Coastal Watershed Planning Assessment Program

Big River Basin Assessment Implementation Summary

November 2006

State of California

Governor, Arnold Schwarzenegger

California Resources Agency

Secretary, Mike Chrisman

California Environmental Protection Agency

Secretary, Alan Lloyd

Big River Assessment Team

Assessment Manager

Scott Downie — California Department of Fish and Game

Fisheries:

Steve Cannata — California Department of Fish and Game
Beatrijs deWaard — Pacific States Marine Fisheries Commission
Cynthia LeDoux-Bloom — California Department of Fish and Game

Forestry and Land Use:

Rob Rutland — California Department of Forestry and Fire Protection

Water Quality:

Elmer Dudik — North Coast Regional Water Quality Control Board

Geology:

Dale Dell'Osso — Department of Conservation/California Geological Survey

Fluvial Geomorphology:

Dawn McGuire — Department of Conservation/California Geological Survey
Currently Department of Fish and Game

Geographic Information System, Data Management, Ecological Management Decision System (EMDS)

Vikki Avara-Snider – GIS & Document Production — Pacific States Marine Fisheries Commission
Kimberly Pettit — Pacific States Marine Fisheries Commission
Steve Cannata - EMDS — California Department of Fish and Game
Chris Fischer - EMDS — California Department of Forestry and Fire Protection
Kevin Hunting - GIS — California Department of Fish and Game
Chris Keithley - EMDS — California Department of Forestry and Fire Protection
Richard Walker, Ph.D. - EMDS — California Department of Forestry and Fire Protection

Research:

John Richardson — Pacific States Marine Fisheries Commission

ACKNOWLEDGEMENTS

The Big River Assessment Team wishes to thank the following for their shared valuable data, assistance, and time: California State Parks, Mendocino Redwood Company, Hawthorne Timber Company, the California Geological Survey, Graham Matthews and Associates, Doug Albin, Scott Monday, Scott Harris, and Dave Wright. We are also very grateful to the numerous private landowners who granted team members access to collect data.

Suggested Citation:

Downie, S., B. deWaard, E. Dudik,D. McGuire, and R. Rutland. 2005. Big River Basin Assessment Report. North Coast Watershed Assessment Program. California Resources Agency, and California Environmental Protection Agency, Sacramento, California.

Table of Contents

Preface to this Summary **1**
Big River Basin Assessment Report Structure and Usage Guide **1**
California's Large Scale Watershed Assessment Program **2**
General Assessment Approach **3**
Big River Basin Profile **5**
Big River Basin Profile Stream Reach Condition EMDS 5
Big River Basin Profile Summary of Tributary Recommendations 6
Big River Basin Profile Summary of Refugia Areas 6
Big River Basin Tributaries by Refugia Category: 7
Big River Basin Profile: Responses to Assessment Question Six: 10
Coastal Subbasin **12**
Introduction 12
Stream Reach Condition EMDS 14
Analysis of Tributary Recommendations 14
Refugia Areas 16
Coastal Subbasin Profile: Responses to Assessment Question Six: 17
Subbasin Conclusions 17
Middle Subbasin **20**
Stream Reach Condition EMDS 20
Analysis of Tributary Recommendations 22
Refugia Areas 23
Middle Subbasin Profile: Responses to Assessment Question Six: 24
Subbasin Conclusions 25
Inland Subbasin **26**
Introduction 26
Stream Reach Condition EMDS 26
Analysis of Tributary Recommendations 29
Refugia Areas 31
Inland Subbasin Profile: Responses to Assessment Question Six: 33
Subbasin Conclusions 33
Summary of Basin Conditions and Recommendations **36**
Geology 36
Land Use Impacts 36
Water Quality 37
Salmonid Populations 37
Salmonid Habitat 37
Limiting Factors Analysis Conclusions 38
Refugia Rating 38
Recommendations 38
Propensity for Improvement **39**
Advantages 39
Challenges 40
Conclusion **40**
Limitations of this Assessment **41**

Big River Basin Assessment Implementation Summary

Preface to this Summary

This summary is intended to present the 2006 Big River Basin Assessment Report's findings and recommendations in as concise a manner as possible. Therefore, the assessment's goals, methods, and analytic tools and systems are only briefly discussed here. Likewise the basin's contextual background, history, and the conditions of its geology, hydrology, vegetation, stream systems, water quality, and land uses are also summarized. To explore those assessment details, and explain the development of these findings and recommendations, the reader is directed to the complete report and its several appendices.

Big River Basin Assessment Report Structure and Usage Guide

The Big River Assessment Report has seven main sections:

- Executive Summary;
- Program Introduction and Overview;
- Assessment Strategy and General Methods;
- Big River Basin Profile and Synthesis;
- Subbasin Profiles and Syntheses;
    - Coastal Subbasin
    - Middle Subbasin
    - Inland Subbasin
- Big River Basin in the Regional Context;
- Appendices.

The order of the three watershed profile sections are all the same:

- Disciplinary findings and analyses;
- Listing of issues raised during the assessment;
- Integrated Analysis (IA);
- Ecological Management Decision Support (EMDS) calculations (limiting factors analysis);
- Tributary recommendations analysis and results;
- Refugia rating analysis and results;
- Responses to the six assessment questions including recommendations (see bolded section below);
- Conclusions.

There are five disciplinary appendices to the Big River Assessment Report:

- Appendix A: Geology;
- Appendix B: Land use and Vegetation;
- Appendix C: EMDS system;
- Appendix D: Hydrology;
- Appendix E: Water Quality;
- Appendix F: Stream Habitat and Fisheries.

Of interest to many readers are the recommendations associated with specific locations in the basin with which they are familiar or in which they have ownership. In the report, basin and subbasin maps are provided at the beginning of each of the three profile sections to help them locate points of interest. By referring to the general tributary refugia rating system results, and the GIS image on page 138, surveyed

streams can be easily determined with their refugia ratings. Discussion concerning the development of the refugia rating system is in the Methods Section beginning on page 41.

Tributary habitat improvement recommendations are summarized and are provided in the appropriate subbasin sections. Following the tributary recommendation tables and discussion, the six guiding assessment questions are answered. In the Big River Profile section the question responses are on pages 139-143; the last question's response is closely related to the earlier recommendation sections, but also presents other potential watershed improvement activities. Question six responses are also presented in this summary. They are organized in five general categories:

- Flow and water quality improvement activities
- Erosion and sediment delivery reduction activities
- Riparian and habitat improvement activities
- Supplemental fish rescue and rearing activities
- Education, research, and monitoring activities

The organization of the Assessment Report's issues, findings, conclusions, and recommendations sections are intended to allow the reader to compare EMDS results, refugia ratings, limiting factors, and the resultant improvement recommendations for logic and appropriateness. Investigators are encouraged to read back through the IA Analysis, disciplinary findings, etc., and to the details contained in the appendices. This should provide a clear understanding of the assessment results and help validate the assessment results.

California's Large Scale Watershed Assessment Program

The Big River Basin Assessment began in 2003 as a project of the North Coast Watershed Assessment Program (NCWAP). That program was established by the state Legislature in July 2000 and was managed by the California Resources Agency and the California Environmental Protection Agency. Participating Resource Agency departments included Fish and Game (CDFG), Forestry and Fire Protection (CDF), Conservation/California Geologic Survey (DOC/CGS), and Water Resources (DWR), in conjunction with the North Coast Regional Water Quality Control Board (NCRWQCB) and State Water Resources Control Board.

In July 2003, after conducting large scale assessments on the Mattole and Gualala rivers, and Redwood Creek, the program was eliminated because of reductions in the state budget. However, large-scale watershed assessment efforts are ongoing by the CDFG's Coastal Watershed Planning and Assessment Program (CWPAP), with input from other Resources Agency departments as resources and schedules allow.

The program's work is intended to provide answers to the following assessment questions at the basin, subbasin, and tributary scales in California's coastal watersheds:

- What are the history and trends of the size, distribution, and relative health and diversity of salmonid populations?
- What are the current salmonid habitat conditions; how do these conditions compare to desired conditions?
- What are the impacts of geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?
- How has land use affected these natural processes and conditions?
- Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What watershed management and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

The assessment program's products are designed to meet these strategic goals:

- Organize and provide existing information and develop limited baseline data to help evaluate the effectiveness of various resource protection programs over time;
- Provide assessment information to help focus watershed improvement programs, and to assist landowners, local watershed groups, and individuals in developing successful projects. This will help guide support programs, such as the CDFG Fishery Restoration Grants Program, toward those watersheds and project types that can efficiently and effectively improve freshwater habitat and lead to improved salmonid populations;
- Provide assessment information to help focus cooperative interagency, nonprofit, and private sector approaches to protect watersheds and streams through watershed stewardship, conservation easements, and other incentive programs;
- Provide assessment information to help landowners and agencies better implement laws that require specific assessments such as the State Forest Practice Act, Clean Water Act, and State Lake and Streambed Alteration Agreements.

General Assessment Approach

Each of the program's participating departments developed data collection and analysis methods used in their basin assessments. The departments also jointly developed a number of tools for interdisciplinary synthesis of information. These tools included models, maps, and matrices for integrating information on basin, subbasin, and stream reach scales to explore linkages among watershed processes, current conditions, and land use. In basins where information was available, these tools provided a framework for identifying refugia areas and factors limiting salmonid productivity, as well as providing a basis for understanding the potential for cumulative impacts from natural and man caused impacts. This information is useful for developing restoration, management, and conservation recommendations.

The general steps in our large-scale assessments include:

Form multi-disciplinary team. In order to assess watershed conditions and processes, several specialists were needed and included: geologists, fluvial geo-morphologists, foresters, water quality analysts, fisheries biologists, habitat specialists, and planners;

Conduct scoping and outreach workshops. In the Big River Basin assessment, a series of meetings with landowners and interested parties provided the team with local, historic knowledge and valuable critical discussion with which to establish the value of the information in hand;

Determine logical assessment scales. The Big River assessment team used the California Watershed Map (CalWater version 2.2a) to delineate the Big River Basin into three subbasins (Coastal, Middle, and Inland) for assessment and analyses purposes (Figure 1);

Discover and organize existing data and information according to discipline. This information was used to form the basis of the disciplinary appendices to the assessment report;

Identify data gaps needed to develop the assessment. Working with limited time and resources constrained the amount of fieldwork that was performed. Fortunately, some data existed prior to this effort in the Big River Basin;

Collect field data. Over 79 miles of new stream data and 58 fishery surveys were performed for this assessment. Water Quality data were collected for this assessment at several locations in the basin, and additional data were provided by private and agency cooperators;

Amass and analyze information. Each agency (except California Geological Survey, which contributed limited information and maps) assembled, interpreted, and summarized data to create various specific reports for inclusion into the Assessment Report;

Construct Integrated Analysis Tables (IA). Through the use of IA Tables the information from various disciplines were compared to one another. These comparisons were used to respond to the Assessment Questions. The IA process also helped to identify watershed conditions;

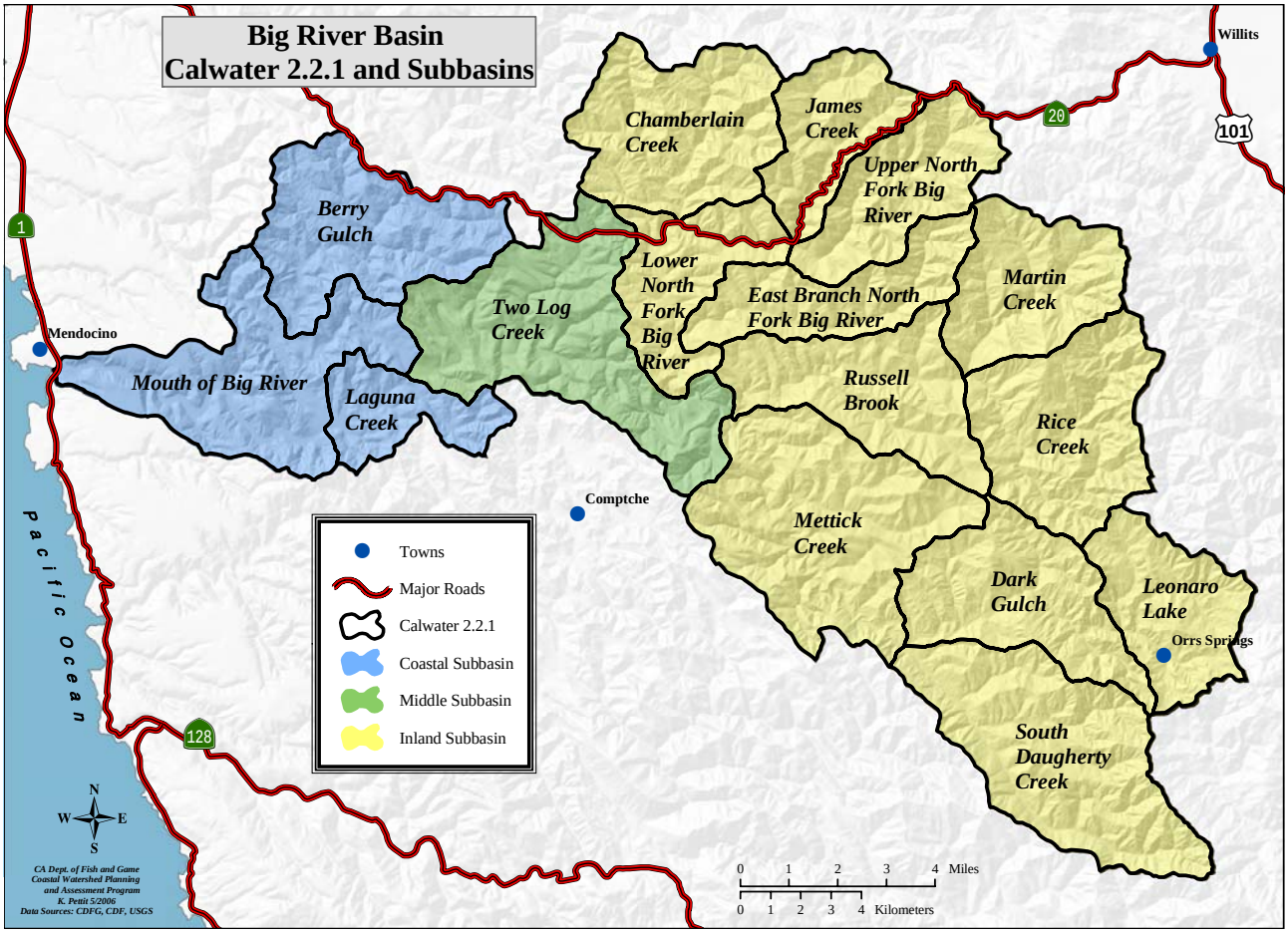

Figure 1. Big River assessment subbasins and CalWater 2.2a Planning Watersheds.

Conduct limiting factors analysis (LFA). The Ecological Management Decision Support system (EMDS) was used, along with expert analysis and local input, to evaluate factors at the tributary scale. These factors were rated to be either beneficial or restrictive to the well being of fisheries. The CDFG Restoration Manual (Flosi et al. 1998), and other literature, provided habitat condition values to help set EMDS reference curves;

Conduct refugia rating analysis. The assessment team created worksheets for rating refugia at the tributary scale. The worksheets have multiple condition factors rated on a sliding scale from high to low quality. Tributary ratings are determined by combining the results of air photo analyses, EMDS, Water Quality data, data in the CDFG tributary reports, and by a multi-disciplinary team of expert analysts. Ratings of various factors are combined to determine an overall refugia ratings on a scale from high to low quality. The tributary ratings are subsequently aggregated at the subbasin scale and expressed as a general estimate of subbasin refugia conditions. Factors with limited or missing data are noted and discussed in the comments section as needed. In most cases, there are data limitations on one to three factors. A discussion of the rating system is located in the assessment report;

Develop conclusions and recommendations. Recommendation tables for watershed and stream improvement activities were developed at the tributary scale based upon stream inventory information, air photo analysis, field verification samples, workshop inputs, and other information. The recommendations are presented at the end of each Profile chapter as answers to the sixth assessment question;

Facilitate monitoring of conditions. CDFG is developing a monitoring program and will facilitate it in the Big River and other assessed watersheds.

Big River Basin

Named for the giant redwood trees that used to line its banks, the Big River drains a 181.1 square mile watershed located in the northern California Coast Range in western Mendocino County, entering the Pacific Ocean at the town of Mendocino, about 10 miles south of Fort Bragg. The Big River Basin extends 24 miles to the east, to within three miles of Willits and Highway 101. It drains primarily from east to west, sharing ridges with the Noyo River and Caspar Creek basins to the north and the Albion and Navarro river basins to the south. Elevations within the Big River Basin range from sea level at the basin outlet to Irene Peak at 2,836 feet, 5 miles south-southwest of Willits in the east end of the Martin Creek Planning Watershed, Inland Subbasin.

The basin's topography is diverse along its length, varying from flat estuarine environments and uplifted marine terraces to rugged mountains with high relief in the eastern portion. It is characterized by narrow ridgelines separated by deeply incised inner gorges of the major river channels and streams draining the watershed.

The western end of the drainage is distinguished by a long estuary laden with mudflats that become narrow floodplains further upriver and occupy a relatively narrow inner gorge. A sand bar at the mouth partially restricts the connection to the sea during low flow periods in the late summer. Tidal influence extends upward from the mouth three miles in the winter and as far as eight miles during the highest spring tides making the Big River Estuary one of the longest estuaries in northern California (Warrick and Wilcox 1981).

Inland areas of the basin are characterized by second growth forest, with some grasslands in the southeast margins. Logging of the basin started in the 1860s near the mouth and gradually moved eastward. Early logging included heavy use of splash dams, effects of which can still be seen today. Most of the basin is currently owned by large timber companies and managed for timber harvest, though the state owns some sections, and there are smaller ownerships as well.

The Big River is listed on the National Rivers Inventory, a list of potential wild, scenic, and recreational river areas within the United States. The river is listed for five outstandingly remarkable values: scenery, recreation, fish, wildlife, and history (NPS 2004).

The basin supports runs of coho salmon (*Oncorhynchus kisutch)* and steelhead trout (*O. mykiss*). Chinook salmon (*O. tshawytscha*) have been reported occasionally, but there is no significant run. Historical accounts indicate that salmon were plentiful and that salmon fishing was a common activity. However, agency reports starting in the 1950s indicate that salmonid populations were depleted and in decline. In recent years, efforts have been underway to recover salmonid stocks of the Big River Basin. For example, local residents and conservation groups recently organized and purchased a 7,342-acre parcel at the mouth of Big River from a timber company and gave it to California Department of Parks and Recreation to be managed for conservation and recreation.

Big River Basin Profile Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the conditions for salmonids in a stream reach based upon water temperature, canopy cover, stream flow, and in channel characteristics. Data used in the Reach EMDS came from CDFG Stream Inventories. Currently, data exist in the Big River Basin to evaluate overall reach, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS functions are in the EMDS Appendix. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual surveys.

EMDS stream reach scores were weighted by stream length to obtain overall scores for subbasins and the entire Big River Basin. Weighted average reach conditions on surveyed streams in the Big River Basin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 1). Suitable conditions exist for canopy across the Big River Basin when the mainstem Big River is not considered; for pool depth in the Coastal and Middle subbasins; and for embeddedness in the Middle Subbasin. Unsuitable conditions exist for pool quality and pool shelter across the Big River Basin.

Table 1. EMDS Anadromous Reach Condition Model results for the Big River Basin. Results are given first for all surveyed reaches and then for only surveyed tributary reaches excluding the mainstem Big River in parentheses.

Subbasin	Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Coastal Subbasin (excluding the mainstem Big River) (N =9)	- (-)	U (U)	- (+++)	U (U)	- (-)	- (--)	+ (--)	- (-)	-- (--)
Middle Subbasin (excluding the mainstem Big River) (N = 5)	- (-)	U (U)	+ (++)	U (U)	- (-)	- (--)	+ (--)	- (--)	+ (-)
Inland Subbasin (N = 41)	-	U	++	U	-	--	--	--	-
Overall (excluding the mainstem Big River) (N = 55)	- (-)	U (U)	+ (++)	U (U)	- (-)	-- (--)	- (--)	-- (--)	- (-)

Key:
+ ++ +++ Highest Suitability
U Insufficient Data or Undetermined
- -- --- Lowest Suitability

Big River Basin Profile Summary of Tributary Recommendations

In order to compare the occurrence of recommendations between the three subbasins in the Big River Basin, the three top ranking recommendations for each tributary were compiled. Each tributary was originally assigned anywhere from zero to ten recommendations, which were ranked in order of importance. Complete tributary recommendations for each subbasin can be found in each of the Subbasin Sections of this report.

The top three recommendations in each tributary were summed for each subbasin (Table 2). In terms of the most frequently given recommendations in each subbasin, the Coastal Subbasin had Roads and Cover recommendations for all nine tributaries and the mainstem surveyed, the Middle Subbasin had Roads and Cover recommendations for three out of five tributaries and the mainstem surveyed, and the Inland Subbasin had Roads recommendations for 24 out of 41 tributaries surveyed. Across the basin, the most frequently given recommendation was Roads.

Table 2. Occurrence of recommendations in first three ranks in surveyed streams.

Subbasin	# of Surveyed Tributaries	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Live-stock	Fish Passage
Coastal	9	39.5	4	9	0	2	5	9	0	0	0	1
Middle	5	9.5	2	3	1	1	2	3	0	1	0	0
Inland	41	105.1	20	24	7	8	20	21	1	4	0	5
Big River Basin	55	154.2	26	36	8	11	27	33	1	5	0	6

Big River Basin Profile Summary of Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Big River Basin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the CCWPAP EMDS at the stream reach scale.

The most complete data available in the Big River Basin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the CCWPAP team.

Salmonid habitat conditions in the Big River Basin are generally best in the Coastal Subbasin, and mixed in the Middle and Inland subbasins. The following refugia area rating table summarizes subbasin salmonid refugia conditions:

Table 3. Subbasin salmonid refugia area ratings in the Big River Basin.

Subbasin	Refugia Categories:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Coastal Subbasin		X				X	X
Middle Subbasin			X				X
Inland Subbasin			X				X

*Ratings in this table are done on a sliding scale from best to worst. Subbasin refugia ratings are aggregated from their tributary ratings.

Big River Basin Tributaries by Refugia Category:

High Quality Habitat, High Quality Refugia Tributaries:

None

High Potential Refugia Tributaries:

Railroad Gulch
Little North Fork Big River
Rocky Gulch
Thompson Gulch
East Branch Little North Fork Big River
Berry Gulch
Berry Gulch Tributary
Two Log Creek
Ayn Creek
Tramway Gulch
Hatch Gulch
North Fork Big River
East Branch North Fork Big River
Bull Team Gulch
Chamberlain Creek
Water Gulch
West Chamberlain Creek

Arvola Gulch
James Creek
South Fork Big River
Ramon Creek
North Fork Ramon Creek
Daugherty Creek
Soda Creek
Gates Creek
Snuffins Creek
Dark Gulch
South Fork Big River Tributary #1
South Fork Big River Tributary #2
Russell Brook
Martin Creek
Martin Creek Right Bank Tributary #1
Valentine Creek

Medium Potential Refugia Tributaries:

Big River Estuary
Big River mainstem in the Coastal, Middle, and Inland subbasins
Laguna Creek
Manly Gulch
Saurkraut Creek
Beaver Pond Gulch
Dunlap Gulch
Frykman Gulch
Water Gulch Tributary
Gulch Sixteen
Gulch Sixteen Tributary
Lost Lake Creek
North Fork James Creek

Biggs Gulch
Mettick Creek
Boardman Gulch
Halfway House Gulch
Johnson Creek (Tributary to Gates Creek)
Horse Thief Creek
Johnson Creek
Pig Pen Gulch
Martin Creek Left Bank Tributary
Martin Creek Right Bank Tributary #2
Rice Creek

Low Quality Habitat, Low Potential Refugia Tributaries:

Dry Dock Gulch
Cookhouse Gulch
Wheel Gulch
Peterson Gulch
Kidwell Gulch
Blind Gulch
Dietz Gulch

Steam Donkey Gulch
Quail Gulch
Park Gulch
Soda Gulch
Poverty Gulch
Anderson Gulch
Montgomery Creek

Data Limited and Critical Contributing Area

Occasionally, individual streams were missing data that would have provided a more complete picture for use in the refugia analysis. In these cases, only one or two of the factors used in the rating process were missing and this did not prevent refugia determination from being estimated. Where there was not enough data to give a stream a refugia rating, the site may have been listed as a critical contributing area based on the suitability of the habitat according to available data. All streams are lacking desired data.

<u>Other Related Refugia Component Categories:</u>

Potential Future Refugia (Non-anadromous)

None

Critical Contributing Area:

Big River Estuary

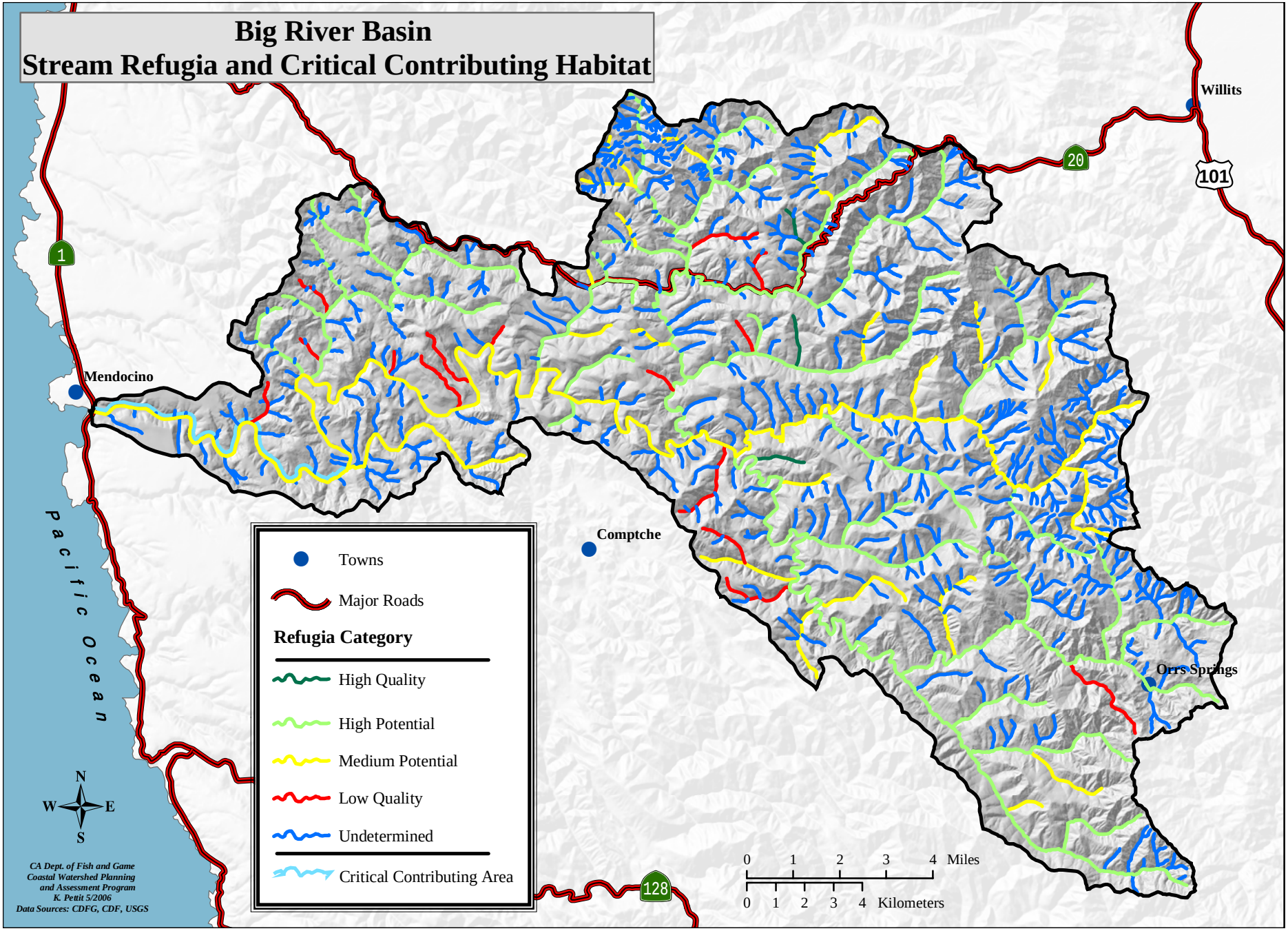

Figure 2. Stream refugia in the Big River Basin.

Big River Basin Profile: Responses to Assessment Question Six:

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Flow and Water Quality Improvement Activities

- To minimize and reduce the effects of water diversions, take action to ensure compliance with state water laws to address seasonal diversion, off-stream reservoirs, bypass flows protective of coho salmon and other anadromous salmonids and the normal hydrograph, and avoidance of adverse impacts caused by water diversion;
- Discourage instream flow diversions in tributaries with cooler water temperatures for thermal refugia delivered to the warmer North and South Forks and mainstem Big River in the summer;
- Land managers should work to reduce the temperature of water flowing into the Middle and Coastal subbasins. In order to do this, they should maintain and/or establish adequate streamside protection zones to increase shade and reduce heat inputs to Big River and its tributaries throughout the basin;
- Follow the procedures and guidelines outlined by NCRWQCB to protect water quality from ground applications of pesticides.

Fish Passage

- Consider modifying debris accumulations to facilitate fish passage where necessary;
- Adequately fund prioritization and upgrading of culverts to provide fish passage within the range of coho salmon and to pass 100-year flows and the expected debris loads.

Erosion and Sediment Delivery Reduction Activities

- To reduce sediment delivery to Big River, land managers should continue their efforts such as road improvements, good maintenance, and decommissioning and other erosion control practices associated with landuse activities throughout the basin. Thirty-six CDFG stream surveys had road sediment inventory and control as a top tier tributary recommendation;
- Support and encourage existing and active road management programs undertaken by landowners throughout the basin;
- Map unstable soils and use soil mapping to guide land-use decisions, road design, THPs, and other activities that can promote erosion;
- Sediment sources from eroding streambanks and adjacent hillslopes should be identified and treated to reduce sediment generation and delivery to creeks;
- Limit unauthorized and impacting winter use of unsurfaced roads and recreational trails to decrease fine sediment loads;
- Develop erosion control projects similar to the North Fork Ten Mile River erosion control plan (Mendocino Department of Transportation 2001).

Riparian and Instream Habitat Improvement Activities

- Improve instream structure for juvenile ambush escape and cover. Thirty-one CDFG stream surveys and the mainstem Big River have increase escape cover as a top tier tributary recommendation;
- Add LWD to stream channels where appropriate/feasible to develop habitat diversity and to increase shelter complexity. In addition, there is a need to leave large wood on stream banks and in estuarine channels for potential recruitment into stream channels and the estuary;
- Maintain and improve existing riparian cover where needed;
- Encourage growth and retention of near-stream conifers;
- Ensure that any land management activities include protection and preservation of stream and riparian habitats and maintain or improve ecological integrity within the basin;
- Ensure that high quality habitat is protected from degradation. Salmonid habitat conditions in the Big River Basin are generally best in the Coastal Subbasin, and mixed in the Middle and Inland subbasins;

- Consider the use of management strategies such as conservation easements to maximize potential benefits to aquatic habitats from near-stream forest protection.

Education, Research, and Monitoring Activities

- State Parks, DFG, MRC, and HTC should continue and expand existing monitoring of anadromous salmonid populations to include some winter and spring fish sampling;
- Support stream gage installations and maintenance to establish a long term record of Big River hydrologic conditions;
- Additional investigations of the physical characteristics of Big River are needed to re-evaluate the Sediment Source Analysis. A regional curve of bankfull dimensions vs. drainage area should be developed for Mendocino County and used to validate CGS (2004) bankfull discharge estimates for Big River;
- Hillslope and in-stream monitoring proposed by the MRC in their Watershed Analysis (2003) should be carried out and additional monitoring programs throughout the basin should be planned with respect to MRC techniques;
- A study examining how sediment plugs moved downstream from historic splash dam locations over time on air photos is recommended;
- Continue water temperature monitoring at current locations and expand these efforts where appropriate;
- Further study of timberland herbicide use is recommended.

Coastal Subbasin

Mouth of Big River in 2002. Copyright (C) 2002-2006 Kenneth & Gabrielle Adelman, California Coastal Records Project, www.Californiacoastline.org

Introduction

The Coastal Subbasin includes all of the watershed area of the mainstem Big River just below its confluence with Peterson Gulch (**Error! Reference source not found.**). This encompasses all of the Big River Estuary. Stream elevations across the subbasin range from sea level to 40 feet at the boundary with the Middle Subbasin. The highest point is above Kidwell Gulch on the border with the Middle Subbasin, at 1,235 feet. The subbasin encompasses 32.5 square miles and occupies 17.9% of the total basin area. The Big River Estuary is large relative to the size of the basin, with tidal influence extending approximately 8.3 miles upstream from the ocean. The estuary is the longest undeveloped estuary in California (Warrick and Wilcox 1981). The mouth of the river is an opening along the north side of Mendocino Bay. The bay is protected by rocky headlands, which minimize wave-induced longshore sediment transport and help the mouth to remain open to the sea year round. The town of Mendocino lies just outside of the Big River Basin, north of the river mouth.

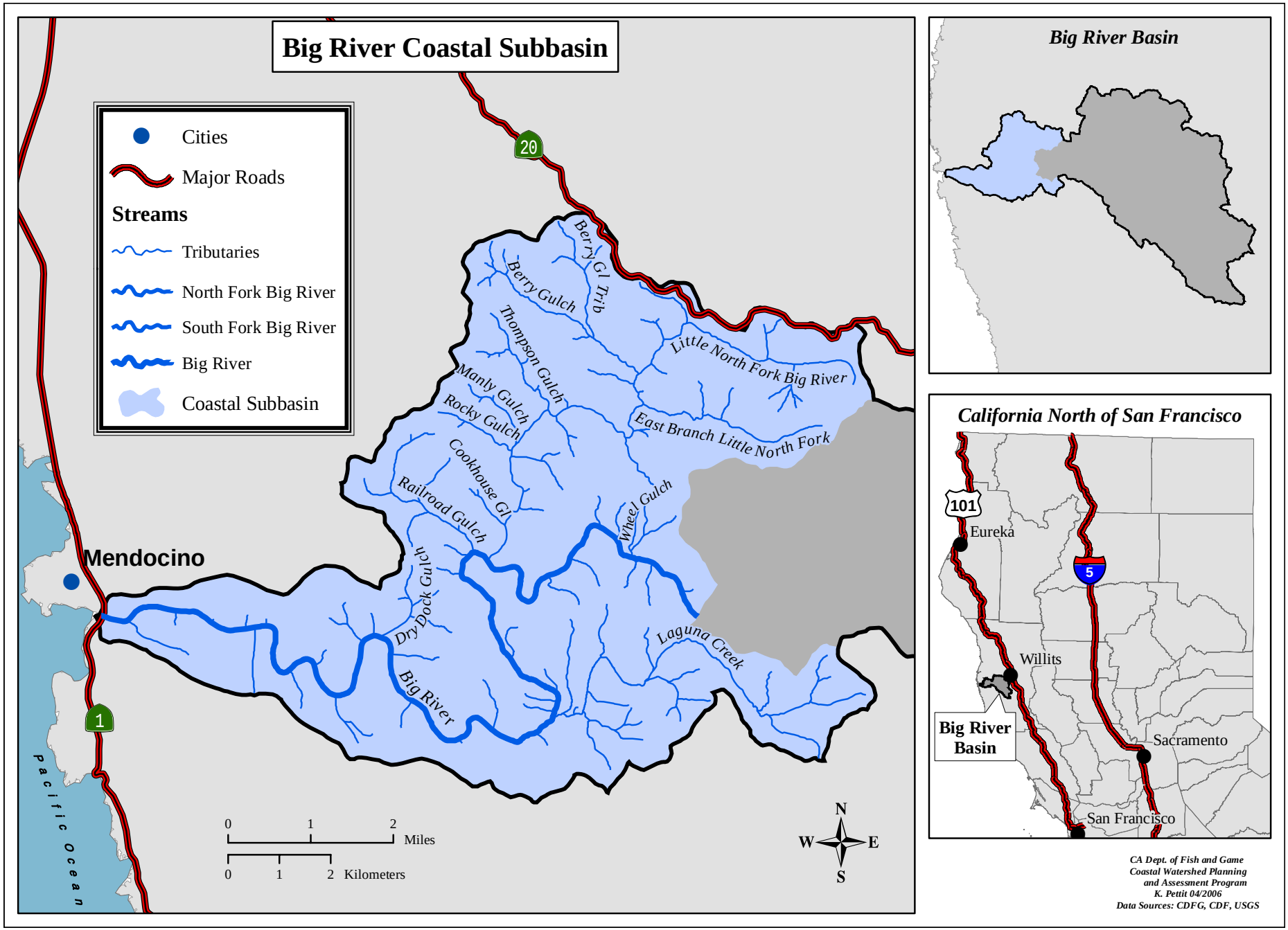

Figure 3. Coastal Subbasin.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the condition for salmonids in a stream reach based upon instantaneous water temperature, riparian vegetation, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG habitat inventory surveys. Currently, data exist in the Big River Basin to evaluate overall reach, water temperature, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. Details on how the EMDS system calculates habitat variables are in the EMDS Appendix. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time surveyed.

EMDS stream reach scores were weighted by stream length to obtain overall scores for tributaries and the entire Coastal Subbasin. Weighted average reach conditions on surveyed streams in the Coastal Subbasin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 4). Suitable conditions exist for canopy across the subbasin except for the mainstem Big River. Laguna Creek has suitable conditions for pool quality, pool depth, and pool shelter. Suitable conditions also exist for pool quality and pool depth in Big River; pool shelter in East Branch Little North Fork Big River; and embeddedness in Rocky Gulch, Manly Gulch, and Big River from Wheel Gulch to Blind Gulch.

One tributary, East Branch Little North Fork Big River, had two years of data, 1996 and 2002. A comparison of the two years data shows an increase in the suitability of canopy and cobble embeddedness and a decline in the suitability of pool shelter.

Table 4. EMDS Anadromous Reach Condition Model results for the Coastal Subbasin.

Stream		Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Coastal Subbasin (excluding the mainstem Big River)		- (-)	U (U)	- (+++)	U (U)	- (-)	- (--)	+ (--)	- (-)	-- (--)
Big River		-	U	---	U	-	+	++	-	--
Laguna Creek		+	U	+++	U	+	++	++	++	---
Railroad Gulch		-	U	+++	U	-	---	---	---	--
Little North Fork Big River		-	U	+++	U	-	--	--	--	--
Rocky Gulch		-	U	+++	U	-	--	---	--	+++
Manly Gulch		-	U	+++	U	-	---	---	---	+
Thompson Gulch		-	U	+++	U	-	--	---	-	--
East Branch of the Little North Fork Big River	1996	-	U	+	U	-	-	---	++	--
	2002	-	U	+++	U	-	-	---	+	-
Berry Gulch		-	U	+++	U	-	--	---	--	--
Berry Gulch Tributary		-	U	+++	U	-	--	---	--	-
Big River (Wheel Gulch to Blind Gulch)		-	U	-	U	-	-	+	--	++

Key: + ++ +++ Highest Suitability
U Insufficient Data or Undetermined
- -- --- Lowest Suitability

Analysis of Tributary Recommendations

CDFG inventoried 39.5 miles on nine tributaries and the mainstem Big River in the Coastal Subbasin. A CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories (Table 5). More

details about the tributary recommendation process are given in the Big River Synthesis Section of the Watershed Profile.

Table 5. Ranked tributary recommendations summary in the Coastal Subbasin based on CDFG stream inventories.

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
Big River	20.3	1	2	4			3		5		
Laguna Creek	1.9	2	3			1	4		5		
Railroad Gulch	1.1		2			3	1				
Little North Fork Big River	3.7	3	1				2				
Rocky Gulch	0.2		2				1				
Manly Gulch	0.7		3				2				1
Thompson Gulch	1.1		2			3	1				
East Branch of the Little North Fork Big River	2.4		4		1	2	3				
Berry Gulch	2.2		2		4	3	1				
Berry Gulch Tributary	1.1		2				1				
Big River Wheel Gulch to Blind Gulch	5.0	3		4	1		2				

Temp = summer water temperatures seem to be above optimum for salmon and steelhead; Pool = pools are below target values in quantity and/or quality; Cover = escape cover is below target values; Bank = stream banks are failing and yielding fine sediment into the stream; Roads = fine sediment is entering the stream from the road system; Canopy = shade canopy is below target values; Spawning Gravel = spawning gravel is deficient in quality and/or quantity; LDA = large debris accumulations are retaining large amounts of gravel and could need modification; Livestock = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; Fish Passage = there are barriers to fish migration in the stream.

In order to further examine Coastal Subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 6). When examining recommendation categories by number of tributaries, the most important recommendation category in the Coastal Subbasin is Instream Habitat.

Table 6. Top three ranking recommendation categories by number of tributaries in the Coastal Subbasin.

Target Issue	Related Table Categories	Count
Erosion / Sediment	Bank / Roads	13
Riparian / Water Temp	Canopy / Temp	2
Instream Habitat	Pool / Cover	15
Gravel / Substrate	Spawning Gravel / LDA	0
Other	Livestock / Barrier	1

However, when comparing recommendation categories in the Coastal Subbasin by number of tributaries could be confounded by the differences in the number of stream miles surveyed on each tributary. Therefore, the number of stream miles in the subbasin assigned to various recommendation categories was calculated (Figure 4). When examining recommendation categories by number of stream miles, the most important recommendation categories in the Coastal Subbasin shift to Erosion/Sediment, Instream Habitat, and Riparian/Water Temperature. These comprise the top tier of recommended improvement activity focus areas.

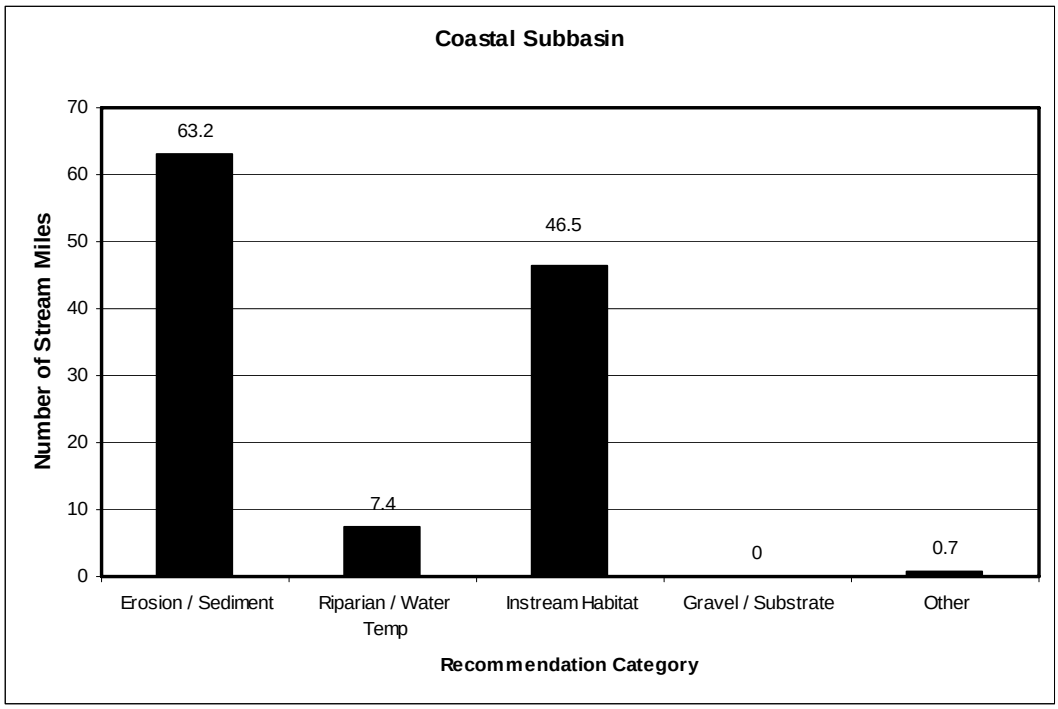

Figure 4. Recommendation categories by stream miles in the Coastal Subbasin.

The high number of Erosion/Sediment, Instream Habitat, and Riparian/Water Temperature recommendations across the Coastal Subbasin indicates that high priority should be given to restoration projects emphasizing sediment reduction, pools, cover, and riparian replanting.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Coastal Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity.

The team also used results from information processed by NCWAP's EMDS at the stream reach scale.

The most complete data available in the Coastal Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Coastal Subbasin on surveyed streams are generally rated as high potential refugia. The Big River Estuary and the Little North Fork Big River provide the best salmonid habitat in this subbasin, while Cookhouse Gulch and Wheel Gulch provide low quality refugia. Additionally, the estuary, mainstem, and Little North Fork Big River serve as critical contributing areas. The following refugia area rating table summarizes subbasin salmonid refugia conditions:

Table 7. Tributary salmonid refugia area ratings in the Coastal Subbasin.

Stream	Refugia Categories*:				Other Categories:		
	High Quality	**High Potential**	**Medium Potential**	**Low Quality**	**Non-Anadromous**	**Critical Contributing Area/Function**	**Data Limited**
Big River Estuary			X			X	X
Big River			X			X	X
Dry Dock Gulch				X			
Laguna Creek			X				X
Railroad Gulch		X					X
Little North Fork Big River		X				X	X
Cookhouse Gulch				X			X
Rocky Gulch		X					X
Manly Gulch				X			X
Thompson Gulch		X					X
East Branch of the Little North Fork Big River		X					X
Berry Gulch		X					X
Berry Gulch Tributary		X					X
Wheel Gulch				X			X
Subbasin Rating		X					X

*Ratings in this table are done on a sliding scale from best to worst.

Coastal Subbasin Profile: Responses to Assessment Question Six:

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Flow and Water Quality Improvement Activities

- Protect instream flows in Little North Fork Big River, Railroad Gulch, and Laguna Creek to help moderate or cool the warmer mainstem Big River in the summer.

Fish Passage

- Consider modifying fish passage barriers on Manly Gulch and small tributaries along the estuary.

Erosion and Sediment Delivery Reduction Activities

- Continue efforts such as road improvements, and decommissioning throughout this subbasin to reduce sediment delivery to Big River and its tributaries. CDFG stream surveys indicated that nine out of eleven surveyed tributaries in this subbasin had road sediment inventory and control as a top tier tributary recommendation;
- Continue to support and encourage current and future road management programs undertaken by California State Parks;
- California State Parks should follow the recommendations of CGS (2004) in treating identified sediment sources on roads and road crossings within Big River State Park;
- All roads within Big River State Park and their associated watercourse crossings required for public safety, existing easements, future restoration effort success, and public access must be maintained to high standards (CGS 2004);
- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams. For example, low impact yarding systems should be used in any timber harvest operations on steep and unstable slopes to reduce soil compaction, surface disturbance, and resultant sediment yield;
- California Department of Parks should consult with appropriate resource professionals to assist in transitioning industrial timberlands on the Big River State Park to self-sustaining forest (CGS 2004).

Riparian and Instream Habitat Improvement Activities

- Where feasible, add LWD to develop habitat diversity in the main channel and to increase shelter complexity for salmonids. CDFG stream surveys indicated that all nine surveyed tributaries and the mainstem Big River have increase shelter as a top tier tributary recommendation;
- Leave large wood in estuarine channels, on the beach, and on stream banks for potential recruitment into the estuary;
- Ensure that this high quality habitat is protected from degradation. The highest stream reach conditions as evaluated by the stream reach EMDS and refugia analysis were found in the Big River Estuary, mainstem Big River, Little North Fork Big River, Railroad Gulch, East Branch Little North Fork Big River, Berry Gulch Tributary, and Rocky, Thompson, and Berry gulches;
- Create a channel under the main road to connect Manly Gulch to Little North Fork Big River to address winter access problems for adult fish at the non-existent channel at Camp Three.

Education, Research, and Monitoring Activities

- Conduct surveys of ten small tributaries entering the estuary through blocked culverts in the Big River State Park to determine if they provide salmonid habitat;
- Establish monitoring stations to track instream sediment along the estuary;
- Continue water temperature monitoring at current locations where high temperatures have been detected on the mainstem Big River;
- Assess water temperature and dissolved oxygen in the estuary as there is currently no data on these indicators;
- Establish long-term water chemistry monitoring stations in the lower mainstem Big River. If there are indications of problems, monitoring should be implemented in tributaries as necessary to determine the source of the problem;

- Encourage the involvement of SONAR in fish and habitat monitoring activities.

Subbasin Conclusions

The Coastal Subbasin contains the Big River Estuary, which is of major importance to fish and wildlife along the Mendocino coast. The estuary provides a large area of wetlands that are essential habitat to many species including salmonids. Salmon and steelhead habitat conditions in the estuary, the mainstem Big River, and the tributaries of the Coastal Subbasin are generally in the early stages of recovery from past disturbance and suitable for salmonid production. Reduced habitat complexity, high water temperatures in the mainstem Big River, and embedded spawning are limiting factors to salmonid populations in some parts of the subbasin.

There are many opportunities for improvements in conditions, especially with the recent creation of the Big River State Park. Water temperature monitoring, road maintenance and decommissioning, and adding LWD to improve channel complexity are examples of appropriate improvement activities that can be initiated in the park. However, aquatic and channel conditions at the most downstream section of a river system are a response to watershed products transported from throughout the basin. Fine sediment and warm water are two watershed products most deleterious to the estuary's fisheries. As such, long term improvements in the estuary must be produced by careful watershed stewardship throughout the Big River Basin.

Middle Subbasin

Mainstem Big River in 2002, Photo by Steve Cannata

Introduction

The Middle Subbasin includes the watershed area of the mainstem Big River just above its confluence with Peterson Gulch up until its confluence with the South Fork Big River, not including the North Fork Big River (Figure 5). Stream elevations range from 40 feet at boundary with the Coastal Subbasin to 210 feet at the confluence with the North Fork Big River. The highest point in the subbasin is above Dietz Gulch at approximately 1,560 feet. The Middle Subbasin is the smallest of the three Big River Subbasins at 17.9 square miles and occupies 9.9% of the total basin area. Most of the subbasin is owned by Hawthorne Timber Company and Mendocino Redwood Company and is managed for timber production.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the conditions for salmonids in a stream reach based upon water temperature, canopy cover, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG Stream Inventories. Currently, data exist in the Big River Basin to evaluate overall reach, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS functions are in the

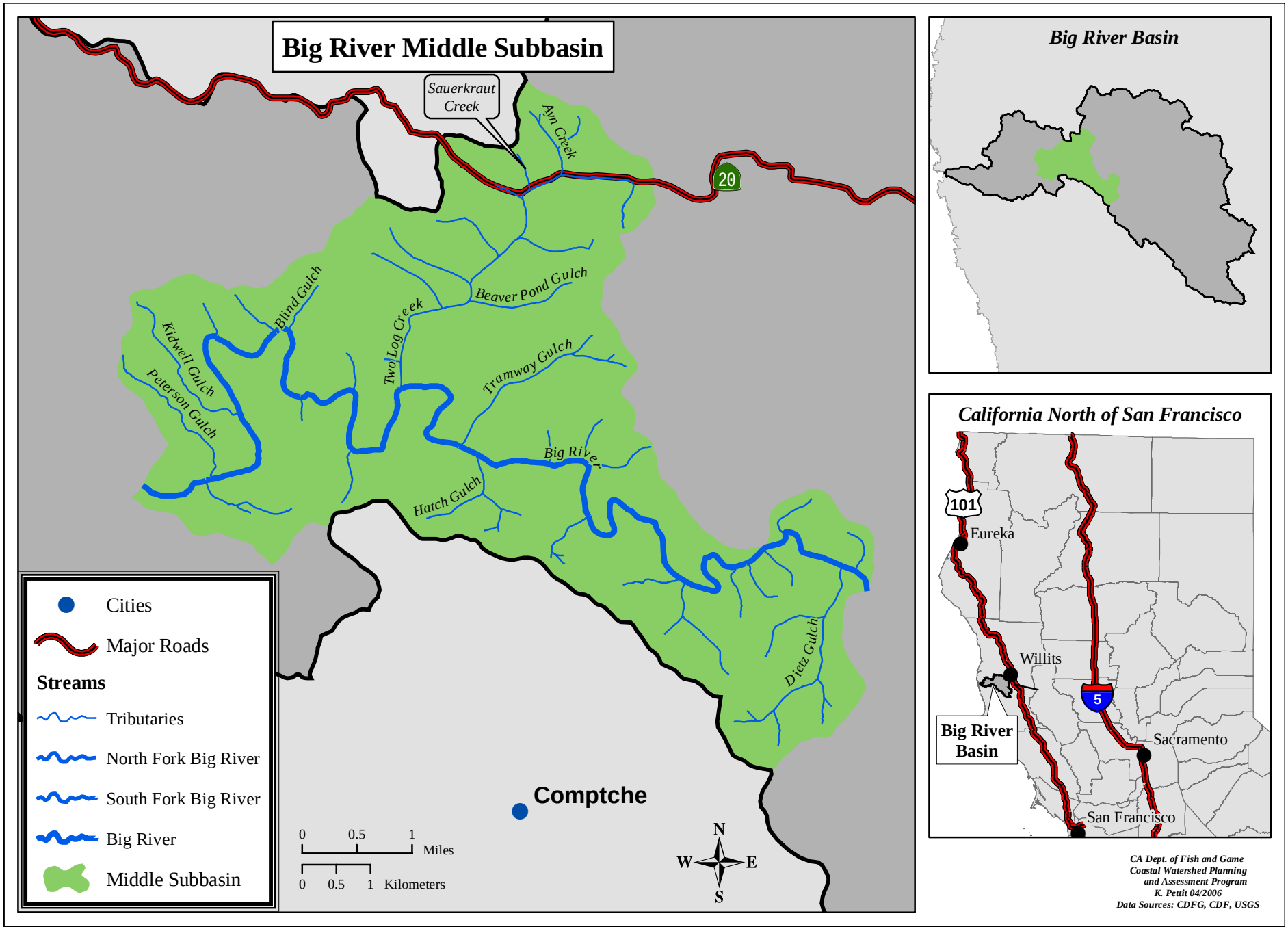

Figure 5. Middle Subbasin.

EMDS Appendix. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual survey.

EMDS stream reach scores were weighted by stream length to obtain overall scores for tributaries and the entire Middle Subbasin. Weighted average reach conditions on surveyed streams in the Middle Subbasin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 9). Suitable conditions exist for canopy across the entire subbasin. Big River from Tramway Gulch to North Fork Big River has suitable conditions for pool quality, pool depth, pool shelter, and embeddedness. Suitable conditions also exist for pool shelter in Hatch Gulch, and embeddedness in Two Log Creek.

One tributary, Two Log Creek, had four years of data, 1996, 1997, 1998, and 2002. A comparison of EMDS results from 1998 and 2002 shows an increase in the suitability of canopy, pool depth, and cobble embeddedness.

Table 8. EMDS Anadromous Reach Condition Model results for the Middle Subbasin.

Stream		Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Middle Subbasin (excluding the mainstem Big River)		- (-)	U (U)	+ (++)	U (U)	- (-)	- (--)	+ (--)	- (--)	+ (-)
Kidwell Gulch		-	U	++	U	-	---	---	---	-
Two Log Creek	1998	-	U	++	U	-	--	---	--	--
	2002	-	U	+++	U	-	--	--	--	+
Saurkraut Creek (Two Log Creek Tributary)		-	U	+++	U	-	-	---	+	---
Ayn Creek (Two Log Creek Tributary)		-	U	++	U	-	--	---	-	---
Big River (Tramway Gulch to North Fork Big River)		+	U	--	U	+	++	+++	+	++
Hatch Gulch		-	U	+++	U	-	-	---	+	---

Key: Highest Suitability: +++ ++ +
Lowest Suitability: - -- ---
U: Insufficient Data or Undetermined

Analysis of Tributary Recommendations

CDFG inventoried 9.5 miles on five tributaries and the mainstem Big River in the Middle Subbasin. A CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories (Table 9). More details about the tributary recommendation process are given in the Big River Synthesis Section of the Watershed Profile.

Table 9. Ranked tributary recommendations summary in the Middle Subbasin based on CDFG Stream Inventories.

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
Kidwell Gulch	0.9		3			1	2		4		
Two Log Creek	3.0	2	3				1				
Sauerkraut Creek	0.1		1								
Ayn Creek	0.3										
Big River Tramway Gulch to North Fork Big River	4.7			2	1		3				
Hatch Gulch	0.5	3	4			1		5	2		

Temp = summer water temperatures seem to be above optimum for salmon and steelhead; Pool = pools are below target values in quantity and/or quality; Cover = escape cover is below target values; Bank = stream banks are failing and yielding fine sediment into the stream; Roads = fine sediment is entering the stream from the road system; Canopy = shade canopy is below target values; Spawning Gravel = spawning gravel is deficient in quality and/or quantity; LDA = large debris accumulations are retaining large amounts of gravel and could need modification; Livestock = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; Fish Passage = there are barriers to fish migration in the stream.

In order to further examine Middle Subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 10). When examining recommendation categories by number of tributaries, the most important recommendation categories in the Middle Subbasin are Erosion/Sediment and Instream Habitat.

Table 10. Top Three ranking recommendation categories by number of tributaries in the Middle Subbasin.

Target Issue	Related Table Categories	Count
Erosion / Sediment	Bank / Roads	5
Riparian / Water Temp	Canopy / Temp	2
Instream Habitat	Pool / Cover	5
Gravel / Substrate	Spawning Gravel / LDA	1
Other	Livestock / Barrier	0

However, comparing recommendation categories in the Middle Subbasin by number of tributaries could be confounded by the differences in the number stream miles surveyed on each tributary. Therefore, the number of stream miles in each subbasin assigned to the various recommendation categories was calculated (Figure 6). When examining recommendation categories by number of stream miles, the most important recommendation categories in the Middle Subbasin are Instream Habitat, Riparian/Water Temperature, and Erosion/Sediment. These comprise the top tier of recommended improvement activity focus areas.

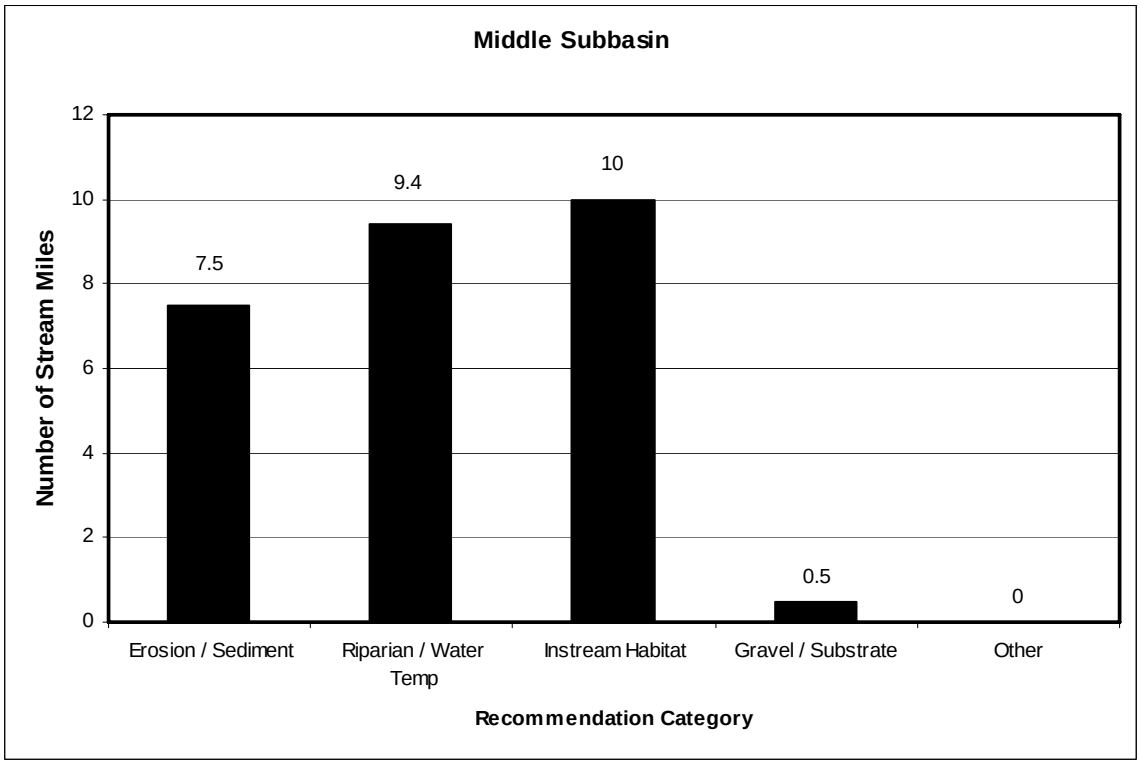

Figure 6. Recommendation categories by stream miles in the Middle Subbasin.

The high number of Instream Habitat, Riparian/Water Temp, and Erosion/Sediment recommendations across the Middle Subbasin indicates that high priority should be given to restoration projects emphasizing pools, cover, riparian replanting, and sediment reduction.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Middle Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by NCWAP's EMDS at the stream reach scale.

The most complete data available in the Middle Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Middle Subbasin on surveyed streams are generally rated as medium potential refugia. Additionally, the mainstem Big River serves as a critical contributing area. The following refugia area rating table summarizes subbasin salmonid refugia conditions:

Table 11. Tributary Salmonid Refugia Area Ratings in the Middle Subbasin.

Stream	Refugia Categories*:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Big River		X				X	X
Peterson Gulch				X			X
Kidwell Gulch				X			X
Blind Gulch				X			X
Two Log Creek		X					X
Saurkraut Creek			X				X
Ayn Creek		X					X
Beaver Pond Gulch			X				X
Tramway Gulch		X					X
Hatch Gulch		X					X
Dietz Gulch				X			X
Subbasin Rating			X				X

*Ratings in this table are done on a sliding scale from best to worst.

Middle Subbasin Profile: Responses to Assessment Question Six:

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Flow and Water Quality Improvement Activities

- Protect instream flows in Two Log Creek and Hatch Gulch to help moderate or cool the warmer mainstem Big River in the summer.

Erosion and Sediment Delivery Reduction Activities

- Continue efforts such as road improvements, and decommissioning throughout this subbasin to reduce sediment delivery to Big River and its tributaries. CDFG stream surveys indicated Kidwell Gulch, Two Log Creek, and Saurkraut Creek have road sediment inventory and control as a top tier tributary improvement recommendation.

Riparian and Instream Habitat Improvement Activities

- Where feasible, add LWD to develop habitat diversity in the mainstem channel and to increase shelter complexity for salmonids. CDFG stream surveys indicated Kidwell Gulch, Two Log Creek, and Big River from Tramway Gulch to North Fork Big River have to increase escape cover as a top tier tributary recommendation;
- Ensure that this high quality habitat is protected from degradation. The highest stream reach conditions as evaluated by the stream reach EMDS and refugia analysis were found in the mainstem Big River, Two Log Creek, Ayn Creek, Tramway and Hatch gulches.

Education, Research, and Monitoring Activities

- Continue water temperature monitoring at current locations where high temperatures have been detected on the mainstem Big River;
- In lower Two Log Creek, both MRC and HTC have temperature monitoring sites in nearly the same location. It may be more effective if one company monitored the site and shared the information with the other while the second monitoring device is deployed at another location.

Subbasin Conclusions

The Middle Subbasin represents a transition zone between the Coastal and Inland subbasins - moving from a heavily marine influenced climate and gentler slopes to larger temperature fluctuations throughout the year and steeper slopes. Although this subbasin is small, just under 10% of the land mass of the Big River Basin, it contains Two Log Creek, an important fish-bearing tributary. Salmon and steelhead habitat conditions in the Middle Subbasin are generally degraded, but support some salmonid production.

This subbasin appears to be impacted by reduced habitat complexity, high water temperatures in the mainstem Big River, and embedded spawning gravels. In addition, this subbasin has a comparatively dense network of roads that provide potential sources of fine sediment input to streams. Historical accounts indicate that stream conditions were favorable for salmonids in the past and certain habitat factors remain favorable in some of the tributaries. Accordingly, there are opportunities for stream improvements and a need to restore areas of stream refugia. Examples of habitat improvement activities include increasing channel complexity, monitoring stream temperatures, road improvements and erosion proofing, and mitigation of stream bank erosion. The natural variability of stability and erodability of the geologic terrains should be considered before project implementation and appropriate BMPs should be followed to minimize erosion and sediment delivery to streams. Current landowners and managers interested and motivated to eliminate impacts related to land use and accelerate a return to the stable, beneficial conditions for salmonid are encouraged to do so, enlisting the aid and support of agency technology, experience, and funding opportunities.

Inland Subbasin

Upper South Fork Big River Watershed, Photo by Bill Lydgate in KRIS. May 2001.

Introduction

The Inland Subbasin includes the entire watershed area of the North Fork Big River, South Fork Big River, and the entire watershed area of the Big River above the confluence with the South Fork Big River (Figure 7). Stream elevations range from 200 feet at the confluence of the mainstem Big River with North Fork Big River to approximately 1300 feet in the headwaters of the tributaries. The highest point in the subbasin is Irene Peak at 2,836 feet. The subbasin encompasses 130.8 square miles, occupying 72.2% of the total basin area. Most of the subbasin is owned by MRC, Strategic Timber Trust, and JDSF and is managed for timber production. There are also a large number of smaller privately owned parcels near the western border and the small hamlet of Orr Springs lies near the headwaters of the South Fork Big River.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the conditions for salmonids in a stream reach based upon water temperature, canopy cover, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG Stream Inventories. Currently, data exist in the Big River Basin to evaluate overall reach, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS functions are in the EMDS Appendix. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual survey.

EMDS stream reach scores were weighted by stream length to obtain overall scores for tributaries and the entire Inland Subbasin. Weighted average reach conditions on surveyed streams in the Inland Subbasin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 12). Suitable conditions exist for canopy across the subbasin except for James Creek; and for pool shelter in East Branch North Fork Big River, West Chamberlain Creek, Daugherty Creek, and Gates Creek. Suitable conditions exist for

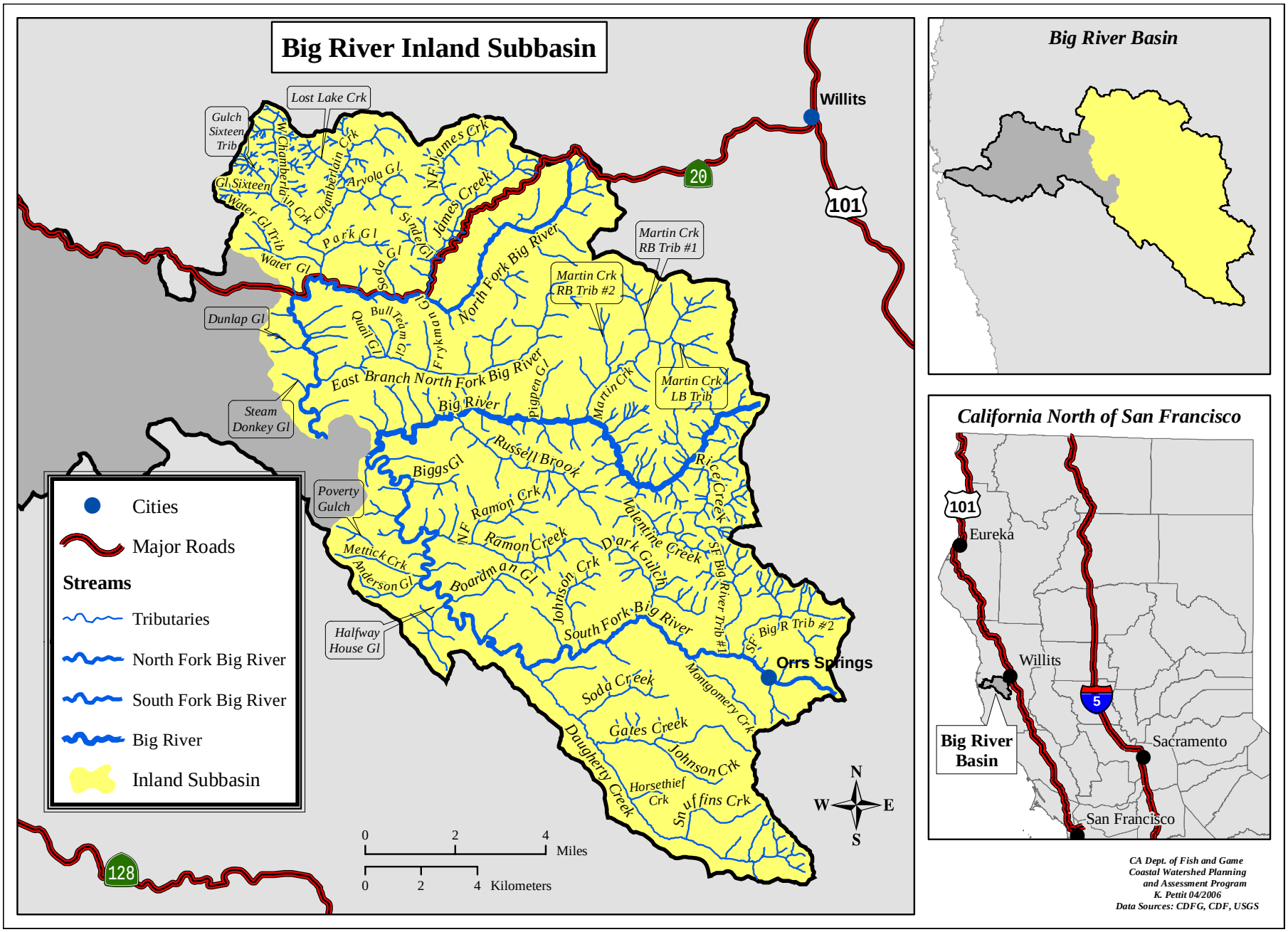

Figure 7. Inland Subbasin.

pool depth for North and South forks of Big River; and for embeddedness in ten creeks in the South Fork drainage. Unsuitable conditions exist for pool quality in all tributaries evaluated.

Six tributaries, North Fork Big River, Daugherty, Soda, Gates, Johnson (tributary to Gates Creek), and Snuffins creeks, had two years of data, 1993, 1995, or 1996 and 1997 or 2002. A comparison of the two years data shows an increase in the suitability of canopy and pool quality and a decline in the suitability of pool depth in North Fork Big River. The other five tributaries showed an increase in the suitability of pool quality, pool shelter, and cobble embeddedness. Suitability of canopy increased in Daugherty, Gates, and Johnson (tributary to Gates) creeks. Suitability of pool depth increased in Daugherty and Gates creeks.

Table 12. EMDS Anadromous Reach Condition Model results for the Inland Subbasin.

Stream		Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Inland Subbasin		-	U	++	U	-	--	--	--	-
North Fork Big River	1996	-	U	-	U	-	-	+	--	-
	1997	-	U	+	U	-	--	--	--	-
East Branch of the North Fork Big River		-	U	+	U	-	-	---	++	--
Chamberlain Creek		-	U	+	U	-	---	---	---	-
Water Gulch		-	U	+++	U	-	--	--	-	-
Water Gulch Tributary		-	U	+++	U	-	---	---	---	-
Park Gulch		-	U	+++	U	-	--	---	-	-
West Chamberlain Creek		-	U	+++	U	-	-	---	+	--
Gulch Sixteen		-	U	+++	U	-	--	---	--	-
Gulch Sixteen Tributary		-	U	+++	U	-	--	---	--	-
Arvola Gulch		-	U	++	U	-	--	---	--	--
Lost Lake Creek		-	U	+++	U	-	---	---	---	-
Soda Gulch		-	U	+++	U	-	---	---	---	---
James Creek		-	U	-	U	-	---	---	---	-
North Fork James Creek		-	U	++	U	-	--	---	-	-
South Fork Big River		-	U	++	U	-	-	+	--	+
Biggs Gulch		-	U	+++	U	-	---	---	---	+
Ramon Creek		-	U	+	U	-	--	---	--	-
North Fork Ramon Creek		-	U	+	U	-	--	---	--	++
Mettick Creek		-	U	+	U	-	---	---	---	+
Poverty Gulch		-	U	+	U	-	--	---	--	U
Anderson Gulch		-	U	+++	U	-	---	---	---	--
Boardman Gulch		-	U	+++	U	-	--	---	--	---
Halfway House Gulch		-	U	++	U	-	---	---	---	+++
Daugherty Creek	1993	-	U	-	U	-	--	---	--	--
	2002	-	U	++	U	-	-	--	+	+
Soda Creek	1995	-	U	++	U	-	---	---	---	-
	2002	-	U	++	U	-	--	---	--	++
Gates Creek	1993	-	U	++	U	-	---	---	---	--
	2002	-	U	+++	U	-	-	--	++	+
Johnson Creek (Gates Creek Tributary)	1993	-	U	++	U	-	---	---	---	---
	2002	-	U	+++	U	-	--	---	--	-
Horse Thief Creek		-	U	+++	U	-	---	---	---	U
Snuffins	1993	-	U	++	U	-	---	---	---	---

Stream	Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Creek (2002) 2002	-	U	++	U	-	--	---	--	-
Johnson Creek	-	U	+	U	-	--	---	-	++
Dark Gulch	-	U	++	U	-	---	---	---	+
Montgomery Creek	-	U	++	U	-	---	---	---	--
South Fork Big River Tributary #1	-	U	+	U	-	--	---	--	-
South Fork Big River Tributary #2	-	U	++	U	-	--	---	--	--
Russell Brook	-	U	++	U	-	--	---	--	--
Martin Creek	-	U	++	U	-	---	---	---	-
Martin Creek Left Bank Tributary	-	U	+++	U	-	---	---	---	--
Martin Creek Right Bank Tributary #1	-	U	++	U	-	---	---	---	--
Martin Creek Right Bank Tributary #2	-	U	+++	U	-	--	---	--	---
Valentine Creek	-	U	++	U	-	---	---	---	-
Rice Creek	-	U	++	U	-	--	---	--	--

Key: Highest Suitability +++ ++ +
Lowest Suitability -- --- -
U Insufficient Data or Undetermined

Analysis of Tributary Recommendations

CDFG inventoried 105.1 miles on 41 tributaries in the Inland Subbasin. A CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories (Table 13). More details about the tributary recommendation process are given in the Big River Synthesis Section of the Basin Profile.

Table 13. Ranked tributary recommendations summary in the Inland Subbasin based on CDFG stream inventories.

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
North Fork Big River	12.0			2			1				
East Branch North Fork Big River	7.4	4	5	6	1	2	3				
Chamberlain Creek	5.1			2			1				
Water Gulch	1.9		2				1				
Water Gulch Tributary	0.4		2				1				
Park Gulch	1.0		2				1				
West Chamberlain Creek	3.5	3	4			1	2				
Gulch Sixteen	0.9		3			1	2				
Gulch Sixteen Tributary	0.4		3				2				1
Arvola Gulch	0.9	4	3		1		2		5		
Lost Lake Creek	0.9	3	4			1	2				
Soda Gulch	0.7		3				2		4		1
James Creek	4.4		2	4		3	1				
James Creek North Fork	2.4		3		1	4	2				
South Fork Big River Part 1	11.7	4	5	2	1	6	3		7		
South Fork Big River Part 2	8.8	2	3				4				1
Biggs Gulch	0.5	5				2		3	4		1
Ramon Creek	3.0	2		4		1			5		3

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
North Fork Ramon Creek	1.5	1	2			3			4		
Mettick Creek	1.0	1	2			3	4				
Anderson Gulch	0.5	1	2			3	4		5		
Boardman Gulch	1.3	1	2			3	4		5		6
Daugherty Creek	8.8			3		1	2				4
Soda Creek	1.7					1	2				
Gates Creek	2.7		1								
Johnson Creek (Gates Creek Tributary)	1.2	3				1	2				
Horse Thief Creek	0.1								1		
Snuffins Creek	1.3		3			1	2		4		
Johnson Creek	0.9	1		3	2	4	5		6		7
Dark Gulch	1.4		2	1	6	4			3		5
Montgomery Creek	0.7	1	2			3	4				5
South Fork Big River Tributary #1	1.1	2		1		3	4				5
South Fork Big River Tributary #2	0.6	2	3		1	4	5				
Russell Brook	4.1	1	2			4	6		3	5	
Martin Creek	3.7	1	2			4	5		3	6	7
Martin Creek Left Bank Tributary	0.6	1	2			3	4		5		
Martin Creek Right Bank Tributary #1	1.5	1				2	3		4		5
Martin Creek Right Bank Tributary #2	0.6	1				2	3		4		5
Valentine Creek	1.8	2	3		1	4	5		6		7
Rice Creek	1.8	2	3		1	4	5		6		7

Temp = summer water temperatures seem to be above optimum for salmon and steelhead; Pool = pools are below target values in quantity and/or quality; Cover = escape cover is below target values; Bank = stream banks are failing and yielding fine sediment into the stream; Roads = fine sediment is entering the stream from the road system; Canopy = shade canopy is below target values; Spawning Gravel = spawning gravel is deficient in quality and/or quantity; LDA = large debris accumulations are retaining large amounts of gravel and could need modification; Livestock = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; Fish Passage = there are barriers to fish migration in the stream.

In order to further examine Inland Subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 14). When examining recommendation categories by number of tributaries, the most important recommendation category in the Inland Subbasin is Erosion/Sediment.

Table 14. Top three ranking recommendation categories by number of tributaries in the Inland Subbasin.

Target Issue	Related Table Categories	Count
Erosion / Sediment	Bank / Roads	44
Riparian / Water Temp	Canopy / Temp	15
Instream Habitat	Pool / Cover	41
Gravel / Substrate	Spawning Gravel / LDA	5
Other	Livestock / Barrier	5

However, comparing recommendation categories in the North Fork Subbasin by number of tributaries could be confounded by the differences in the number stream miles surveyed on each tributary. Therefore, the number of stream miles in each subbasin assigned to the various recommendation categories was calculated (Figure 8). When examining recommendation

categories by number of stream miles, the most important recommendation categories in the Inland Subbasin shift to Instream Habitat, Erosion/Sediment, and Riparian/Water Temp. These comprise the top tier of recommended improvement activity focus areas.

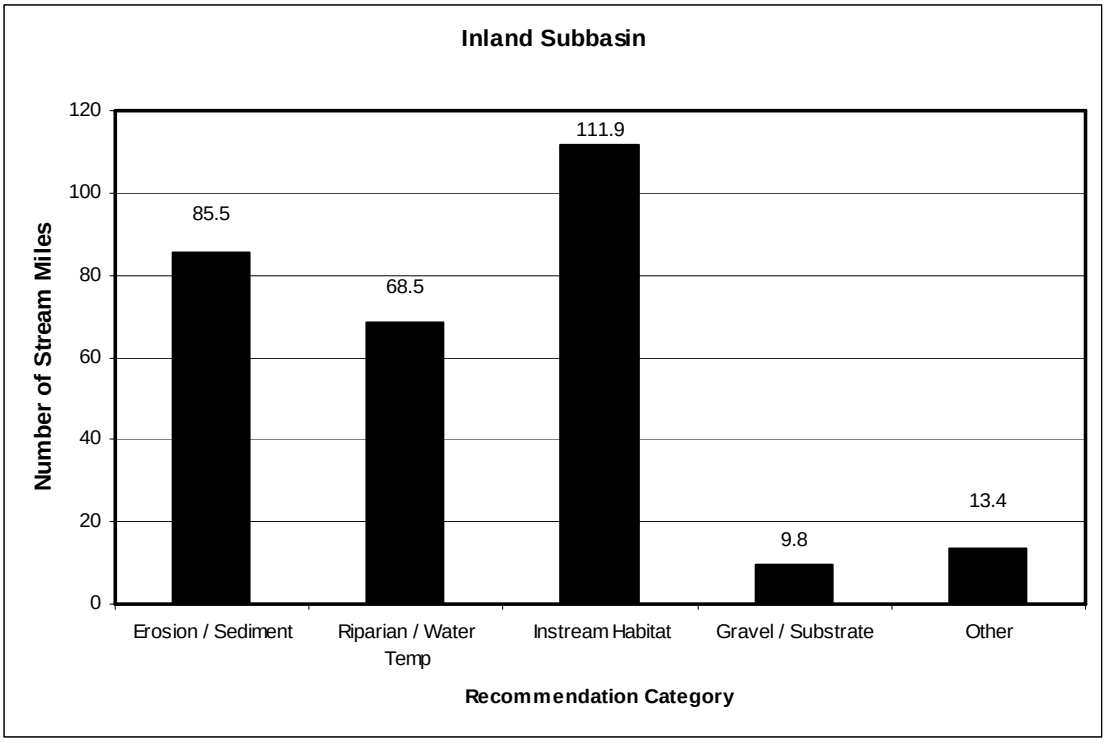

Figure 8. Recommendation categories by stream miles in the Inland Subbasin.

The high number of Instream Habitat, Erosion/Sediment, and Riparian/Water Temp recommendations across the Inland Subbasin indicates that high priority should be given to restoration projects emphasizing pools, cover, sediment reduction, and riparian replanting.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Inland Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by NCWAP's EMDS at the stream reach scale.

The most complete data available in the Inland Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Inland Subbasin on surveyed streams are generally rated as medium potential refugia. North Fork Big River, East Branch North Fork Big River, Chamberlain Creek, Water Gulch, West Chamberlain Creek, Arvola Gulch, South Fork Big River, Daugherty Creek and Gates Creek provide the best salmonid habitat in this subbasin. Stream Donkey, Quail, Soda, and Poverty gulches provide low quality refugia. Additionally, the North Fork and South Forks Big River and Daugherty Creek serve as critical contributing areas. The following refugia area rating table summarizes subbasin salmonid refugia conditions:

Table 15. Tributary Salmonid Refugia Area Ratings in the North Fork Subbasin.

Stream	Refugia Categories*:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
North Fork Big River		X				X	X
Stream Donkey Gulch				X			X
Dunlap Gulch			X				X
East Branch North Fork Big River		X					X
Quail Gulch				X			X
Bull Team Gulch		X					X
Frykman Gulch			X				X
Chamberlain Creek		X					X
Water Gulch		X					X
Water Gulch Tributary			X				X
Park Gulch				X			X
West Chamberlain Creek		X					X
Gulch Sixteen			X				X
Gulch Sixteen Tributary			X				X
Arvola Gulch		X					X
Lost Lake Creek			X				X
Soda Gulch				X			X
James Creek		X					X
James Creek North Fork			X				X
South Fork Big River		X				X	X
Biggs Gulch			X				X
Ramon Creek		X					X
North Fork Ramon Creek		X					X
Mettick Creek			X				X
Poverty Gulch				X			X
Anderson Gulch				X			X
Boardman Gulch			X				X
Halfway House Gulch			X				X
Daugherty Creek		X				X	X
Soda Creek		X					X
Gates Creek		X					X
Johnson Creek (Gates Creek Tributary)			X				X
Horse Thief Creek			X				X
Snuffins Creek		X					X

Stream	Refugia Categories*:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Johnson Creek			X				X
Dark Gulch		X					X
Montgomery Creek				X			X
South Fork Big River Tributary #1		X					X
South Fork Big River Tributary #2		X					X
Big River mainstem		X					X
Russell Brook		X					X
Pig Pen Gulch			X				X
Martin Creek		X					X
Martin Creek Left Bank Tributary			X				X
Martin Creek Right Bank Tributary #1		X					X
Martin Creek Right Bank Tributary #2			X				X
Valentine Creek		X					X
Rice Creek			X				X
Subbasin Rating			X				X

*Ratings in this table are done on a sliding scale from best to worst.

Inland Subbasin Profile: Responses to Assessment Question Six:

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Flow and Water Quality Improvement Activities

- Protect instream flows in James Creek, Chamberlain Creek, East Branch North Fork Big River, Montgomery Creek, and Russell Brook to help moderate or cool the warmer North and South Forks and mainstem Big River in the summer;
- Ensure that adequate streamside protection measures are used to provide shade canopy and reduce heat inputs to the North and South Forks Big River, mainstem Big River, and Daugherty Creek.

Fish Passage

- Consider modifying fish passage barriers on Dark Gulch, Johnson Creek, an Unnamed tributary to the South Fork of the Big River, Gulch Sixteen Tributary, and Soda Gulch.

Erosion and Sediment Delivery Reduction Activities

- Continue efforts such as road improvements and decommissioning throughout this subbasin to reduce sediment delivery to Big River and its tributaries. CDFG stream surveys indicated that road sediment inventory and control were top tier tributary recommendations in:

  Anderson Gulch
  Arvola Gulch
  Boardman Gulch
  Dark Gulch
  Gates Creek
  Gulch Sixteen
  Gulch Sixteen Tributary
  James Creek
  Martin Creek
  Martin Creek Left Bank Tributary
  Mettick Creek
  Montgomery Creek
  North Fork James Creek
  North Fork Ramon Creek
  Park Gulch
  Rice Creek
  Russell Brook
  Soda Gulch
  South Fork Big River
  South Fork Big River Tributary #2
  Valentine Creek
  Water Gulch
  Water Gulch Tributary

- Sediment sources from eroding streambanks and adjacent hillslopes should be identified and treated to reduce sediment generation and delivery to creeks in the Chamberlain Creek PW, South Fork drainage, and the headwaters drainage.

Riparian and Instream Habitat Improvement Activities

- Consider adding pool enhancement elements (e.g. LWD) to increase the number of pools or deepen existing pools and add shelter complexity to all surveyed tributaries in the North Fork drainage, Daugherty, Soda, Johnson (tributary to Gates Creek), and Snuffins creeks, and the right bank tributaries of Martin Creek;
- Consider modifying debris accumulations in Horsethief Creek, Dark Gulch, Russell Brook, and Martin Creek to facilitate fish passage;
- Ensure that this high quality habitat is protected from degradation. The highest stream reach conditions as evaluated by the stream reach EMDS and refugia analysis were found in the North Fork Big River, East Branch North Fork Big River, Chamberlain Creek, Water Gulch, West Chamberlain Creek, Arvola Gulch, South Fork Big River, Daugherty Creek and Gates Creek.

Education, Research, and Monitoring Activities

- Continue water temperature monitoring at current locations where high temperatures have been detected on the mainstem Big River, North and South Forks Big River, James, Gates, Martin, Ramon, and Daugherty creeks;
- Conduct a stream habitat survey of the mainstem Big River upstream from the confluence with North Fork Big River.

Subbasin Conclusions

The Inland Subbasin is the largest of the Big River Subbasins. Additionally, land use impacts in this subbasin occurred later in time than the other two subbasins due to its location further inland, away from easy ocean access. Much of this subbasin is owned and managed by the JSDF and large timber companies. Salmon and steelhead habitat conditions in the Inland Subbasin are generally degraded, but support some salmonid production. Salmonid populations are currently

being limited by reduced habitat complexity, high water temperatures, low summer stream flows, embedded spawning gravels, and artificial passage barriers. However, historical accounts indicate that stream conditions were favorable for salmonid populations in the past.

There are many opportunities for improvements in stream conditions in this subbasin as well as a great need to restore areas of stream refugia. Surveys by landowners, water temperature monitoring, riparian canopy restoration, improvements to channel complexity such as additional LWD are examples of such opportunities. The stability and erosiveness of terrain should be considered before project implementation and appropriate BMPs should be followed to minimize erosion and sediment delivery to streams. Conditions beneficial to salmonids may be further enhanced in this subbasin through encouraging all motivated subbasin landowners to use good land stewardship practices and enlisting the aid and support of agency technology, experience, and funding opportunities.

Big River Basin in the Regional Context

The Big River Basin is a fairly small watershed located on the Mendocino coast, far from major metropolitan areas. The 2000 Census counted just over 500 people in the basin and most of the land is owned by large timber companies or in public ownership. The predominant landuse both historically and currently is timber harvest. Much of the basin has been harvested multiple times. Prior to 1920, 27 splash dams were used across the basin and these impacted all downstream channels. However, historical accounts indicate that the coho salmon and steelhead trout in the Big River Basin appeared to begin declining in the 1950s. This could indicate that the watershed impacts from tractor logging were more related to the salmonid decline than splash damming. Current salmonid populations appear to be limited by poor quality summer rearing and overwintering habitat due to reduced habitat complexity, high water temperatures in the mainstem Big River, low summer stream flows in tributaries in the Inland Subbasin, embedded spawning gravels, and artificial passage barriers. Landowners have shown great interest in recovering the fisheries resources of the basin and restoration projects on both public and private lands hold much promise for the future.

Summary of Basin Conditions and Recommendations

Geology

- The Big River Basin is primarily comprised of Coastal Belt Franciscan Complex, which is relatively stable compared to the mélange terrane of the Central Belt found only in the upper parts of the watershed;
- The Coastal and Middle subbasins have lower relief and longer slopes while the Inland Subbasin has a high percentage of area in higher slope classes;
- Steep slopes, weathered and fractured marine sedimentary rock, tectonic activity, locally thick colluvial soils, a history of timber harvest practices, and the occurrence of high intensity rainfall events combine to make mass wasting a common occurrence in the Big River Basin;
- A study of landslides on MRC ownership within the basin, which comprises 29% of the basin, found that the vast majority of landslides occurred on slopes greater than 60%, and few landslides on lower gradient slopes were not triggered by roads or skid trails.

Land Use Impacts

- Roads, timber harvesting, and grasslands are listed in the Total Maximum Daily Loads as major sources of human-related sediment into streams;
- There has been a significant increase in road building since 1989 across the basin, especially in the Coastal and Middle subbasins. However, new roads have been built to higher standards, on ridge-tops, and are paved; thus creating less of a sediment source;
- Construction of near stream railroads in the Coastal and Middle subbasins and North Fork Big River and roads throughout the basin constricted stream channels and destabilized streambanks;
- Studies in the basin have indicated that over half of the shallow-seated landslides are associated with roads and that these landslides contributed sediment to watercourses in the study period of 1970 to 2000;

- Over 40 years of splash dam logging across the basin before 1920 led to stream channels that are deeply entrenched, cut down to bedrock in many places, lacking functional floodplains, and depleted of LWD;
- As a result of timber harvest, the current landscape is comprised of smaller diameter forest stands than in the past, this limits the recruitment potential of large woody debris to streams and contributes to a lack of instream habitat complexity;

Water Quality

- Water temperatures at monitoring sites in the mainstem of the Big River and larger tributaries in the Inland Subbasin such as the North and South forks Big River were unsuitable for salmonids. Temperatures Coastal and Middle tributaries were generally suitable for salmonids;

Salmonid Populations

- Both historic and current data are limited. Little data are available on population trends, relative health, or diversity. According to NOAA Fisheries listing investigations, the populations of salmonids have likely decreased in the Big River Basin as they have elsewhere along California and the Pacific Coast;
- Based on limited CDFG, USFWS, HTC, MRC, and SONAR presence surveys and surveys documented by NMFS since the 1960s, the distributions of coho salmon and steelhead trout do not appear to have changed;
- More reaches surveyed by CDFG and MRC since 1990 had steelhead trout that coho salmon;
- Thirty tributaries, the mainstem Big River, and the estuary had records of coho salmon and steelhead trout since 1990. Twenty additional tributary also recorded only steelhead trout.

Salmonid Habitat

- Salmonid habitat conditions in the Big River Basin are generally best in the Coastal Subbasin, and mixed in the Middle and Inland subbasins;
- Several reaches where fine sediment data has been collected indicate that levels are high and conditions may be unsuitable for salmonids;
- Cobble embeddedness in spawning gravels in many surveyed tributaries across the basin indicated that conditions were unsuitable for salmonid spawning success. In addition measured permeability in spawning areas in Daugherty and Ramon creeks indicated significant amounts of fine materials;
- Canopy cover was suitable for salmonids on all surveyed reaches within the basin except for James Creek and the mainstem Big River. As a larger order stream, the mainstem Big River is expected to have lower canopy levels.
- In general, a high incidence of shallow pools, and a lack of cover and large woody debris have contributed to a simplification of instream salmonid habitat in surveyed tributary reaches and the estuary;
- Fish passage barriers have been identified in seven surveyed tributaries across the basin and small tributaries along the estuary are blocked to fish passage by perched culverts. Additionally, areas of dry channel in some tributaries in the drier summer months may indicate fish passage problems.

Limiting Factors Analysis Conclusions

Based on available information for the Big River Basin, the team believes that current negative salmonid habitat conditions include:

- Reduced habitat complexity;
- High water temperatures in the mainstem Big River;
- Low summer stream flows in tributaries in the Inland Subbasin;
- Embedded spawning gravels;
- Fish passage barriers.

Refugia Rating

Based on this assessment of watershed processes and conditions, fishery status, and current salmonid habitat, the Big River Basin has medium potential as refugia for salmon and steelhead trout. Salmonid habitat conditions in the Big River Basin are generally best in the Coastal Subbasin, and mixed in the Middle and Inland subbasins.

Recommendations

Flow and Water Quality Improvement Activities

- Protect instream flows in tributaries with cooler water temperatures for thermal refugia from the warmer North and South Forks and mainstem Big River in the summer;
- To minimize and reduce the effects of water diversions, take actions to improve SWRCB coordination with other agencies to address season of diversion, off-stream reservoirs, bypass flows protective of coho salmon and other anadromous salmonids and natural hydrograph, and avoidance of adverse impacts caused by water diversion;
- Land managers should work to reduce the temperature of water flowing into the Middle and Coastal subbasins. In order to do this, they should maintain and/or establish adequate streamside protection zones to increase shade and reduce heat inputs to Big River and its tributaries throughout the basin;
- Follow the procedures and guidelines outlined by NCRWQCB to protect water quality from ground applications of pesticides.

Erosion and Sediment Delivery Reduction Activities

- To reduce sediment delivery to Big River, land managers should continue their efforts such as road improvements, good maintenance, and decommissioning and other erosion control practices associated with landuse activities throughout the basin. Thirty-six CDFG stream surveys had road sediment inventory and control as a top tier tributary recommendation;
- Support and encourage existing and active road management programs undertaken by landowners throughout the basin;
- Sediment sources from eroding streambanks and adjacent hillslopes should be identified and treated to reduce sediment generation and delivery to creeks;
- Map unstable soils and use soil mapping to guide land-use decisions, road design, THPs, and other activities that can promote erosion;
- Limit winter use of unsurfaced roads and recreational trails by unauthorized and impacting uses to decrease fine sediment loads;
- Develop erosion control projects similar to the North Fork Ten Mile River erosion control plan (Mendocino Department of Transportation 2001).

Riparian and Habitat Improvement Activities

- Improve instream structure for juvenile ambush escape and cover, including the addition of LWD to develop habitat diversity and to increase shelter complexity, where appropriate/feasible. Thirty-one CDFG stream surveys and the mainstem Big River have increase escape cover as a top tier tributary recommendation. In addition, there is a need to leave large wood on stream banks and in estuarine channels for potential recruitment into stream channels and the estuary;
- Maintain and improve existing riparian cover where needed;
- Ensure that any land management activities include protection and preservation of stream and riparian habitats and maintain or improve ecological integrity within the basin;
- Consider modifying debris accumulations to facilitate fish passage where necessary;
- Adequately fund prioritization and upgrading of culverts to provide coho salmon passage within the range of coho salmon and to pass 100-year flows and the expected debris loads;
- Ensure that high quality habitat is protected from degradation. Salmonid habitat conditions in the Big River Basin are generally best in the Coastal Subbasin, and mixed in the Middle and Inland subbasins;
- Consider the use of management strategies such as conservation easements to maximize potential benefits to aquatic habitats from near-stream forest protection.

Education, Research, and Monitoring Activities

- State Parks, DFG, MRC, and HTC should continue and expand existing monitoring of anadromous salmonid populations to include some winter and spring fish sampling;
- Support stream gage installations and maintenance to establish a long term record of Big River hydrologic conditions;
- Additional investigations of the physical characteristics of Big River are needed to re-evaluate the Sediment Source Analysis. A regional curve of bankfull dimensions vs. drainage area should be developed for Mendocino County and used to validate CGS (2004) bankfull discharge estimates for Big River;
- Hillslope and in-stream monitoring proposed by the MRC in their Watershed Analysis (2003) should be carried out and additional monitoring programs throughout the basin should planned with respect to be comparable to MRC techniques;
- A study examining how sediment plugs moved downstream from historic splash dam locations over time on air photos is recommended;
- Continue water temperature monitoring at current locations and expand these efforts where appropriate;
- Further study of timberland herbicide use is recommended.

Propensity for Improvement

Advantages

The Big River Basin has several advantages for planning and implementing successful salmonid habitat improvement activities that include:

- An expanding group of cooperative landowners that includes both public and private landowners from all thee subbasins in the Big River that are interested in improving watershed and fishery conditions. The effect of this is the ability to choose locations for projects where the best result can be achieved in the shortest time period;

- The recent purchase of a large portion of the estuary and transfer to the State of California for management as a park also will likely improve temperature and sediment conditions in that area of the Big River Basin;
- Much Of the basin is in the ownership of a few large landowners, making the creation and implementation of a coordinated basin-wide watershed program simpler;
- This assessment provides focus on watershed conditions and processes from the basin scale, through the subbasin scale, and down to the level of specific tributaries. This helps focus project design efforts so that local landowners can pursue the development of site specific improvement projects on an adaptive basis;
- Like most river systems, Big River coho salmon and steelhead trout meta-populations have evolved and adapted to the basin's unique conditions. Although these meta-populations are likely below historic levels, there remain local stocks that can take advantage of improved conditions.

Challenges

The Big River Basin also has some challenges confronting efforts to improve watershed and fish habitat conditions, and increase anadromous fish populations:

- Not all landowners are interested in salmonid habitat improvement efforts. Without a watershed wide cooperative land-base, treatment options are limited. In some cases this can remove some key areas from consideration of project development;
- Current levels of coho salmon and steelhead meta-populations could limit the amount of needed straying to rapidly colonize fish into improved or expanded habitat conditions.

Conclusion

The likelihood that any North Coast basin will react in a responsive manner to management improvements and restoration efforts is a function of existing watershed conditions. In addition, the status of processes influencing watershed condition will affect the success of watershed improvement activities. A good knowledge base of these current watershed conditions and processes is essential for successful watershed improvement.

Acquiring this knowledge requires property access. Access is a requirement to design, implement, monitor, and evaluate suitable improvement projects. Thus, systematic improvement project development is dependent upon the cooperative attitude of resource agencies, watershed groups and individuals, and landowners and managers.

The Big River assessment has considered a great deal of available information regarding watershed conditions and processes in the basin. This long assessment process has identified problems and made recommendations to address them while considering the advantages and challenges of conducting watershed improvement programs in the Big River Basin.

After considering these problems, recommendations, advantages and challenges, the Big River Basin appears to be an excellent candidate for a successful long-term, programmatic watershed improvement effort. According to the current refugia analysis, the Big River has medium potential to become a basin with high quality fishery refugia. Reaching that goal is dependent upon the formation of a well organized and thoughtful improvement program founded on broad based community support for the effort.

Limitations of this Assessment

This watershed assessment provides useful and valuable information and represents a considerable effort of the involved agencies, contractors, and public. It was limited in duration, scope, detail, and analysis level due to constraints in budget, time, access, and overall resources. Specific limitations are presented below to put the assessment in context.

- This assessment only addresses habitat conditions in the Big River Basin. Ocean habitat conditions are not addressed;
- Data collected from individual stream reaches or point locations within them were described in relation to their streams or subbasins. As descriptions and inferences are extrapolated from those data to larger regional and basin scales, the certainty associated with those conclusions and inferences is reduced;
- CGS produced GIS data and maps. Preliminary interpretations based on geologic and geomorphic data are presented herein;
- CDFG's habitat inventory surveys provided instream condition data to the EMDS Stream Reach Model, the Limiting Factors Analysis, and the Restoration Recommendations and Priorities. However, not all subbasin streams were surveyed. Basin wide 34.1% of the stream length was surveyed;
- A lack of information on the suitability and/or use of the estuarine habitat for rearing and over-wintering by juvenile salmonids;
- CDF's land use analysis used aerial photos exclusively;
- Monitoring of two water temperature sites on James Creek in 1994 was conducted by JSF. Although the raw data are not available, summary data such as MWAT and maximum temperature was reported (Valentine 1994). Neither of these sites appeared in the FSP data;
- Many of the water temperature data loggers were set to collect data at 120 or 144 minutes. Previous research (Lewis et al. 2000) suggests that monitoring intervals greater than 96 minutes may result in missing the instantaneous peak temperatures. Therefore, it is possible that the MWMT and overall maximum temperatures may be slightly understate these values;
- It is presumed that all of the monitoring locations, except the MWA sites, are representative of the conditions in their respective stream reaches. For example, for water temperature monitoring sites, it was assumed that the data loggers were placed in a location that was representative of the average summer water temperatures in their respective thermal reach. MWA's stated goal was to monitor thermal refugia for salmonids. Therefore, these temperature monitors were generally placed in deep pools and other areas where you would expect water temperatures to be lower than the average for the thermal reach;
- In many sites throughout the Big River Basin, jumps in water temperatures in excess of 4°F were observed in consecutive measurements. In no case was it determined that a data set should be excluded because of this temperature variation. In absence of any other abnormal data characteristics, it was hypothesized that the observed temperature jump was likely the result of sudden direct exposure of sunlight in the thermal reach. If this is the case, it would be naturally occurring and representative of stream conditions. However, study of these cyclical temperature increases should be undertaken to verify the cause;
- Only surface water quality was assessed. In the instances where the streams are "gaining" (receiving groundwater input), the surface water will be a combination of surface run-off and groundwater. Therefore, surface water quality was assessed under the assumption that any influence from groundwater would appear in the overall surface water quality.

Groundwater water quality data, if it exists, was not incorporated separately into this assessment;

- As mentioned previously, the bulk sediment sampling for both MRC and GMA were collected using a gravimetric technique, which can lead to significantly different results from the volumetric technique that the Big River TMDL target is based on. Furthermore, MRC reported the gravimetric fractions of the entire bulk sediment samples, while GMA only reported the subsurface fractions of the samples. Therefore, even through data from MRC and GMA was reportedly collected in a similar manner, the data may be skewed relative to each other;
- During the review of the raw water temperature data plots, it was noted that there were, in some cases, unusual diurnal fluctuations. Typically, these types of issues were resolved by comparing the periods of unusual fluctuations with the same period of record at other sites in the subbasin. By close inspection of other nearby sites, it was often discovered that while they do not exhibit such dampened diurnal fluctuations, they do show a similar pattern in the fluctuations. Data loggers that exhibited unusual diurnal fluctuations that appeared to be unresponsive to temperature changes in their respective subbasin would be indicative of equipment or battery failure. In the Big River Basin, only one data set was not used for this type of problem. This was the single season recorded at Lower Quail Gulch (MRC 75-20), which did not appear to respond to basin-wide temperature variations and may have malfunctioned. Additional years of data are needed at this site to determine if it is characteristic of the site or if it was indeed a malfunctioning unit. Any file that did not cover the period of June 21 to August 15 or by visual inspection appeared to miss the peak temperatures were flagged. In the Big River Basin, six such temperature files were not used because it was determined that the recorded period likely missed the peak temperatures;
- The EMDS model used is preliminary; not all components of the model are currently in use due to data and modeling issues (i.e., stream temperature, fish passage, stream flow); not all data layers used in the model were fully subjected to quality control review.