 | 530 | 320 | 250 | 980 | 0 | 8 | 16 | 19 | 12 | 9 | 36 | 45 | 56 | 76 | 92 | 100 | 100 |

# II-4: Summary of Habitat Types and Biological Inventory of the North Fork Garcia River, Estuary, and Mainstem Garcia River, Prepared by Jan Derksen, Ph.D., December 1991

SUMMARY OF HABITAT TYPES AND

BIOLOGICAL INVENTORY OF THE

NORTH FORK GARCIA RIVER ESTUARY AND MAINSTEM GARCIA RIVER

Prepared by

Jan Derksen, Ph.D.

December 10, 1991

# TABLE 1.

Garcia River North Fork

12/09/91 Summary of habitat types

| # Unit | Habitat Type | % Units | Mean Length (Ft) | Total Length (Ft) | % Total Length | Mean Width (Ft) | Mean Depth (Ft) | Mean Max Depth | Mean Area (Sq Ft) | Total Area (Ft) | Mean Volume (Cu Ft) | Total Volume (Cu Ft) | Mean Res Pool Vol (Sq Ft) | Mean Shelter Rating | Mean % Rt Bank Cover | Mean % Lt Bank Cover | Mean % Canopy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | L6R | 6.8 | 56.2 | 843.0 | 4.1 | 19.3 | .4 | .9 | 1117 | 1676 | 468 | 7024 | | 31.8 | 58.0 | 58,0 | 43.7 |
| 23 | HGR | 10.4 | 41.5 | 955.0 | 4.7 | 15.7 | .5 | 1.0 | 707 | 1626 | 373 | 8568 | | 81.3 | 51.4 | 51.4 | 63.2 |
| 14 | CAS | 6.3 | 31.9 | 447.0 | 2.2 | 17.4 | .5 | 1.2 | 670 | 938 | 286 | 4007 | | 167.6 | 39.3 | 39.3 | 39.3 |
| 16 | RUN | 7.2 | 102.3 | 1636.0 | 8.0 | 15.9 | .6 | 2.3 | 1714 | 2742 | 1081 | 17289 | | 42,9 | 62.5 | 62.5 | 58.4 |
| 52 | SRN | 23.5 | 200.9 | 10447.0 | 51.3 | 17.2 | .6 | 1.6 | 3606 | 18752 | 2250 | 116981 | | 81,7 | 42.7 | 42.7 | 47.7 |
| 2 | TRP | .9 | 46.5 | 93.0 | .5 | 13.0 | .0 | 2.1 | 588 | 117 | 574 | 1149 | 934.0 | 81,0 | 25.0 | 25.0 | 50.0 |
| 16 | MCP | 7.2 | 53.5 | 856.0 | 4.2 | 16.1 | .3 | 2.9 | 830 | 1407 | 1263 | 20212 | 2273.6 | 69,3 | 41.3 | 41.3 | 45.6 |
| 19 | STP | 8.6 | 120.7 | 2293.0 | 11.3 | 17.5 | .9 | 2.2 | 2296 | 4362 | 2345 | 44555 | 4600.4 | 113.2 | 34.2 | 34.2 | 42.6 |
| 15 | LSL | 6.8 | 44.6 | 669.0 | 3.3 | 17.8 | .2 | 2.8 | 777 | 1166 | 947 | 14209 | 1883.0 | 125.0 | 38.0 | 38.0 | 50.7 |
| 9 | L5R | 4.1 | 55.7 | 501.0 | 2.5 | 16.0 | ,2 | 2.6 | 1005 | 904 | 1343 | 12090 | 2573.2 | 83.7 | 60.0 | 60.0 | 53.3 |
| 18 | LSBK | 8.1 | 47.6 | 856.0 | 4.2 | 15.1 | .2 | 2.8 | 717 | 1291 | 892 | 16048 | 1848.7 | 64,7 | 27.8 | 27.8 | 52,2 |
| 8 | LSBC | 3.6 | 39.6 | 317.0 | 1.6 | 18.0 | .2 | 2.7 | 716 | 572 | 891 | 7127 | 1734.5 | 75.0 | 43.8 | 43.8 | 38.8 |
| 6 | PLP | 2.7 | 30.5 | 183.0 | ,9 | 22.0 | .5 | 3.0 | 763 | 457 | 1132 | 6790 | 1930.8 | 123.5 | 23.3 | 23.3 | 20.0 |
| 1 | SCP | .5 | 58.0 | 58.0 | .3 | 5.0 | .3 | .9 | 290 | 29 | 87 | 87 | | 81.0 | 50.0 | 50.0 | 80.0 |
| 3 | BPB | 1.4 | 23.3 | 70.0 | .3 | 18.7 | .1 | 2.3 | 455 | 136 | 495 | 1484 | 652.6 | 75.0 | 36.7 | 36.7 | 46.7 |
| 1 | BPR | .5 | 13.0 | 13.0 | .1 | 10.0 | .0 | 2.2 | 130 | 13 | 130 | 130 | 234. n | 75.0 | 70.0 | 70.0 | 40.0 |
| 3 | DPL | 1.4 | 39.7 | 119,0 | .6 | 14.0 | .1 | 2.6 | 547 | 164 | 531 | 1743 | 1207.1 | 68.3 | 20.0 | 20.0 | 50.0 |

| Total : | Total Length | Total Area | | Total Volume |
|---|---|---|---|---|
| 221 | 20,356.00 (Ft) | 8.35 | Acres | 279,492 |

Garcia River Estuary and Main Stem

12/09/91 Summary of habitat types

| # Unit | Habitat Type | % Units | Mean Length (Ft) | Total Length (Ft) | % Total Length | Mean Width (Ft) | Mean Depth (Ft) | Mean Max Depth | Mean Area (Sq Ft) | Total Area (Ft) | Mean Volume (Cu Ft) | Total Volume (Cu Ft) | Mean Res Pool Vol (Sq Ft) | Mean Shelter Rating | Mean % Rt Bank Cover | Mean % Lt Bank Cover | Mean % Canopy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | LGR | 27.5 | 129.0 | 5936.0 | 14,4 | 32,9 | .7 | 1.2 | 4063 | 18669 | 2767 | 127275 | | 26.4 | 90.2 | 90.2 | 13.6 |
| 18 | GLD | 10.8 | 351.9 | 6334.0 | 15,4 | 48.5 | 1.0 | 2.2 | 18916 | 34048 | 21878 | 393797 | 85319.5 | 51.8 | 92.8 | 92.8 | 27.0 |
| 27 | RUN | 16.2 | 323.4 | 8733.0 | 21.2 | 35,6 | 1.1 | 2.2 | 12299 | 33206 | 15282 | 412603 | -4351.5 | 45.0 | 89.6 | 89.6 | 16.8 |
| 8 | MCP | 4.8 | 258.6 | 2069.0 | 5.0 | 48.3 | 2.8 | 4.5 | 13438 | 10790 | 38781 | 310248 | 52666,4 | 112.4 | 97.5 | 97.5 | 23.1 |
| 22 | CRP | 13.2 | 343.4 | 7555,0 | 18,3 | 45.1 | 2.9 | 5.2 | 17117 | 37657 | 49875 | 1097257 | 87867.4 | 115.3 | 84.1 | 84.1 | 25.9 |
| 16 | L5L | 9.6 | 266.6 | 4265.0 | 10.4 | 37,1 | 2.1 | 3.3 | 12002 | 19203 | 21334 | 341349 | 33737.6 | 114.4 | 82.5 | 82.5 | 25.0 |
| 9 | LSR | 5.4 | 172.1 | 1549.0 | 3,8 | 39.7 | 2.4 | 7.6 | 7740 | 6965 | 22568 | 203109 | 62657.6 | 79,3 | 85.6 | 85.6 | 23.1 |
| 3 | LSBK | 1.8 | 321.3 | 964.0 | 2.3 | 47.7 | 2.3 | 4,5 | 15352 | 4605 | 36205 | 108615 | 63391.1 | 133.0 | 83.3 | 83.3 | 38.3 |
| 5 | LSBC | 3.0 | 239.6 | 1198.0 | 2.9 | 42.0 | 2,3 | 4.3 | 10401 | 5200 | 26622 | 133110 | 42712.7 | 94.2 | 98.0 | 98.0 | 27.0 |
| 8 | SCP | 4.8 | 200.0 | 1600.0 | 3.9 | 19.5 | .8 | 2.6 | 3831 | 3064 | 3572 | 28576 | 9181.0 | 66.4 | 91.3 | 91.3 | 41.5 |
| 1 | BPB | .6 | 200.0 | 200.0 | .5 | 5.0 | ,7 | 2.2 | 1000 | 100 | 700 | 700 | | 180.0 | 100.0 | 100.0 | 100.0 |
| 1 | BPR | .6 | 189.0 | 189,0 | .5 | 4.0 | .6 | 3.0 | 756 | 75 | 454 | 454 | 2116.8 | 105,0 | 100.0 | 100.0 | 90.0 |
| 2 | BPL | 1.2 | 207.0 | 414.0 | 1.0 | 15.0 | 1.5 | 4.5 | 3115 | 623 | 4392 | 8784 | 11457.6 | 126.0 | 80.0 | 80.0 | 70.0 |
| 1 | DPL | .6 | 174.0 | 174.0 | .4 | 48.0 | 1.3 | 2.1 | 8352 | 835 | 10858 | 10855 | | 25.0 | 100.0 | 100.0 | 15.0 |

| Totals: | Total Lena | | Total Area | | Total Volume |
|---|---|---|---|---|---|
| 167 | 41,180.00 | (Ft) | 40.19 | Acres | 3,176,733 |

TABLE 2.

North Fork Garcia

12/09/91 Summary of habitat types

| Unit # | Habitat Type | % Units | Mean Length (Pt) | Total Length (Ft) | % Total Length | Mean Width (Ft) | Mean Depth (Ft) | Mean Max Depth | Mean Area (Sq Ft) | Total Area (Ft) | Mean Volume (Cu Ft) | Total Volume (Cu Ft) | Mean Res Pool Vol (Sq Ft) | Mean Shelter Rating |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68 | FLATWATER | 30.8 | 177.7 | 12083 | 59.4 | 16.9 | .6 | 1.7 | 3161.0 | 214947.0 | 1975 | 134270.2 | | 72.6 |
| 101 | POOL | 45.7 | 59.7 | 6028 | 29.6 | 16.7 | 1.2 | - 2.6 | 1051.7 | 106221.0 | 1244 | 125623.6 | 2037.6 | 90.8 |
| 52 | RIFFLE | 23.5 | 43.2 | 2245 | 11.0 | 17.2 | .4 | 1.0 | 815.4 | 42400.0 | 377 | 19598.4 | | 90.2 |

Garcia Estuary and Main Stem

12/10/91 Summary of habitat types

| Unit # | Habitat Type | % Units | Mean Length (Ft) | Total Length (Ft) | % Total Length | Mean Width (Ft) | Mean Depth (Ft) | Mean Max Depth | Mean Area (Sq Ft) | Total Area (Ft) | Mean Volume (Cu Ft) | Total Volume (Cu Ft) | Mean Res Pool Vol (Sq Ft) | Mean Shelter Rating |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | FLATWATER | 26.9 | 334.8 | 15067 | 36.6 | 40.7 | 1.1 | 2.2 | 14.946 | 672549.0 | 17920 | 806.400 | 62901.8 | 47.3 |
| 76 | POOL | 45.5 | 265.5 | 20177 | 49.0 | 38.5 | 2.2 | 4,5 | 11.727 | 891225.2 | 29514 | 2,243,058 | 56717.7 | 104.7 |
| 4ft | RIFFLE | 27.5 | 129.0 | 5936 | 14.4 | 32.9 | .1 | 1.2 | 4.063 | 186892.0 | 2767 | 127,275 | | 26.4 |

Table 3.

North Fork Garcia

12/09/91 Summary of habitat types Page 1

| Unit | Habitat Type | % Units | Mean Length (Ft) | Total Length (Ft) | % Total Length | Mean Width (Ft) | Mean Depth (ft) | Mean Max Depth | Mean Area (Sq Ft) | Total Area (Ft) | Mean Volume (Cu Ft) | Total Volume (Cu Ft) | Mean Res Pool Vol (Sq Ft) | Mean Shelter Rating |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | BACKWATER | 3.6 | 32.5 | 260 | 1.3 | 14.1 | 1.0 | 2.2 | 428.0 | 3424.0 | 431 | 3444.4 | 916.1 | 73.3 |
| 14 | CASCADE | 6.3 | 31.9 | 447 | 2.2 | 17.4 | .5 | 1.2 | 670.0 | 9380.0 | 286 | 4006.6 | | 167.6 |
| 63 | FLATWATER | 30.8 | 177.7 | 12033 | 59.4 | 16.9 | .6 | 1.7 | 3161.0 | 214947.0 | 1975 | 134270.2 | | 72.6 |
| 37 | MAIN | 16.7 | 87.6 | 3242 | 15.9 | 16.7 | 1.1 | 2.5 | 1591.2 | 58876.0 | 1782 | 65916.1 | 2574.9 | 92.5 |
| 38 | RIFFLE | 17.2 | 47.3 | 1798 | 8.8 | 17.1 | .4 | 1.0 | 868.9 | 33020.0 | 410 | 15591.8 | | 61.7 |
| 56 | SCOUR | 25.3 | 45.1 | 2526 | 12.4 | 17.1 | 1.2 | 2.8 | 784.3 | 43921.0 | 1005 | 56263.1 | 1966.8 | 92.2 |

Garcia Estuary and Main Stem

cc12/10/91 Summary of habitat types

| Unit # | Habitat Type | % Units | Mean Length (Ft) | Total Length (Ft) | % Total Length | Mean Width (Ft) | Mean Depth (Ft) | Mean Max Depth | Mean Area (Sq Ft) | Total Area (Ft) | Mean Volume (Cu Ft) | Total Volume (Cu Ft) | Mean Res Pool Vol (Sq Ft) | Mean Shelter Rating |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | BACKWATER | 7.8 | 198.2 | 2577 | 6.3 | 18.7 | .9 | 2.8 | 3,614 | 46985.0 | 3798 | 49,371 | 8497.1 | 85.3 |
| 45 | FLATWATER | 26.9 | 334.8 | 15067 | 36.6 | 40.7 | 1.1 | 2.2 | 14,946 | 672549.0 | 17920 | 806,400 | 62901.8 | 47.8 |
| 8 | MAIN | 4.8 | 258.6 | 2069 | 5.0 | 45.3 | 2.8 | 4.5 | 13,488 | 107906.0 | 38781 | 310,248 | 52666.4 | 112.4 |
| 46 | RIFFLE | 27.5 | 129.0 | 5936 | 14.4 | 32.9 | .7 | 1.2 | 4.063 | 186892.0 | 2767 | 127,275 | | 26.4 |
| 55 | SCOUR | 32.9 | 282.4 | 15531 | 37.7 | 41.7 | 2.5 | 4.9 | 13,388 | 736334.2 | 34244 | 1,883,440 | 64425.1 | 108.2 |

TABLE 4.

- .....

North Fork Garcia

12/09/91 Summary of Maximum pool depths

| # Unit | Hab. Type Code | % Units | <1 Ft Max Depth | <1 Ft % Occur | 1-<2 Ft Max Depth | 1-<2 Ft %. Occur | 3-<4 Ft Max Depth | 3-<4 Ft % Occur | >4 Ft Max Depth | >4 Ft % Occur |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 | LGR | 6.8 | 9 | 32.1 | 6 | 6.5 | | 0.0 | | 0.0 |
| 23 | HGR | 10.4 | 10 | 35.7 | 13 | 14.0 | | 0.0 | | 0.0 |
| 14 | CAS | 6.3 | 3 | 10.7 | 10 | 10.3 | | 0.0 | | 0.0 |
| 16 | RUN | 7.2 | 1 | 3.6 | 13 | 14.0 | | 0.0 | 1 | 14.3 |
| 52 | SRN | 23.5 | 4 | 14.3 | 37 | 39.8 | | 0.0 | | 0.0 |
| 2 | TRP | .9 | | 0.0 | 1 | 1.1 | | 0.0 | | 0.0 |
| 16 | MCP | 7.2 | | 0.0 | 2 | 2.2 | 4 | 18.2 | 2 | 28.6 |
| 19 | STP | 8.6 | | 0.0 | 7 | 7.5 | 2 | 9.1 | | 0.0 |
| 15 | LSL | 6.8 | | 0.0 | 1 | 1.1 | 4 | 18.2 | 1 | 14.3 |
| 9 | LSR | 4.1 | | 0.0 | 1 | 1.1 | 3 | 13.6 | | 0.0 |
| 18 | LS8K | 8.1 | | 0.0 | | 0.0 | 6 | 27.3 | 1 | 14.3 |
| 9 | LSBC | 3.6 | | 0.0 | 1 | 1.1 | 1 | 4.5 | 1 | 14.3 |
| 6 | PLP | 2.7 | | 0.0 | 1 | 1.1 | 2 | 9.1 | 1 | 14.3 |
| 1 | SCP | .5 | 1 | 3.6 | | 0.0 | | 0.0 | | 0.0 |
| 3 | BPB | 1.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 1 | BPR | .5 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 3 | DPL | 1.4 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |

Garcia Estuary and Main Stem

12/09/91 Summary of maximum pool depths

| # Unit | Hab. Type Code | % Units | <1 Ft Max Depth | <1 Ft %. Occur | 1-<2 Ft Max Depth | 1-<2 Ft % Occur | 3-<4 Ft Max Depth | 3-<4 Ft % Occur | >4 Ft Max Depth | >4 Ft % Occur |
|---|---|---|---|---|---|---|---|---|---|---|
| 46 | LGR | 27.5 | 22 | 73.3 | 17 | 48.6 | | 0.0 | | 0.0 |
| 18 | GLD | 10.8 | 2 | 6.7 | 6 | 17.1 | 2 | 8.7 | 1 | 2.3 |
| 27 | RUN | 16.2 | 3 | 10.0 | 9 | 25.7 | 7 | 30.4 | | 0.0 |
| 3 | MCP | 4.3 | | 0.0 | | 0.0 | 1 | 4.3 | 6 | 14.0 |
| 22 | CRP | 13.2 | 1 | 3.3 | | 0.0 | 4 | 17.4 | .17 | 39.5 |
| 16 | LSL | 9.6 | 2 | 6.7 | 1 | 2.9 | 3 | 13.0 | 6 | 14.0 |
| 9 | LSR | 5.4 | | 0.0 | 1 | 2.9 | 1 | 4.3 | 6 | 14.0 |
| 3 | LSBK | 1.3 | | 0.0 | | 0.0 | 1 | 4.3 | 2 | 4.7 |
| 5 | LSBC | 3.0 | | 0.0 | | 0.0 | 2 | 3.7 | 1 | 4.7 |
| 3 | SCP | 4.3 | | 0.0 | | 2.9 | 1 | 4.3 | 1 | 2.3 |
| 1 | BPB | .6 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |
| 1 | BPR | .6 | | 0.0 | | 0.0 | 1 | 4.3 | | 0.0 |
| 2 | BPL | 1.2 | | 0.0 | | 0.0 | | 0.0 | 2 | 4.7 |
| 1 | DPL | .6 | | 0.0 | | 0.0 | | 0.0 | | 0.0 |

Table 5.

North Fork Garcia

12/09/91 Summary of dominant substates

| # | Hab. Type Code | Silt Clay | % Silt Clay | # Sand Domnt | % Sand Domnt | # Gravel Domnt | % Gravel Domnt | # Small Cobbl | % Small Cobble | # Small Cobble | % Small Cobble | # Boulder | % Boulder | # Bedrock Domnt | % Bedrock Domnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | LGR | 0 | 0.0 | 0 | 0.0 | 8 | 20.0 | 12 | 37.8 | 7 | 28.9 | 3 | 13.3 | 0 | 0.0 |
| 23 | HGR | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 15 | 31.9 | 14 | 36.2 | 17 | 31.9 | 0 | 0.0 |
| 14 | CAS | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 12 | 57.1 | 14 | 35.7 | 2 | 7.1 |
| 16 | RUN | 0 | 0.0 | 3 | 8.3 | 11 | 25.0 | 8 | 27.1 | 8 | 31.3 | 2 | 8.3 | 0 | 0.0 |
| 52 | SRN | 0 | 0.0 | 0 | 0.0 | 15 | 16.7 | 34 | 31.4 | 17 | 16.7 | 37 | 34.6 | 1 | .6 |
| 2 | TRP | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 33.3 | 0 | 0.0 | 2 | 50.0 | 1 | 16.7 |
| 16 | MCP | 0 | 0.0 | 8 | 25.0 | 7 | 20.8 | 0 | 0.0 | 6 | 18.8 | 10 | 33.3 | 1 | 2.1 |
| 19 | STP | 0 | 0.0 | 1 | 3.5 | 8 | 21.1 | 2 | 7.0 | 8 | 26.3 | 18 | 38.6 | 1 | 3.5 |
| 15 | LSL | 0 | 0.0 | 3 | 6.7 | 12 | 37.8 | 4 | 15.6 | 3 | 8.9 | 8 | 31.1 | 0 | 0.0 |
| 9 | LSR | 0 | 0.0 | 2 | 14.8 | 7 | 29.6 | 1 | 3.7 | 6 | 40.7 | 1 | 3.7 | 1 | 7.4 |
| 18 | LSBK | 1 | 1.9 | 7 | 18.5 | 13 | 31.5 | 3 | 7.4 | 2 | 7.4 | 8 | 27.8 | 2 | 5.6 |
| 8 | LSBC | 0 | 0.0 | 6 | 33.3 | 3 | 12.5 | 0 | 0.0 | 2 | 16.7 | 5 | 37.5 | 0 | 0.0 |
| 6 | PLP | 0 | 0.0 | 2 | 11.1 | 2 | 11.1 | 1 | 11.1 | 0 | 0.0 | 6 | 61.1 | 1 | 5.6 |
| 1 | SCP | 0 | 0.0 | 0 | 0.0 | 1 | 33.3 | 0 | 0.0 | 0 | 0.0 | 1 | 66.7 | 0 | 0.0 |
| 3 | BPB | 0 | 0.0 | 2 | 33.3 | 1 | 11.1 | 0 | 0.0 | 0 | 0.0 | 3 | 55.6 | 0 | 0.0 |
| 1 | BPR | 0 | 0.0 | 1 | 66.7 | 1 | 33.3 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 3 | DPL | 0 | 0.0 | 1 | 22.2 | 2 | 22.2 | 1 | 22.2 | 1 | 22.2 | 1 | 11.1 | 0 | 0.0 |

Garcia Estuary and Main Stem

12/09/91 Summary of dominant substrates

| # | Hab. Type Code | # Silt Clay | % Silt Clay | # Sand Domnt | % Sand Domnt | # Gravel Domnt | % Gravel Domnt | # Small Cobbl | % Small Cobble | # Small Cobble | % Small Cobble | # Boulder | % Boulder | # Bedrock Domnt | % Bedrock Domnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | LGR | 0 | 0.0 | 14 | 20.7 | 45 | 42.2 | 31 | 37.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 18 | GLD | 6 | 14.8 | 11 | 35.2 | 17 | 44.4 | 2 | 5.6 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 27 | RUN | 1 | 1.2 | 14 | 23.4 | 26 | 42.0 | 13 | 23.4 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 8 | MCP | 0 | 0.0 | 8 | 33.3 | 8 | 66.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 22 | CRP | 1 | 3.0 | 22 | 42.4 | 21 | 54.5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 16 | LSL | 0 | 0.0 | 14 | 35.4 | 16 | 56.3 | 2 | 8.3 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 9 | LSR | 0 | 0.0 | 8 | 37.0 | 9 | 55.6 | 1 | 7.4 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 3 | LSBK | 0 | 0.0 | T 0 | 33.3 | T | 66.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 5 | LSBO | 6 | 0.0 | 4 | 26.7 | 5 | 66.7 | 1 | 6.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 8 | SCP |  | 16.7 | 5 | 33.3 | 6 | 37.5 | 2 | 12.5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 1 | BPB | 1 | 33.3 | 0 | 0.0 | 1 | 66.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 1 | BPR | 1 | 33.3 | 1 | 66.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 2 | BPL | 0 | 0.0 | 2 | 50.0 | 2 | 50.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 1 | DPL | 0 | 0.0 | 1 | 33.3 | 1 | 66.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |

Table 6.

North Fork Garcia

12/09/91 Summary of mean percent cover

| # | Mean % Undercut Banks | Mean % Sand | Mean % Lwd | Mean % Root Mass | Mean % Terr. Veget. | Mean % Aqua. Veget. | Mean % White Water | Mean % Boulder | Mean % Bedrock Ledges |
|---|---|---|---|---|---|---|---|---|---|
| LGR | 1.0 | 2.6 | 2.3 | | 5.4 | | 1.4 | 6.9 | |
| HGR | 45.0 | 2.6 | 3.7 | 5.0 | 5.0 | 5.0 | 7.7 | 18.9 | |
| CAS | | 4.0 | 3.7 | | 7.5 | | 21.2 | 31.4 | 17.5 |
| RUN | 1.0 | 2.9 | 3.0 | 2.6 | 4.7 | | | 8.8 | |
| SRN | 1.0 | 2.8 | 2.4 | 2.0 | 3.7 | | 4.0 | 16.8 | 5.0 |
| TRP | | 3.5 | 5.0 | | | | | 17.5 | 3.5 |
| MCP | 5.0 | 33.3 | 5.7 | 5.4 | 6.0 | | | 14.1 | 3.6 |
| STP | 2.0 | 3.1 | 3.4 | 3.2 | 2.8 | | 5.8 | 26.1 | 4.6 |
| LSL | 4.0 | 9.3 | 16.7 | 7.3 | 6.4 | | | 8.5 | 2.0 |
| LSR | 6.8 | 4.2 | 6.4 | 7.6 | 4.8 | | 20.0 | 6.9 | |
| LSBK | 3.0 | 3.3 | 3.5 | 5.0 | 5.0 | | 6.0 | 12.9 | 5.6 |
| LSBC | 1.0 | 2.0 | 3.6 | 10.0 | 5.0 | | 2.0 | 16.3 | |
| PLP | | 20.0 | 21.0 | 7.5 | 10.0 | | 3.8 | 20.0 | 8.8 |
| SCP | | 2.0 | | | 5.0 | | | 20.0 | |
| BPB | | | 5.0 | | | | | 23.3 | |
| BPR | | | | 5.0 | 10.0 | | | 10.0 | |
| DPL | | 5.0 | 5.0 | | 5.0 | | | 15.0 | 5.0 |

Garcia Estuary and Main Stem

12/09/91 Summary of lean percent cover

| # | Mean % Undercut Banks | Mean % Swd | Mean % Lwd | Mean % Root Mass | Mean % Terr. Veget. | Mean % Aqua. Veget. | Mean % White Water | Mean % Boulder | Mean % Bedrock Ledges |
|---|---|---|---|---|---|---|---|---|---|
| LGR | 4.0 | 5.2 | 4.0 | 5.6 | 11.5 | 2.7 | 9.7 | | |
| GLD | 4.3 | 7.5 | 1.3 | 4.9 | 17.9 | 3.9 | | | |
| RUN | 5.0 | 6.4 | 2.0 | 3.6 | 12.3 | 3.9 | | 4.3 | |
| MCP | 5.8 | 10.1 | 5.5 | 9.3 | 19.4 | 2.5 | 1.0 | | |
| CRP | 6.6 | 12.2 | 7.3 | 6.9 | 20.3 | 2.9 | | 5.3 | |
| LSL | 5.2 | 15.4 | 11.5 | 4.6 | 14.4 | 3.1 | | 5.0 | 5.0 |
| LSR | 5.0 | 10.0 | 6.3 | 6.7 | 13.8 | 1.2 | 1.0 | | |
| LSBK | 6.0 | 6.7 | 5.0 | 5.0 | 5.0 | 1.0 | | 11.7 | 6.7 |
| LSBO | 5.0 | 8.3 | 5.0 | 10.0 | 5.3 | 3.0 | | 12.0 | 5.0 |
| SCP | 4.0 | 15.8 | 1.0 | 5.0 | 12.1 | 4.5 | | 2.0 | 5.0 |
| BPB | 10.0 | 10.0 | 10.0 | 10.0 | 20.0 | | | | |
| BPR | 5.0 | 10.0 | 5.0 | 5.0 | 10.0 | | | | |
| BPL | 7.5 | 10.0 | 20.0 | 15.0 | 12.5 | | | 1.0 | |
| DPL | 5.0 | 10.0 | | | 10.0 | | | | |

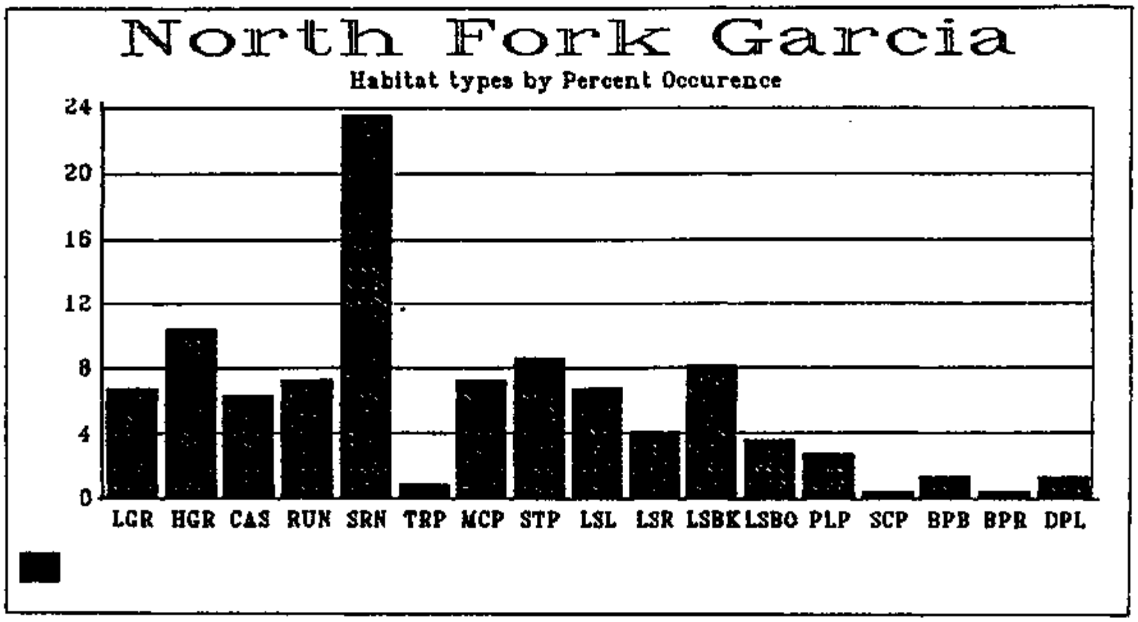
Table 7.

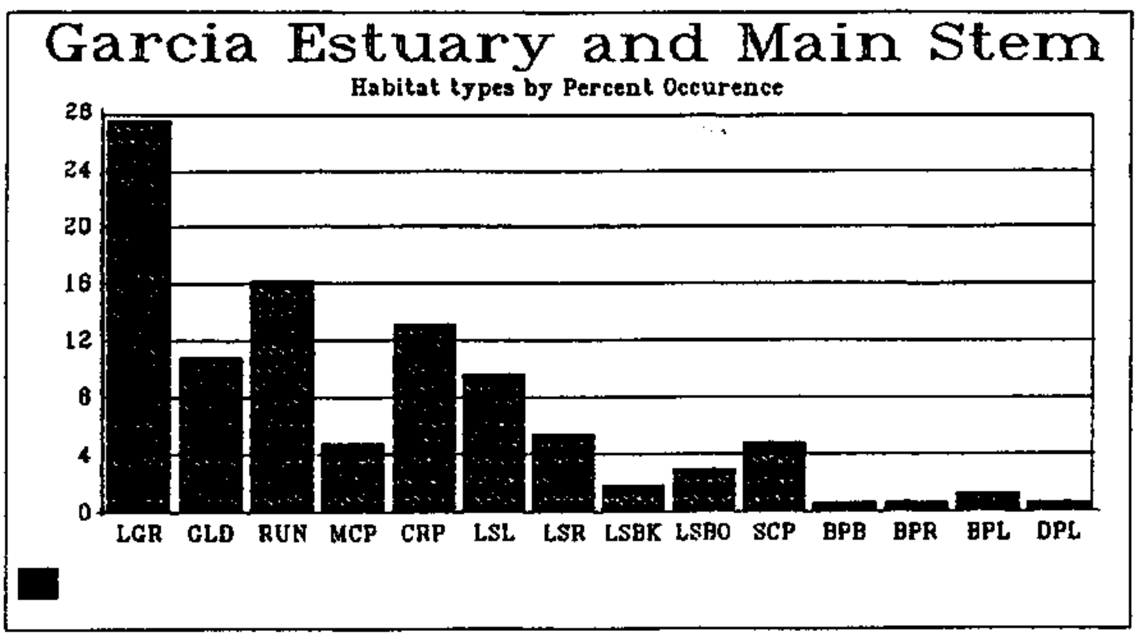
North Fork Garcia
12/09/91 Summary of Biological Inventory

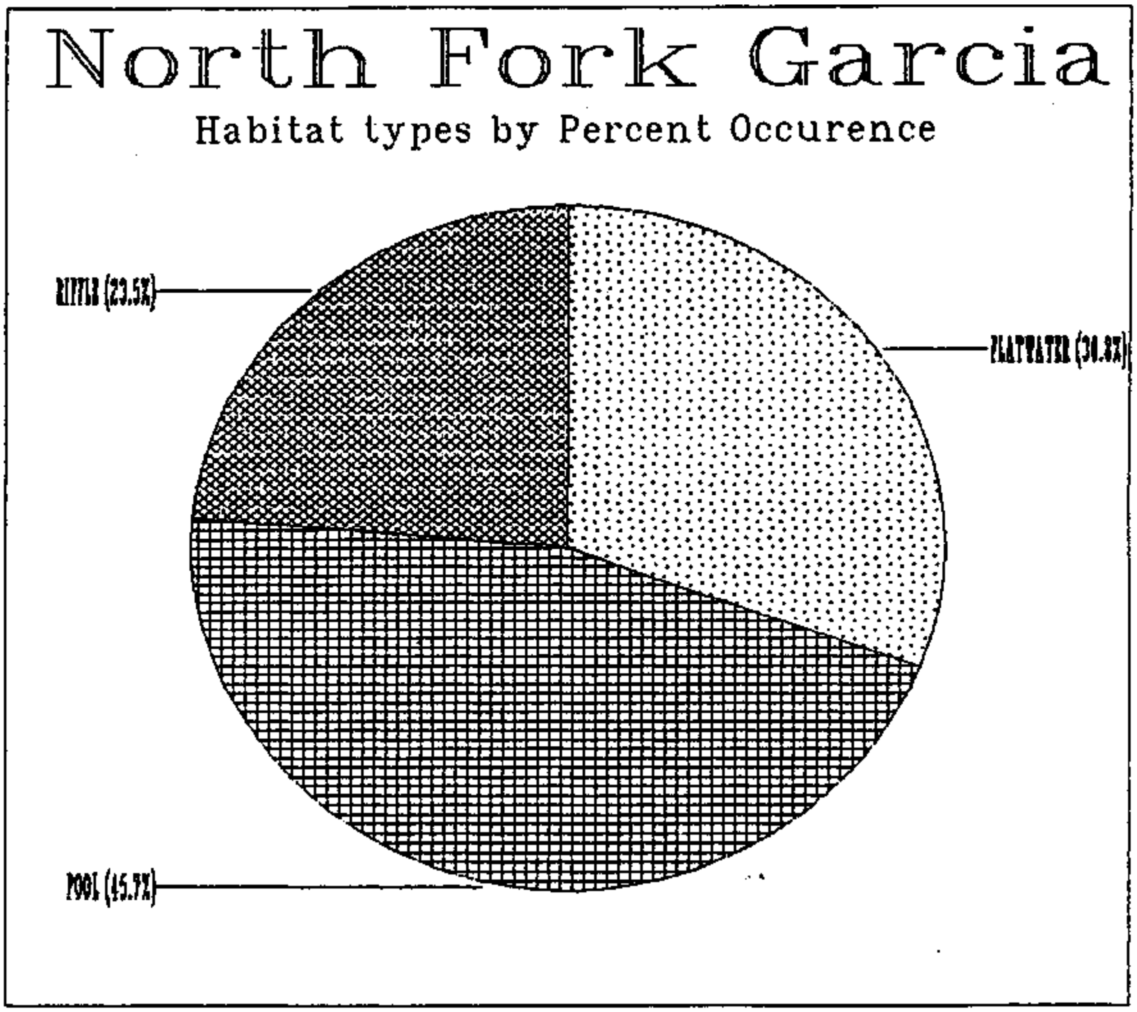
| # | Hab. Type Code | Mean Length | Mean Width | Mean Depth | Mean Max Depth | Mean Area | Total Area | Mean % Canopy | Mean 0+ SH | Total 0+ SH | Mean 1+ SH | Total 1+ SH | Mean 2+ SH | Total 2+ SH | Mean 0+ Density SH | Mean 1+ Density SH | Mean 2+ Density SH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LGR | 45.0 | 20.0 | .4 | .9 | 812 | 2436 | 16.7 | 32.7 | 98 | 3.3 | 10 | | | .04315 | .00445 | 0.00000 |
| 7 | HGR | 50.4 | 16.1 | .5 | 1.2 | 801 | 5608 | 64.3 | 20.0 | 140 | 1.3 | 9 | | | .01852 | .00140 | 0.00000 |
| 1 | CAS | 16.0 | 17.0 | .6 | 1.2 | 272 | 272 | 90.0 | 3.0 | 3 | 0.0 | 0 | | | .01103 | 0.00000 | 0.00000 |
| 3 | RUN | 74,7 | 17.7 | .6 | 1.2 | 1323 | 3970 | 55.0 | 66.3 | 199 | 3.3 | 10 | | | .06797 | .00303 | 0.00000 |
| 4 | SRN | 123.3 | 15.3 | .7 | 1.6 | 1828 | 7310 | 67.5 | 50.0 | 200 | 8.0 | 32 | 1.0 | 1 | .02336 | .00426 | .00019 |
| 1 | TRP | 41.0 | 16.0 | .8 | 1.3 | 656 | 656 | 40.0 | 34.0 | 34 | 3.0 | 3 | | | .05133 | .00457 | 0.00000 |
| 1 | MCP | 57.0 | 16.0 | .9 | .2 | 912 | 912 | 70.0 | 59.0 | 59 | 6.0 | 6 | | | .06469 | .00658 | 0.00000 |
| 4 | STP | 54.3 | 15.9 | .8 | 9 | 956 | 3422 | 62.5 | 35.5 | 142 | 2.8 | 11 | | | .03847 | .00310 | 0.00000 |
| 2 | LSL | 56.0 | 16.5 | .0 | 2.3 | 942 | 1883 | 65.0 | 38.0 | 76 | 5.0 | 10 | 1.0 | 1 | .05197 | .00667 | .00073 |
| 1 | L3R | 71.0 | 12.0 | .8 | .4 | 852 | 852 | 40.0 | 55.0 | 55 | 8.0 | 8 | | | .06455 | .00939 | 0.00000 |
| 4 | LSBK | 50.3 | 15.3 | .4 | .0 | 761 | 3042 | 70.0 | 20.8 | 83 | 3.5 | 14 | | | .02574 | .00462 | 0.00000 |
| 2 | LSBC | 44.0 | 20.5 | .6 | .8 | 909 | 1817 | 25.0 | 55.0 | 110 | 4.5 | 9 | 3.0 | 3 | .05658 | .00454 | .00123 |
| 1 | BPB | 20.0 | 20.0 | .0 | .4 | 400 | 400 | 90.0 | 14.0 | 14 | 2.0 | 2 | | | .03500 | .00500 | 0.00000 |
| 1 | DPL | 36.0 | 19.0 | .0 | 2.4 | 684 | 684 | 70.0 | 34.0 | 34 | 3.0 | 3 | | | .04971 | .00439 | 0.00000 |

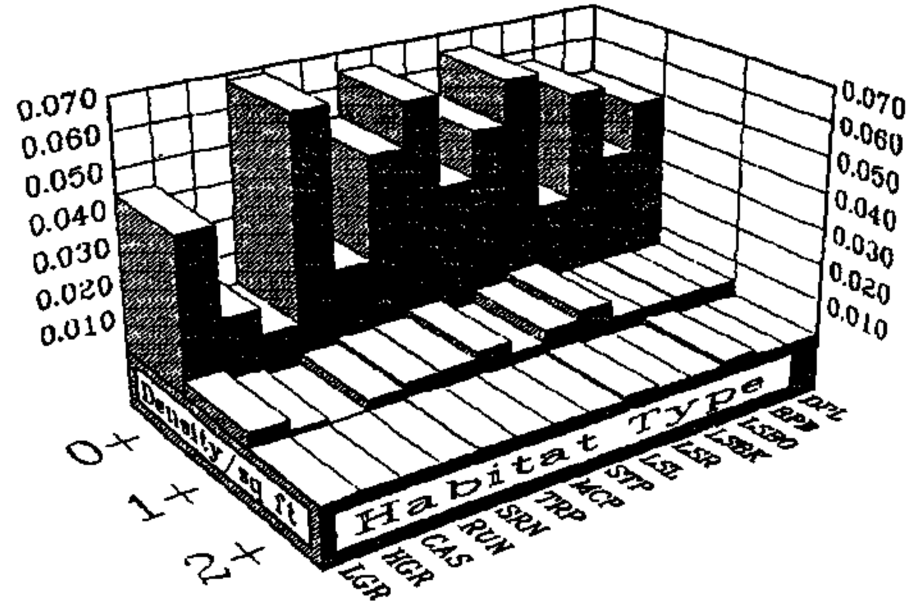
Garcia Estuary and Main Stem
12/10/91 Summary of Biological Inventory

| # | Hab. Type Code | Mean Length | Mean Width | Mean Depth | Mean Max Depth | Mean Area | Total Area | Mean % Canc | Mean 0+ SH | Total 0+ SH | Mean 1+ SH | Total 1+ SH | Mean 2+ SH | Total 2+ SH | Mean 0+ Density SH | Mean 1+ Density SH | Mean 2+ Density SH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | LGR | 157 | 34 | .5 | 1.2 | 5586 | 72619 | 7 | 26.1 | 339 | 19.0 | 247 | 1.3 | 17 | .00536 | .00382 | .00042 |
| 3 | GLD | 679 | 68 | .8 | 2.1 | 39011 | 117034 | 18 | 32.3 | 97 | 43.0 | 129 | 0.0 | 0 | .00085 | .00108 | 0.00000 |
| 7 | RUN | 375 | 33 | 1.8 | 2.2 | 15512 | 108581 | 16 | 34.6 | 242 | 13.9 | 97 | 4.1 | 29 | .00457 | .00126 | .00052 |
| 3 | MCP | 304 | 56 | 3.6 | 5.3 | 16313 | 48938 | 40 | 23.3 | 70 | 42.0 | 126 | 11.7 | 35 | .00115 | .00201 | .00062 |
| H | CRP | 374 | 38 | 2.8 | 5.4 | 15043 | 165468 | 25 | 133.7 | 1471 | 195.3 | 2148 | 35.1 | 386 | .01346 | .01806 | .00351 |
| 9 | LSL | 338 | 40 | 2.1 | 3.1 | 16063 | 144568 | 22 | 141.7 | 1275 | 164.2 | 1478 | 15.3 | 138 | .14011 | .09108 | .01092 |
| 2 | LSR | 122 | 33 | 2.2 | 16.2 | 4595 | 9189 | 30 | 52.5 | 105 | 50.0 | 100 | 31.0 | 62 | .01089 | .00985 | .00840 |
| 1 | LSBK | 424 | 39 | 2.2 | 3.9 | 16536 | 16536 | 20 | 0.0 | 0 | 2.0 | 2 | 0.0 | 0 | 0.00000 | .00012 | 0.00000 |
| 2 | LSBO | 190 | 45 | 1.5 | 3.5 | 9045 | 18090 | 30 | 15.0 | 30 | 13.5 | 27 | 2.5 | 5 | .00316 | .00271 | .00053 |
| 1 | SCP | 150 | 21 | .8 | 2.6 | 3150 | 3150 | 70 | 0.0 | 0 | 2.0 | 2 | 7.0 | 7 | 0.00000 | .00063 | .00222 |
| 1 | DPL | 174 | 43 | 1.3 | 2.1 | 8352 | 8352 | 15 | 265.0 | 265 | 180.0 | 180 | 27.0 | 27 | .03173 | .02155 | .00323 |


North Fork Garcia
Habitat types by Percent Occurence
24
20
16
12
8
4
0
LGR HGR CAS RUN SRN TRP MCP STP LSL LSR LSBK LSBO PLP SCP BPB BPR DPL


Garcia Estuary and Main Stem
Habitat types by Percent Occurence
28
24
20
16
12
8
4
0
LGR GLD RUN MCP CRP LSL LSR LSBK LSBO SCP BPB BPR BPL DPL

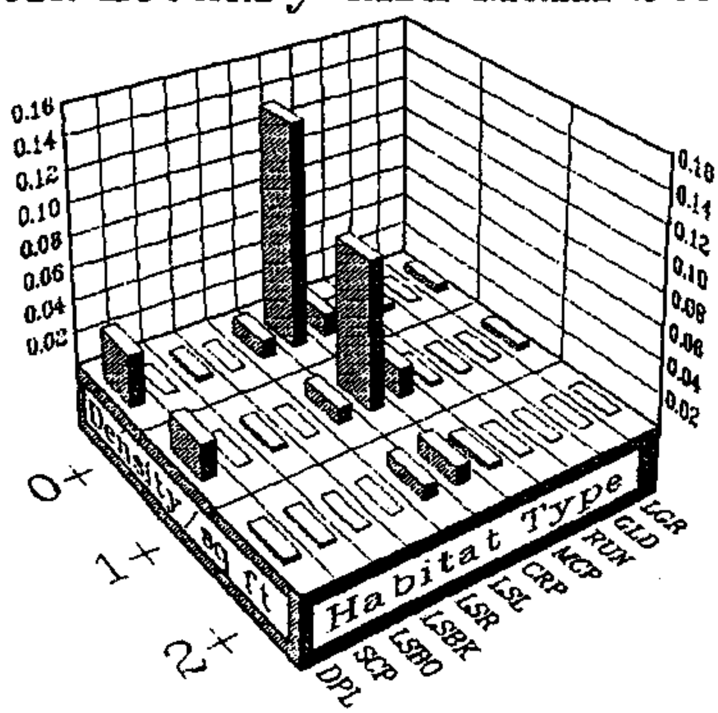

North Fork Garcia
Habitat types by Percent Occurence
RIFFLE (23.5%)
FLATWATER (30.8%)
POOL (45.7%)




**North Fork Garcia**

**Steelhead densities per Habitat types**

## Garcia Estuary and Main Stem




Steelhead densities per Habitat types

# Appendix III

# Information and Diagrams Pertaining to Recommendations

# III-1: Large Debris Revetment Diagrams (Rosgen)

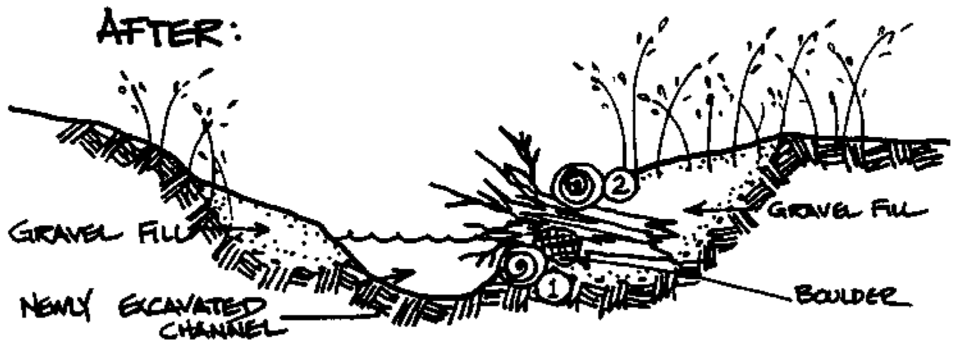
## LARGE DEBRIS REVETMENT:
### FOR BANK STABILIZATION & FISH HABITAT

(ROSGEN, 1991)

CROSS-SECTION:

BEFORE:


AFTER:




NOTE: 1) WILLOWS PLANTED IN FILLED & PROTECTED AREA AT TIME OF WORK.

2) ROOT WAD PLACED TO BE PARTLY UNDERWATER AT LOW FLOW.

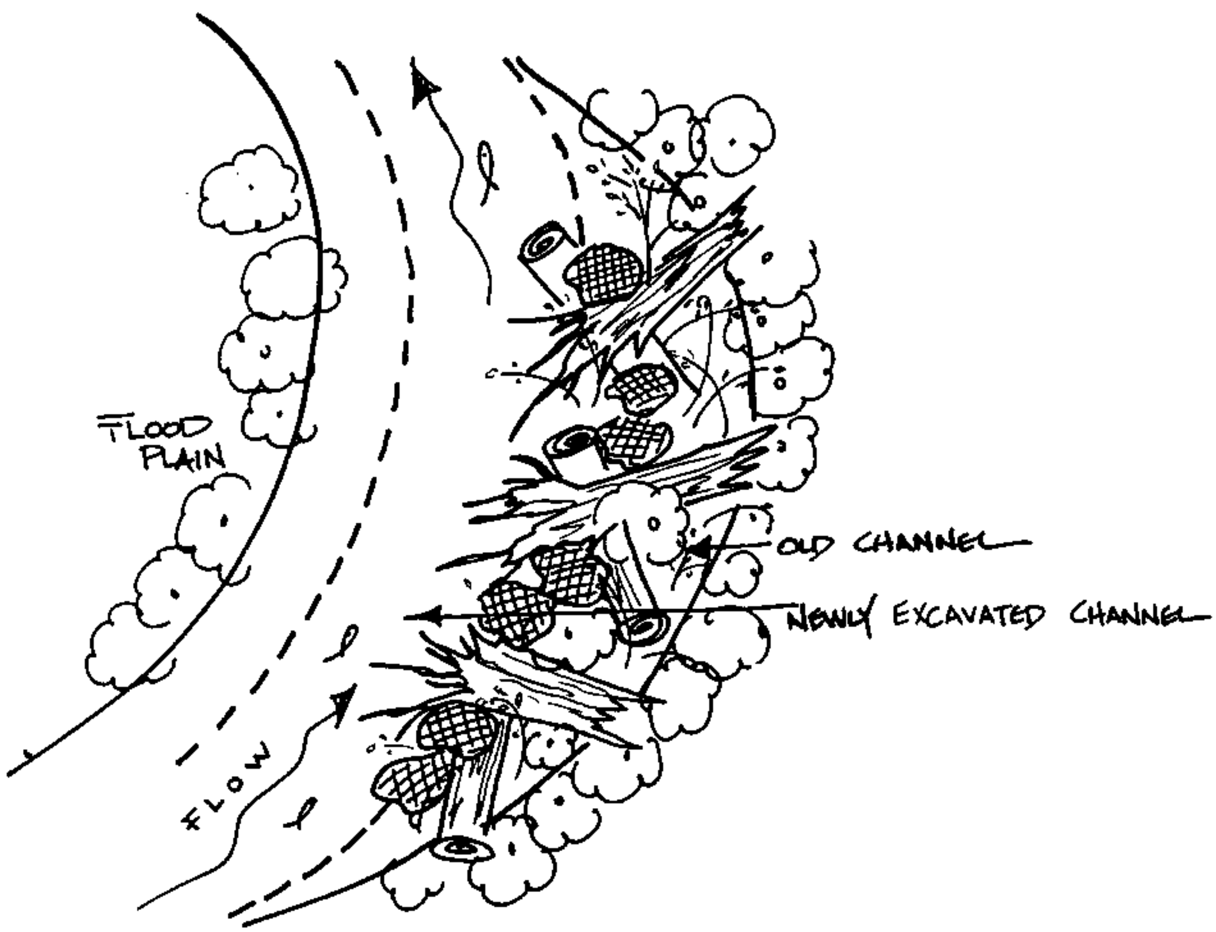
3) NOTE PLACEMENT OF FOOTER LOG ① & HIGH STAGE DEFLECTOR LOG ②.

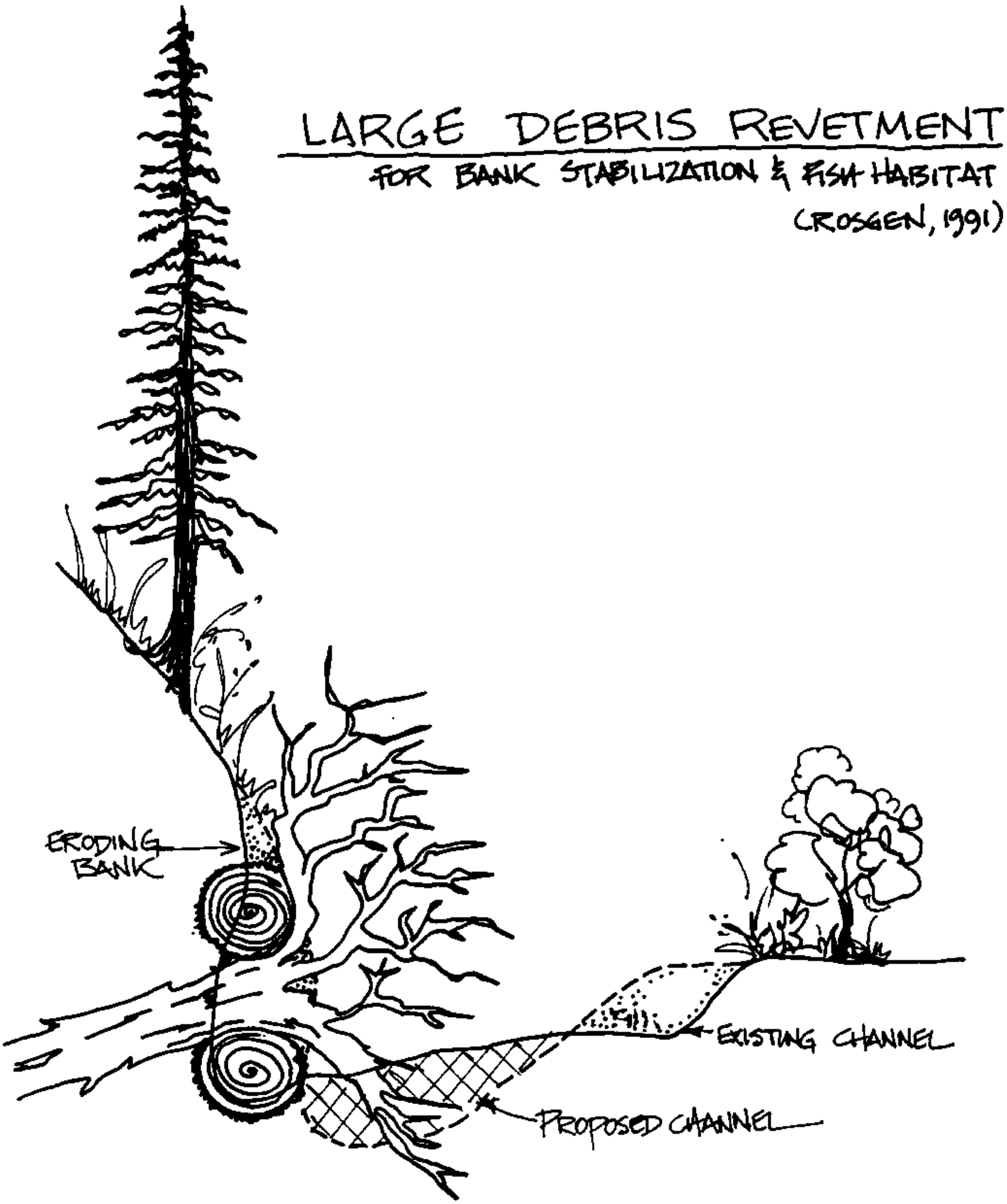
4) NOTE BOULDER PLACEMENT TO KEY STRUCTURE TOGETHER.

# LARGE DEBRIS REVETMENT

FOR BANK STABILIZATION & FISH HABITAT
(ROSGEN, 1991)

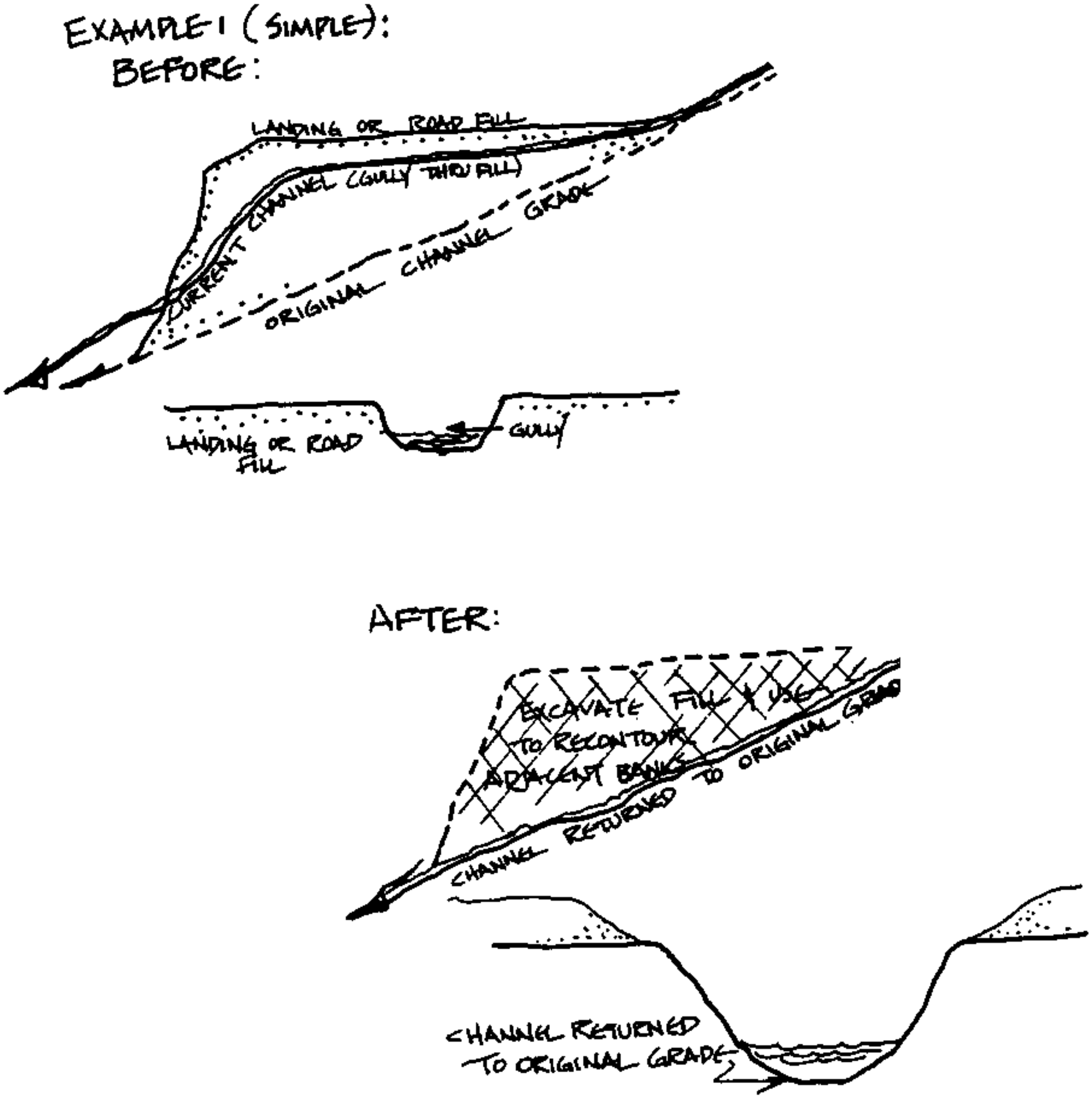
PLAN VIEW:




LARGE DEBRIS REVETMENT
FOR BANK STABILIZATION & FISH HABITAT
(ROSGEN, 1991)
ERODING BANK
EXISTING CHANNEL
PROPOSED CHANNEL

# III-2: Diagram 3.3 (acc. Recommendation 3.3) — Recontouring

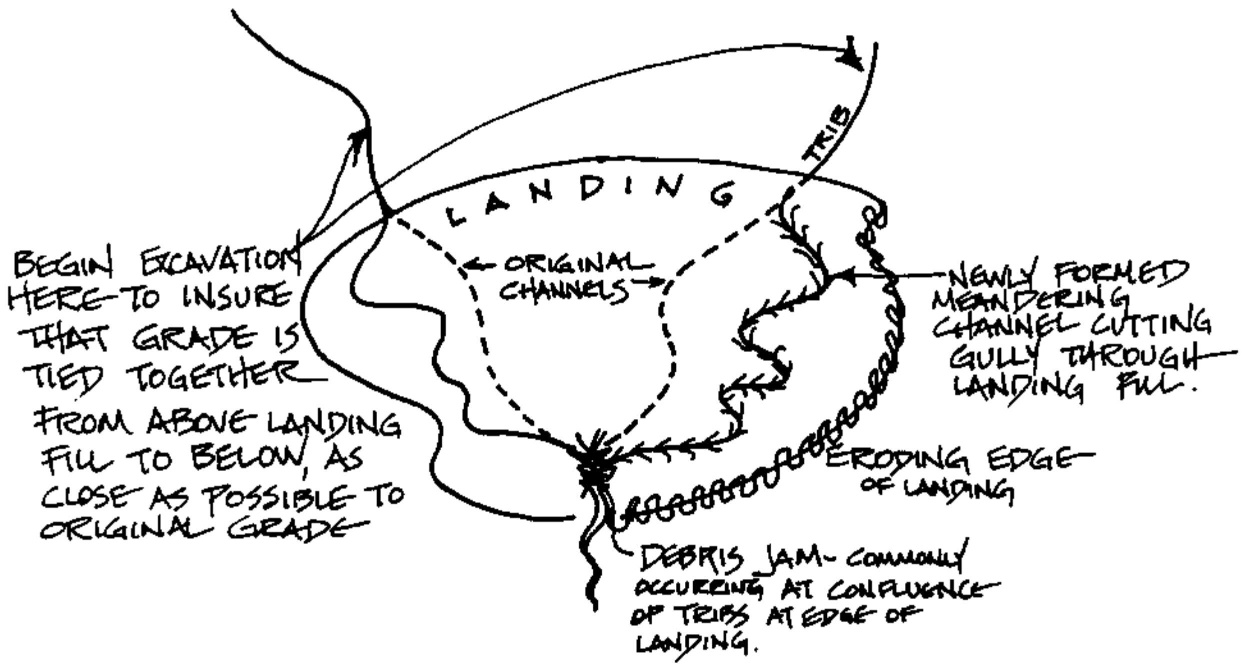
DIAGRAM 3.3
RECONTOURING CROSSINGS & LANDINGS



# DIAGRAM 3.3 (con't.)

## RECONTOURING CROSSINGS & LANDINGS

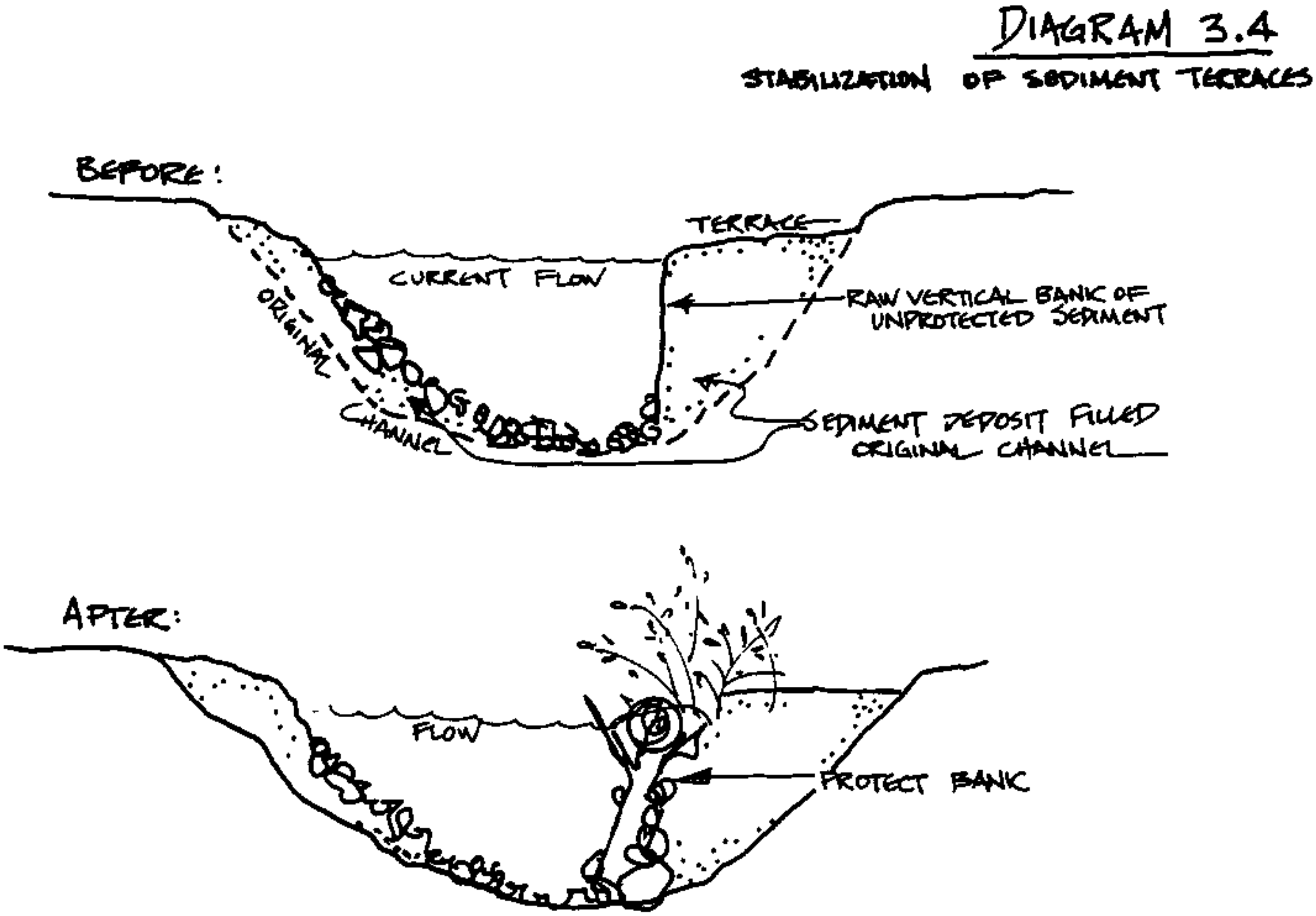
EXAMPLE 2 (COMPLICATED):




USE EXCAVATED MATERIAL TO RE-CONTOUR (RE-LANDSCAPE) LANDING SITE WITH OBJECTIVE OF RETURNING TO ORIGINAL GRADE & CONTOURS WHERE POSSIBLE.

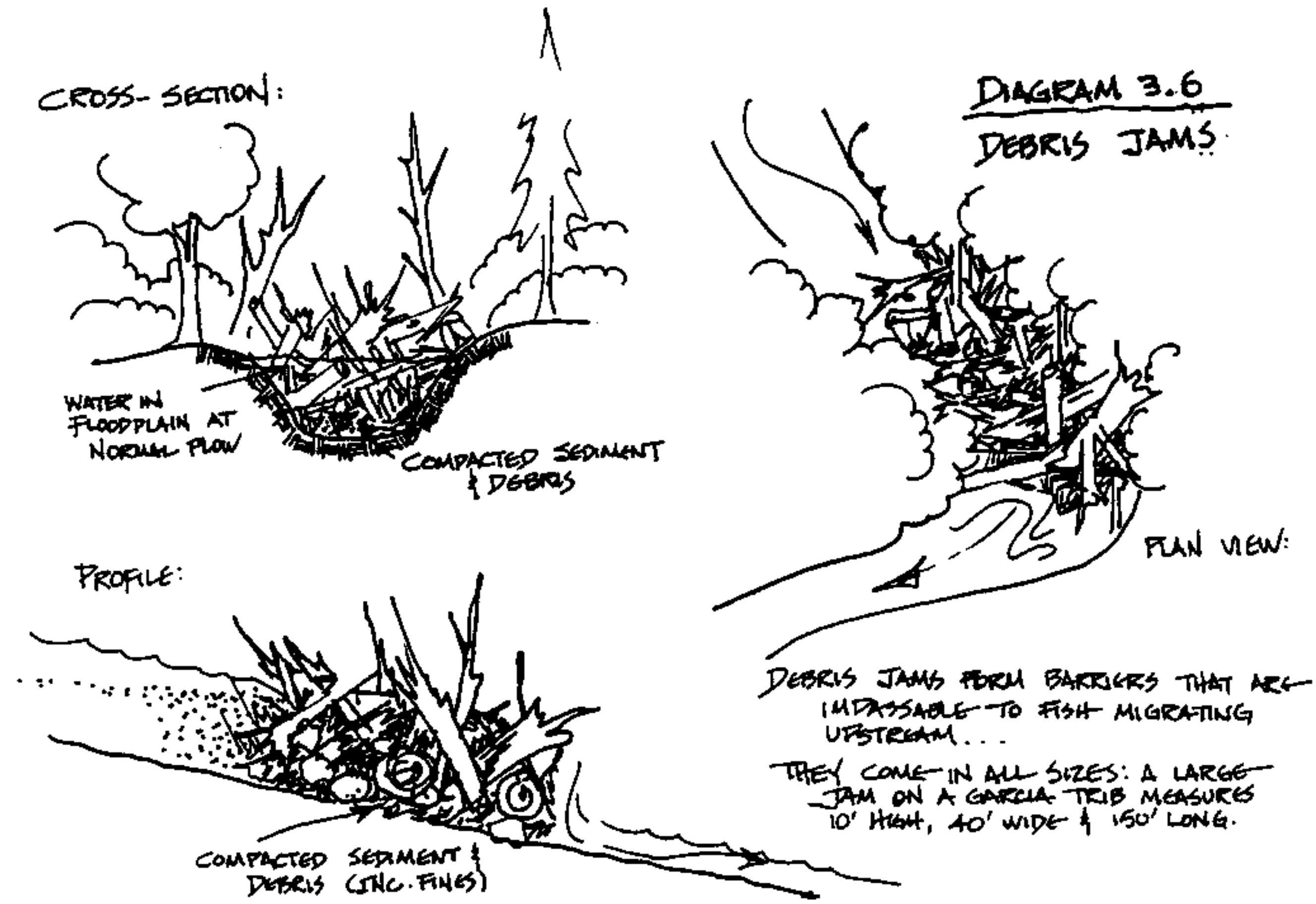
NOTE: ON SMALLEST CLASS III WATERCOURSES, THE SIMPLEST EXCAVATION AND RECONTOURING, FOLLOWED BY STRAWING, SEEDING & PLANTING CAN BE SUCCESSFUL. ON LARGER CLASS I's & II's WHERE FLOW HAS MORE ENERGY, INCREASED GRADIENT CONTROL & BANK PROTECTION MEASURES MUST BE IMPLEMENTED TO MINIMIZE FURTHER SEDIMENTATON & NEGATIVE IMPACTS.

# III-3: Diagram 3.4 (acc. Recommendation 3.4) — Stabilization of Sediment Terraces




NOTE: THIS RECOMMENDATION APPLIES TO SMALLER UPSLOPE TRIBS, WHERE VOLUME OF FLOW AND GRADIENT ARE RELATIVELY LOW & SURFACE REVETMENT IS ADEQUATE. EXACT TREATMENT IS ALWAYS SITE-SPECIFIC. BOTH ROCK & WOODY DEBRIS FOUND ON SITE CAN BE USED TO PROTECT BANKS. RECOMMENDED PLANTINGS / TRANSPLANTINGS INCLUDE BERRIES, JUNCUS, WILLOW, ALDER, CONIFERS, DEPENDING ON AVAILABILITY AND NATIVE SPECIES.

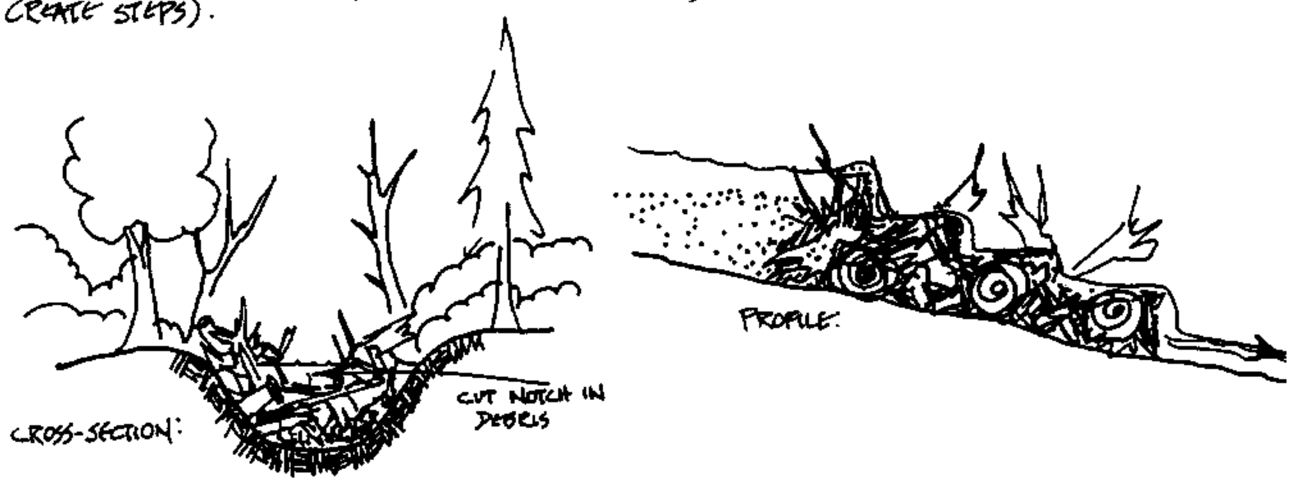
# III-4: Diagram 3.6 (acc. Recommendation 3.6) — Debris Jams




TWO OPTIONS FOR TREATMENT:

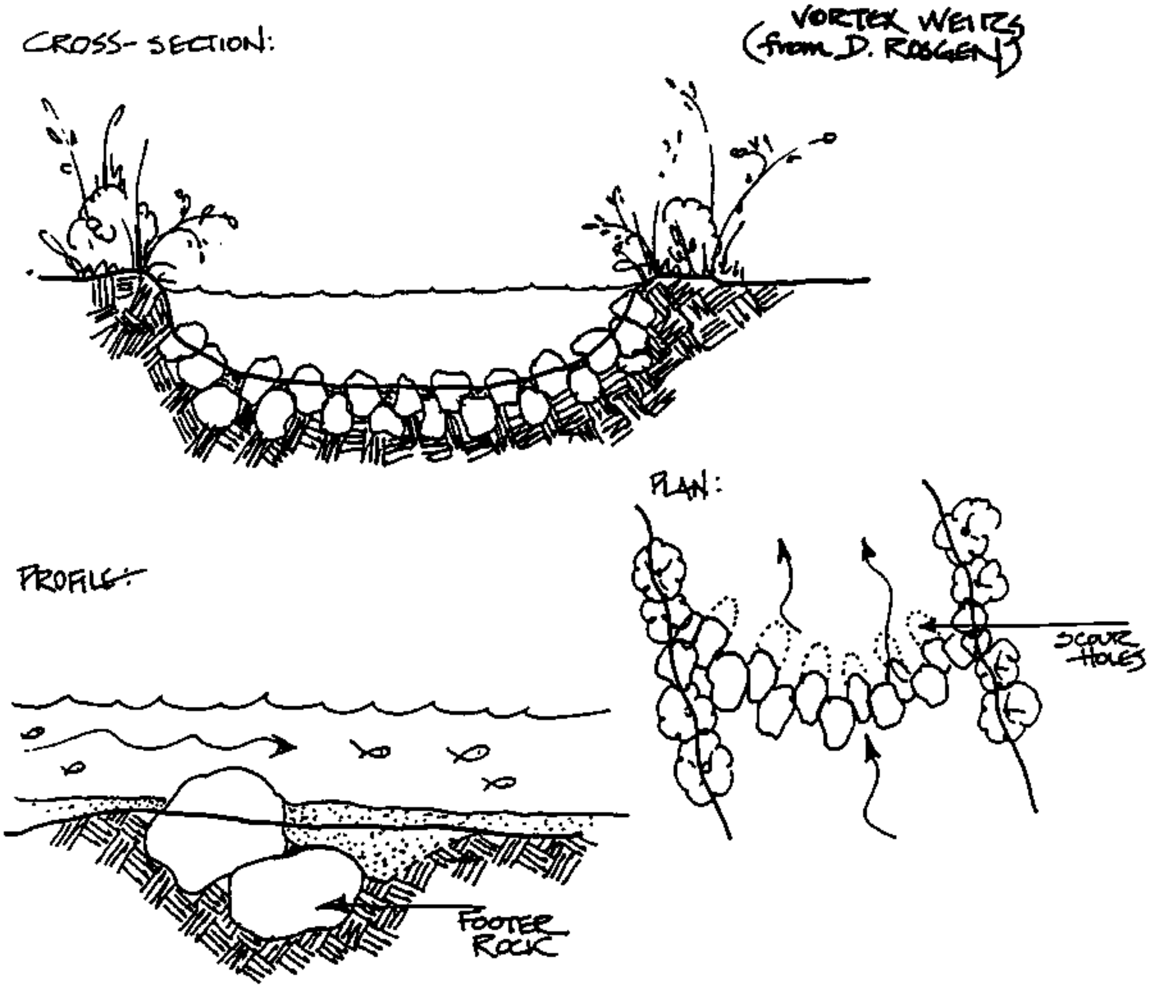
1) WHERE ACCESSIBLE TO HEAVY EQUIPMENT, REMOVE ALL DEBRIS & EXCAVATE SEDIMENT BUILD-UP BEHIND JAM TO GREATEST POSSIBLE DEGREE. RECONTOUR ADJACENT BANKS & CHANNEL USING GRADE CONTROL & BANK PROTECTION STRUCTURES (VORTEX WEIRS, RIP RAP, LOG SILLS, ETC.) TO MINIMALLY IMPACT CHANNEL DOWNSTREAM. USE SOUND REDWOOD REMOVED FROM JAM FOR STRUCTURES.

2) WHERE INACCESSIBLE TO HEAVY EQUIPMENT OR WHERE DESIREABLE, DO NOT REMOVE DEBRIS, BUT RATHER STEP DOWN FLOW BY CUTTING NOTCHES IN DEBRIS (OR REMOVING PARTS OF DEBRIS TO CREATE STEPS).



# III-5: Diagram 3.8 (acc. Recommendation 3.8) - Vortex Wiers

DIAGRAM 3.8




THE OBJECTIVE OF THIS STRUCTURE IS TO:

1) PROVIDE INSTREAM COVER IN THE RIFFLE REACH.

2) DEEPEN FEEDING AREAS IN THE RIFFLE REACH.

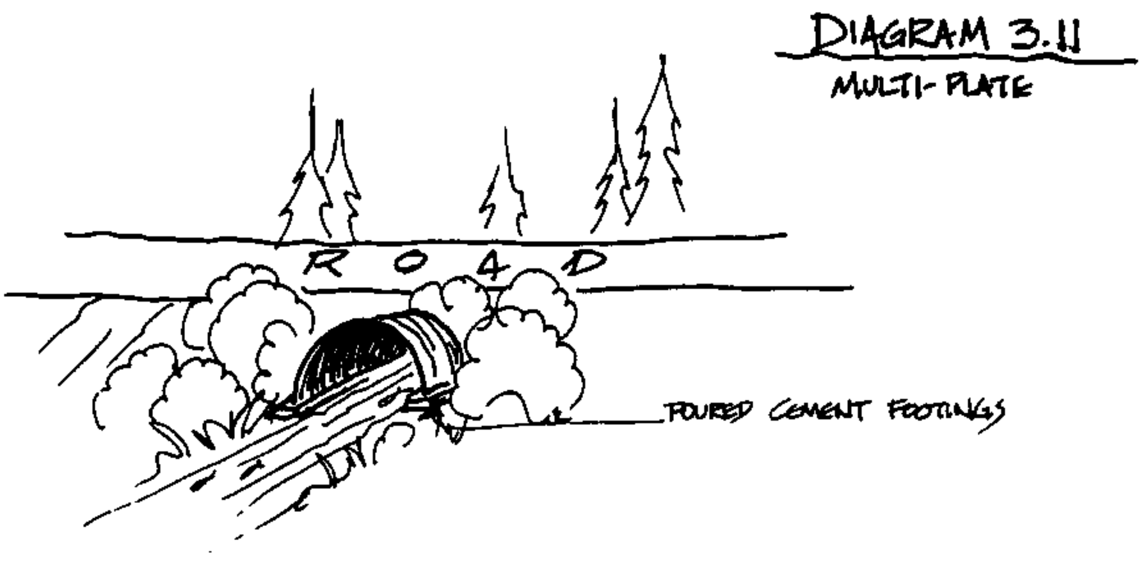
3) PROVIDE WIDER RANGE OF VELOCITIES FOR HOLDING WATER AT HIGH FLOW WITHOUT CREATING BACKWATER & SEDIMENT DEPOSITION.

4) ACT AS GRADE CONTROL STRUCTURE WITHOUT UPSTREAM LATERAL MIGRATION, BANK EROSION, & AGGRADATION.

5) MAINTAIN LOW WIDTH/DEPTH RATIO WHICH WILL REDUCE THE LIKELIHOOD OF BAR DEPOSITION & MAINTAIN SEDIMENT TRANSPORT CAPACITY OF THE STREAM.

SOURCE: <u>SHORT COURSE ON STREAM CLASSIFICATIONS & APPLICATIONS</u>, 1991, by D.L. ROSGEN

# III-6: Diagram 3.11 (acc. Recommendation 3.11) - Multi-Plates



# Appendix IV

# General Cost Estimates and Funding Possibilities

# IV-1: General Cost Estimates

APPENDIX IV-1
COST ESTIMATES

The following cost estimates are to be used as guides for prioritizing the recommendations am for developing a basic understanding of relative costs.

Estimates for some recommendations are given in unit terms, i.e., cost per foot or cost per cubic yard, while other costs can only be estimated for the job.

The estimates are for cost of construction and do not include the cost of preparing final detailed plans or the cost of obtaining permits.

At this stage of the planning process even unit prices cannot be exact due to unknown variable such as cost of access development and cost of materials.

| Recommendation | Cost Estimate Description |
|---|---|
| | **AREA 1: THE ESTUARY** |
| Rec. 1.1 A | $25-$70/lineal foot (channel realignment and bank protection) |
| Rec. 1.1B | $100+/lineal foot (channel realignment and bank protection) |
| Rec. 1.2 | Specific plans are required to make cost estimate |
| Rec. 1.3 | $50-$75/lineal foot (bank protection) |
| Rec. 1.4 | $300-$2000 for each structure (debris cover for fish) |
| Rec. 1.5 | Needs further study |
| | **AREA 2: THE LOWER 7 MILES** |
| Rec. 2.1 | $100-$5000+ for each fish habitat structure |
| Rec. 2.2 | $0.50-$2.50/tree for site prep, planting, and browse protection (riparian planting) |
| Rec. 2.3 | $50042000 for each site (remove and transplant willows) |
| Rec. 2.4 | N/A |
| Rec. 2.5 | N/A |
| | **AREA 3: THE UPPER TRIBUTARIES** |
| Rec. 3.1 | $25-$50/lineal foot using large woody debris and transplants |
| Rec. 3.2 | N/A |
| Rec. 3.3 | $200415,000+ for each job (recontour old instream landings and crossings) |

| | |
|---|---|
| Rec. 3.4 | \$1.00-\$10.00/lineal foot (stabilize instream sediment terraces) |
| Rec. 3.5 | \$0.50-\$3.00/lineal foot (excavate well defined channel) |
| Rec. 3.6 | \$500-\$15,000+ for each job (stabilize stored sediment behind log jams) |
| Rec. 3.7 | \$100-\$5000+ for each fish habitat structure |
| Rec. 3.8 | \$0.50-\$3.00/lineal foot (remove cemented cobble and define channel) |
| Rec. 3.9 | No estimate |
| Rec. 3.10 | \$0.50-\$2.50/tree for site prep, planting, and browse protection (riparian planting) |
| Rec. 3.11 | \$500-\$15,000+/crossing (replace or modify culverts that are fish migration barriers) |
| Rec. 3.12 | No estimate |

# IV-2: Possible Funding Sources

POTENTIAL FUNDING SOURCES/APPENDIX

| GRANT NAME | $ AMOUNT | DATE PROPOSAL DUE |
|---|---|---|
| 319h - State Water Resources Control Board | $40-100,000 | Dec. 21 |
| Forest Stewardship Program CDF&FP | $15,000 | May 4 |
| Fish & Game Salmon Restoration Fund | $20-100,000 | April 3 |
| * Wildlife Conservation Board | | OPEN |
| * Prop. 70 | | quarterly |
| * Salmon Stamp | | |
| Coastal Conservancy | $100,000- | OPEN |
| | $1,000,000 | quarterly |
| U.S. Fish 7 Wildlife Service Habitat Restoration (Wetland or Salmon) | $30,000 | Dec. 31 |
| Near Coastal Waters (EPA) | | March 13 |
| Urban Streams - DWR | $30,000 | |
| Resource Cons. Fund - CARCD | $1,000 | |
| Sustainable Agricultural Projects | Variable | |
| Integrated Hardwood/Research Proposals | | Variable |

COST SHARE PROGRAMS

| | | |
|---|---|---|
| Agricultural Conservation Program (ACP) - ASCS | $3,500/yr | OPEN |
| Forest Improvement Program ASCS | $10,000/yr | |
| CFIP - CA Forest Improvement Program - CDF | | OPEN |
| Stewardship Incentives Program | $10,000/yr | |

# Appendix V

# Recommended Guidelines and Information for Future Action

# V-I: Outline of Tasks Recommended for a Comprehensive Gravel Management Plan for the Garcia River

I. Identify current status

A. Establish base map

1. Obtain mylars of aerial photos for the lower 13 miles of the river at scale of 1" = 200' if possible, but no smaller than 1" = 500'.
2. Delineate specific features, such as pools, riffles, runs, bars, terraces (active and inactive), riparian vegetation, etc.
3. Locate all data collection sites, i.e., cross section sites, longitudinal profile points, gravel sampling sites, gauging stations, weather stations, biological sampling sites, etc.
4. Locate other pertinent sites, i.e., gravel mining operations (past, active, and proposed), bridges, etc.

B. Establish channel geometry by collecting appropriate data, including but not limited to:

1. Channel cross sections
2. Longitudinal profiles
3. Gravel samples
4. Core samples.

C. Develop accurate monitoring program to identify current replenishment rates. This program should include but not be limited to the following:

1. Cross sections

   a. At sites where past or current gravel operations have occurred or are occurring - above and below active sites as well as on the site.
   b. At sites unimpacted by recent gravel mining.
   c. Cross sections at active mining operations should be taken each spring or early summer before extraction and in the fall after extraction. All other cross sections should be taken during the summer.

2. Gravel sampling - should be done in spring before extraction at active gravel sites, and any time during summer at all other sites.

D. Establish current biological status of river, including but not limited to:

1. Fish populations
2. Other wildlife populations
3. Habitat typing
4. Condition of riparian vegetation
5. Stream substrate analysis
6. Status of estuary

E. Study current river flow
  1. Reestablish gauging station
  2. Establish stage recoring at each extraction site
  3. Establish precipitation stations

II. Study historical status
  A. Interpret historical aerial photos, maps and cross sections
  B. Study other historical records (books, interviews, etc.)
  C. Review precipitation records
  D. Review gauging records
  E. Attempt to establish historical replenishment rates

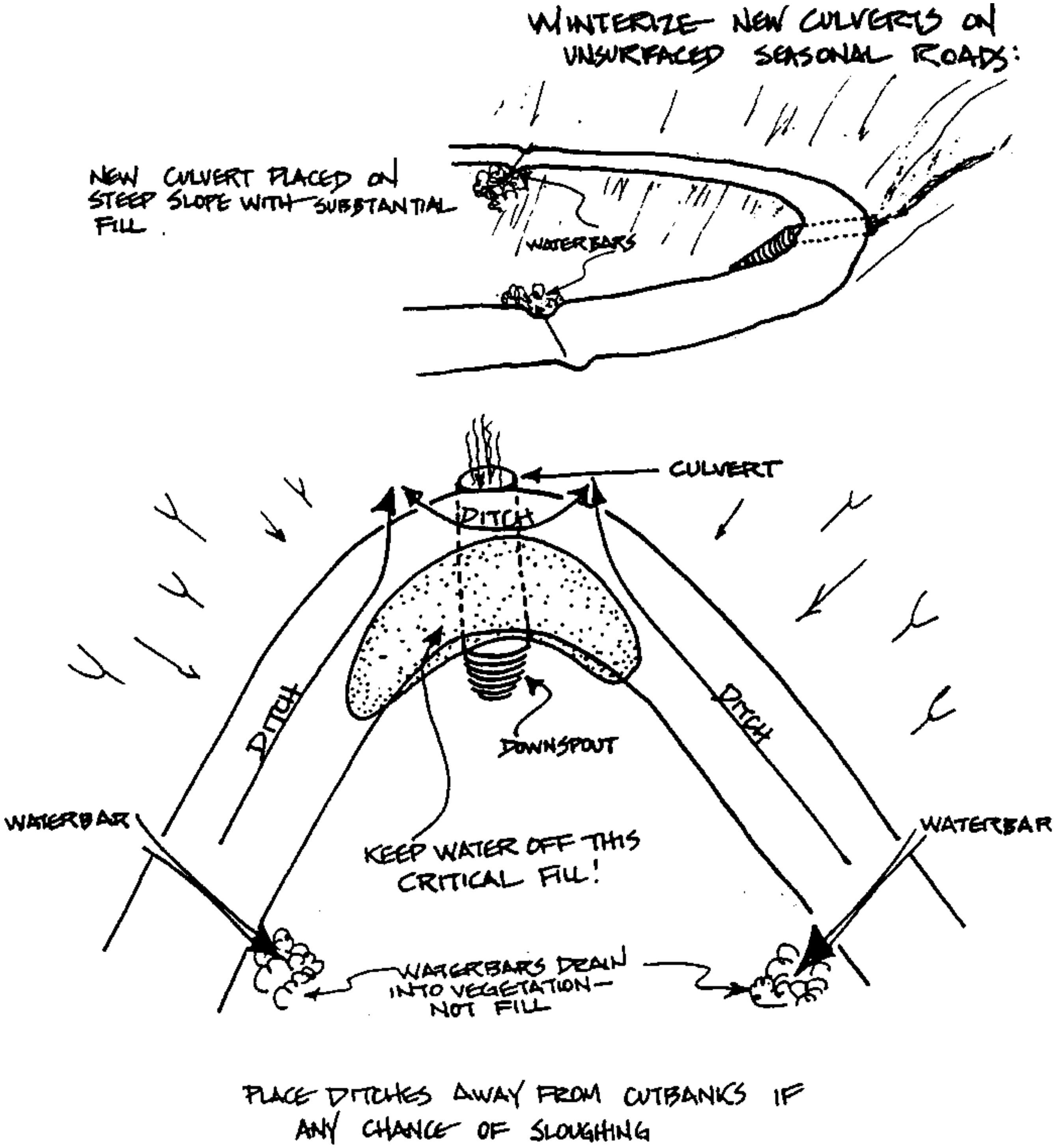
III. Develop gravel management goals and objectives based on:
  A. Analysis of current status
  B. Comparison of historical status and current status
  C. Social, political and economic considerations

IV. Establish permit process
  A. Lead agency must be able to:
    1. Define necessary monitoring
    2. Analyze data from monitoring
    3. Formulate policy from analysis
    4. Enforce policy

  B. Further input and guidelines for lead agency:
    1. 3-year maximum permit (could be reviewed over time)
    2. Permit reviewed annually
    3. Permit fees must cover real costs
    4. Mandatory monitoring at operator's expense should include but not be limited to:
      a. Cross sections in spring and fall to show actual volume removed and replenishment rates.
      b. Flow stage recording
      c. Operator can run his own cross sections if properly trained.

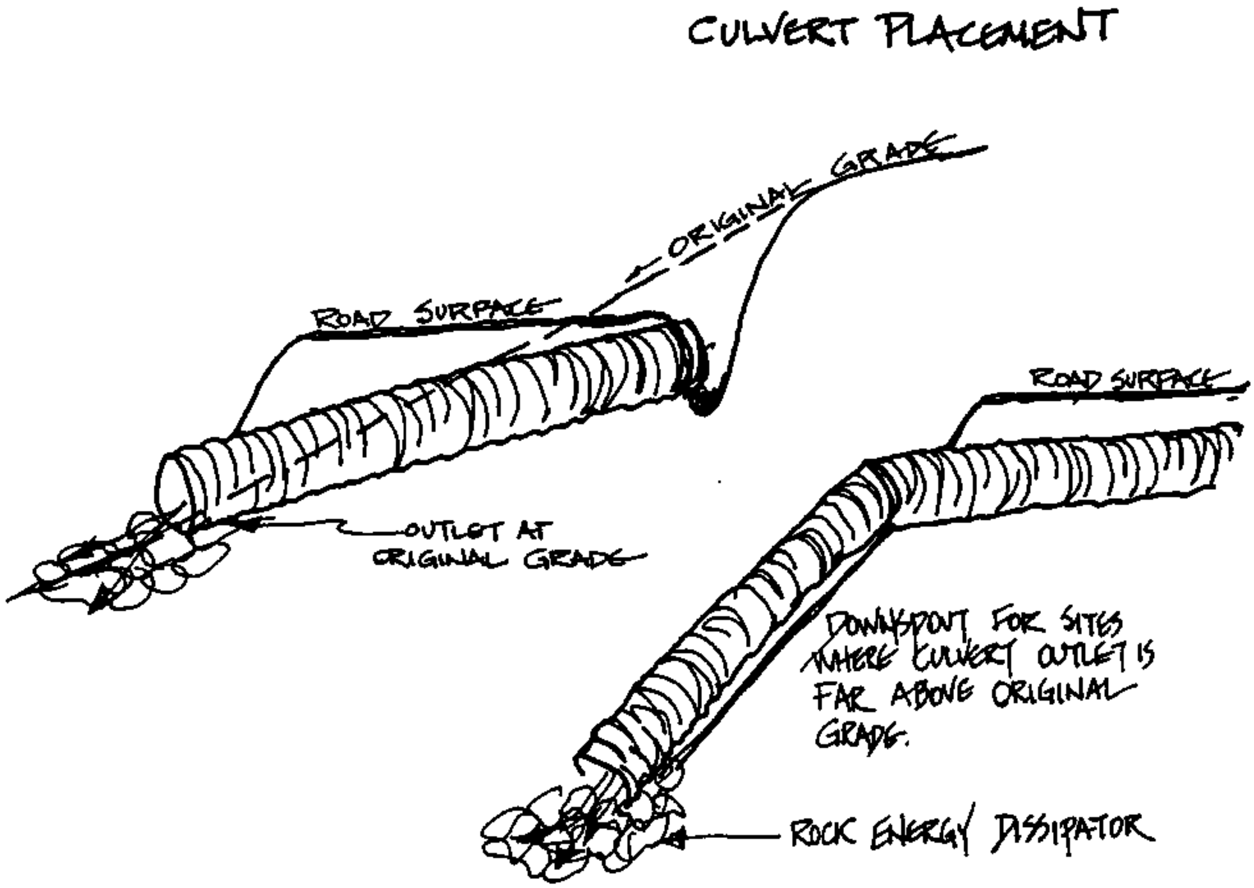
    5. Operator must mitigate to insure no cumulative loss of fish habitat.
    6. Whenever possible, out of stream sources for gravel should be encouraged (i.e., upslope quarries, gravel terraces, etc.).
    7. Experimental or innovative gravel extraction methods (alternatives to skimming) should be permitted if they are carefully reviewed and monitored.
    8. This gravel management plan should be reviewed regularly and changed as real data from monitoring dictates.

* Winterize new culverts on unsurfaced seasonal roads (such as haul and ranch roads) by protecting fill from surface erosion. This can be done by insloping road surface at crossing, or outsloping the road surface using a berm to channel the road surface runoff away from the fill. If there is a chance of bank sloughing, ditching can be done as shown in the diagram below:



Cover culverts at temporary summer crossings of Class I and n streams with clean rock from instream or from upslope quarry. Do not use dirt.

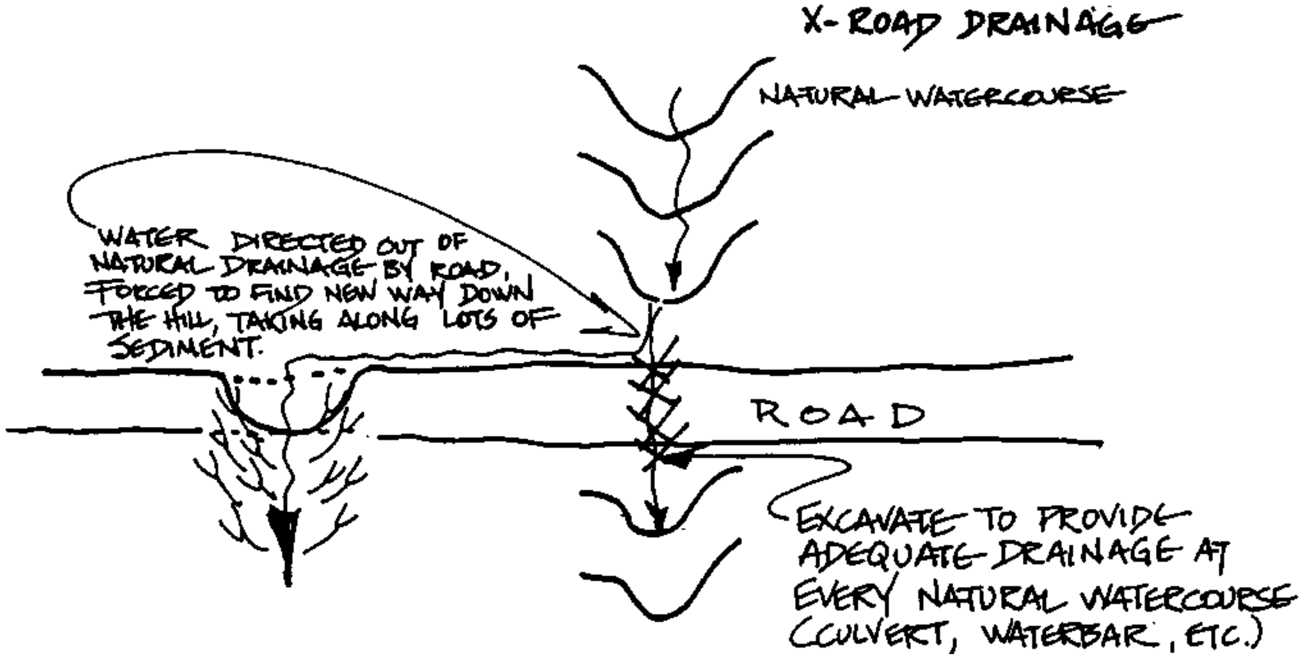
* Place culverts at grade of original drainage where possible. Where this is not possible, provide downspout or enery dissipator to return water from sulvert outlet to drainage at original grade. (See diagram.)



# V-2: Road Construction and Maintenance Guidelines

**SUGGESTED ROAD CONSTRUCTION AND MAINTENANCE GUIDELINES**

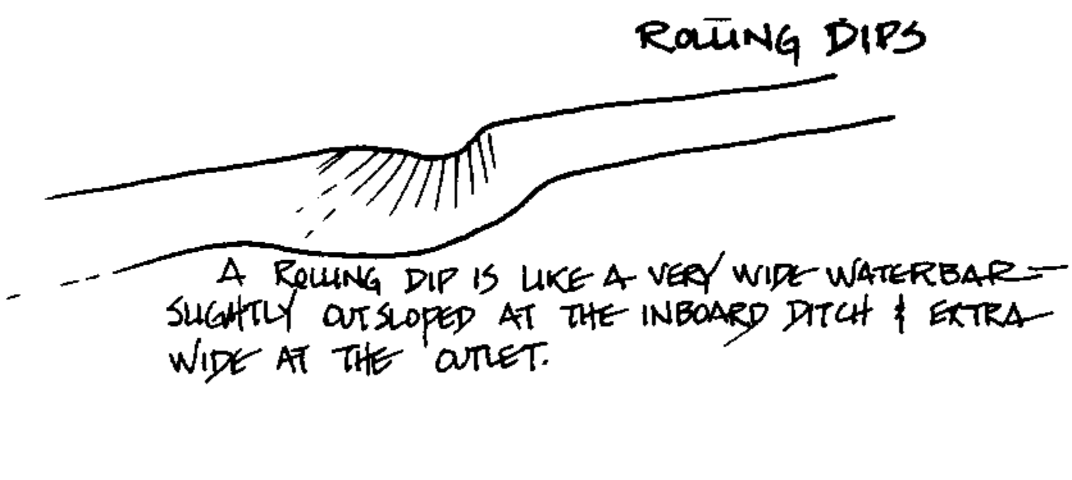
*** Provide cross-road drainage at every natural watercourse. (See diagram.)**



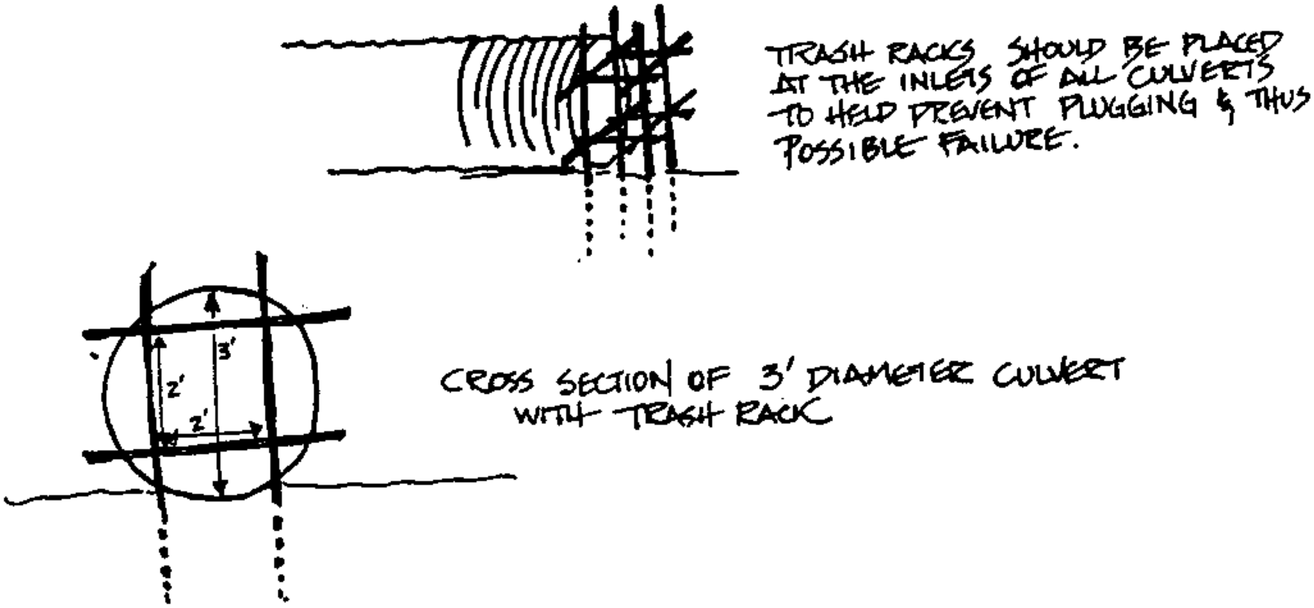

* Construct new roads during dry season, but early enough that soil moisture is still adequate for compaction. Water road for compaction if necessary.

* Build smallest road possible to meet the objective.

* Provide road surface drainage by a combination of the following: outsloping, utilizing
natural variations in grade, and rolling dips. (See diagram.)

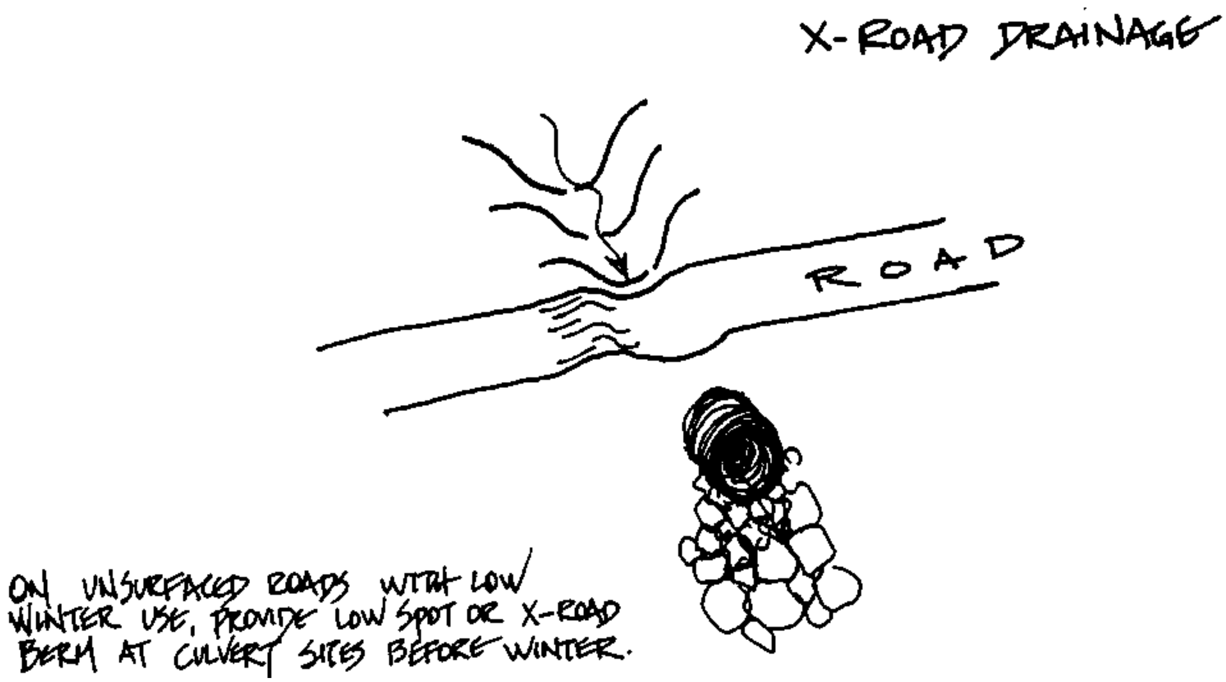


* Place effective trash racks at all culverts. (See diagram.)




* Use culverts ONLY on permanent roads where there is a regular maintenance program.

* On unsurfaced roads where winter use is low, provide low spot or cross-road berm at
every culvert before the onset of winter. (See diagram.)



## V-3: Land Ownership Map