United States
Department of
Agriculture

**River Basin
Planning Staff**

Soil
Conservation
Service

Forest
Service

Davis,
California

February 1989

EAST BRANCH NORTH FORK

FEATHER RIVER

EROSION INVENTORY REPORT

THIS REPORT IS A RECONNAISSANCE LEVEL STUDY AND IS NOT TO BE USED FOR SITE SPECIFIC PURPOSES. THIS INFORMATION IS TO BE USED FOR <u>GENERAL PLANNING AND DECISION MAKING</u> TO DETERMINE AREAS FOR FURTHER DETAILED STUDIES ON SPECIFIC SUBWATERSHEDS. THE NUMBERS GIVEN ARE FOR <u>COMPARISON PURPOSES ONLY AND ARE NOT ABSOLUTE</u>.

EAST BRANCH NORTH FORK
FEATHER RIVER
EROSION INVENTORY REPORT

Plumas County, California

FEBRUARY 1989

Prepared By:
RIVER BASIN PLANNING STAFF
USDA-Soil Conservation Service
Forest Service
DAVIS, California

In Cooperation With:
Memorandum Of Agreement/Coordinated Resource Management Group

Principal Contributors Leading to the Publication of this Report:

Field Crew:

Patricia Bever, Field Crew Leader, Plumas Corporation
Susan Fregien, Plumas Corporation
Mike Kossow, FS
Clay Clifford, FS
Heidi Weinert, DWR

USDA Forest Service

Greenville

Ken Roby, District Resource Officer
Ken Cawley, District Hydrologist

Quincy

Chuck Sturry, Forest Watershed Officer
Terry Benoit, Forest Hydrologist
Allen King, Forest Geologist

La Porte

Chris Frye, Forest Fishery Biologist

Pacific Gas and Electric Company

San Francisco

Larry Harrison, Project Manager
Wing Lee, Civil Engineer
Larry Carver, Land Planning Analyst

San Ramon

Donna Lindquist, Research Biologist

Plumas Corporation

Quincy

Leah Wills, Erosion Control Project Coordinator

USDA Soil Conservation Service

Davis

Lyle Steffen, State Geologist
Robin White, River Basin Planning Staff Geologist
Mike Rogers, Geologist
Kim Schwab, Geologist
Norman Evanstad, Geologist

Red Bluff

Joe Jahnke, Area Soil Scientist

Loyalton

Dan Kaffer, District Conservationist

Susanville

Steven Slusser, Soil Scientist

TABLE OF CONTENTS

EAST BRANCH OF THE NORTH FORK FEATHER RIVER WATERSHED EROSION INVENTORY REPORT

SUMMARY of FINDINGS

Different sponsors feel there are different criteria for ranking subwatersheds. Until these criteria are defined, the rate of sedimentation (tons/mi^2) will be used to define the severity of the problem in this report. All of the sediment yields were measured at Rock Creek Reservoir, which marks the mouth of the East Branch North Fork Feather River Watershed Study Area (EBNFFR) (Figure 1). The Above Antelope Lake Subwatershed (#12) has the highest average rate of sediment yield. The highest average rate of sediment production to the mouth of the study area is from the North Fork of the Feather River (Subwatershed #3). Seven other subwatersheds produce sediment higher than the average for the EBNFFR watershed study area (excluding Above Antelope Lake), which is 1,040 tons per square mile per year. These subwatersheds are North Fork of the Feather River (#3), Wolf Creek-Round Valley (#9), Upper Spanish Creek-Rock Creek (#5), Lower Spanish Creek (#6), Last Chance Creek (#13), Húngary Creek-Middle Indian Creek (#11), and Greenhorn Creek (#7). Including Above Antelope Lake (#12), the average sediment yield to the end of the study area becomes 1,120 tons per square mile per year.

The primary sources of sediment are streambank erosion and sheet and rill erosion on road cut/fill slopes. Bank erosion on tributary streams to the major streams in the valleys contribute 40 percent of the sediment to the mouth of the watershed. Road cut/fill slopes contribute an additional 43 percent and the banks of the major creeks in the valleys add about 15 percent of the total sediment production in the EBNFFR Watershed. Sheet and rill erosion on the ground and road surfaces, and gully erosion contribute approximately 2 percent (Table B).

Any potential erosion control work should focus on controlling tributary streambank erosion in the problem subwatersheds listed above. Stabilization of the major creeks in their valley floors will also help control erosion. Controlling erosion from road cuts would also significantly reduce sediment reaching the mouth of the study area.

INTRODUCTION

A reconnaissance level erosion inventory was made in the watershed of the East Branch of the North Fork Feather River in Plumas County, California from June 29 to December 4, 1987. The downstream end of the study area was located at Rock Creek Dam. The purpose of the inventory was to locate and quantify the

sources of erosion and sediment causing problems both in the watershed and at offsite locations.

Streambank erosion is voiding pasture, range and forest land and destroying riparian habitat. Road surfaces and cut/fill slopes are eroding causing traffic disruption, increasing county, state and federal maintenance costs and contributing to onsite and offsite water quality problems. Stream bottom degradation is lowering the water table in the valleys causing changes in the riparian habitat as well as the adjacent grazing lands. Bottom degradation in the valleys is translated into tributary stream bottom and bank erosion in the hills surrounding the valleys. Past and present land use is causing increased volumes of runoff which causes gully erosion and contributes to the channel erosion problems.

The sediment that results from all the erosion sources is causing water quality problems which result in losses in fishery habitat and recreation days (Chapman 1962, Megahan 1972, Duncan and Ward 1985). The sediment is trapped behind hydroelectric dams on the Feather River and impairs their flood control capability and power generation storage. The sediment deposition limits the use of the dams to simple diversion structures. Maintenance dredging at the diversion intakes, sediment effects on the operation of spill-gates controlling release-flows over the dams and turbine wear are some of the types of problems caused by the sediment at the dams.

Private entities, individuals and public agencies formed a local group in 1984 that began working towards finding solutions to some of the erosion and sediment problems in the EBNFFR Watershed. A memorandum of agreement (MOA) was developed and in 1987 the group adopted Coordinated Resource Management and Planning (CRM) as its' organizational tool to accomplish its objectives. Representatives of the Soil Conservation Service (SCS) proposed to this group in 1986 that an erosion inventory should be made so that any future projects would be implemented in the subwatersheds that were producing the highest rates of sediment. The inventory would also determine which erosion sources were producing the most sediment so as to facilitate analysis of alternative treatments based on their per ton cost effectiveness in reducing erosion and sedimentation.

The study was supported by several of the MOA/CRM group members. Pacific Gas & Electric (PG&E) provided $15,000.00 for two field geologists working for the Plumas Corporation in Quincy. Two technicians, housing and field vehicles were provided by the US Forest Service (FS), Plumas National Forest in Quincy. The FS also contributed $2,500.00 for additional field work. The California Department of Water Resources (DWR) in Red Bluff also provided a technician and vehicle.

The SCS provided guidance and training during the inventory through their Loyalton field office. They also contributed

$5,200 for additional field work beyond that funded by the FS and PG&E. Most of the data reduction and sample extrapolation was done by one of the Plumas Corporation field geologists at the SCS office in Davis. FS hydrologists also provided assistance during this data reduction and sample extrapolation phase.

SCOPE, INTENSITY, AND STUDY USE

The purpose of this report is to provide the MOA/CRM group a reconnaissance level inventory based on 300 samples for the entire 776,533 acres. This information is to be used for <u>general planning and decision making</u> to determine areas for further detailed studies on specific subwatersheds. The numbers given are for comparison purposes only and are not absolute.

When a specific subwatershed is chosen, additional and more specific information will be gathered and analyzed.

STUDY AREA

The study area is a portion of the East Branch of the North Fork Feather River located in Plumas County approximately 100 air miles north-northeast of Sacramento. The study area comprises 1,208.8 square miles (773,630 acres). The majority of the study area is located in the Plumas National Forest (PNF). Table A shows the relationship between the subwatersheds in the study area and PNF subwatershed numbers. The largest towns in the area are Quincy and Greenville.

In the original study, the EBNFFR watershed was divided into 13 study units based on similarities in climate, vegetative cover, topography, and soil parent material (Figure A1 in Appendix A). Sample sites were selected to occur on different soils, slopes, and vegetative cover. Table A1 in Appendix A shows some of the physical characteristics of the study units. The study unit boundaries were made to coincide with subwatershed boundaries in the Plumas National Forest database, except the five valley areas (American, Meadow, Thompson, Indian, and Genesee) were grouped into one study unit. Also, the railroad land was grouped into a separate study unit.

Field sample data was first expanded to the above 13 study units. The erosion by source for each study unit is displayed in Tables A-1 to A-14 (Appendix A).

At the May 17, 1988 CRM meeting, members agreed the data should be presented by hydrologic or subwatershed boundaries. The 15 subwatersheds are shown in Figure 1. The study units were recombined into the PNF subwatersheds using percentages based on the area of each study unit within the subwatershed boundary.

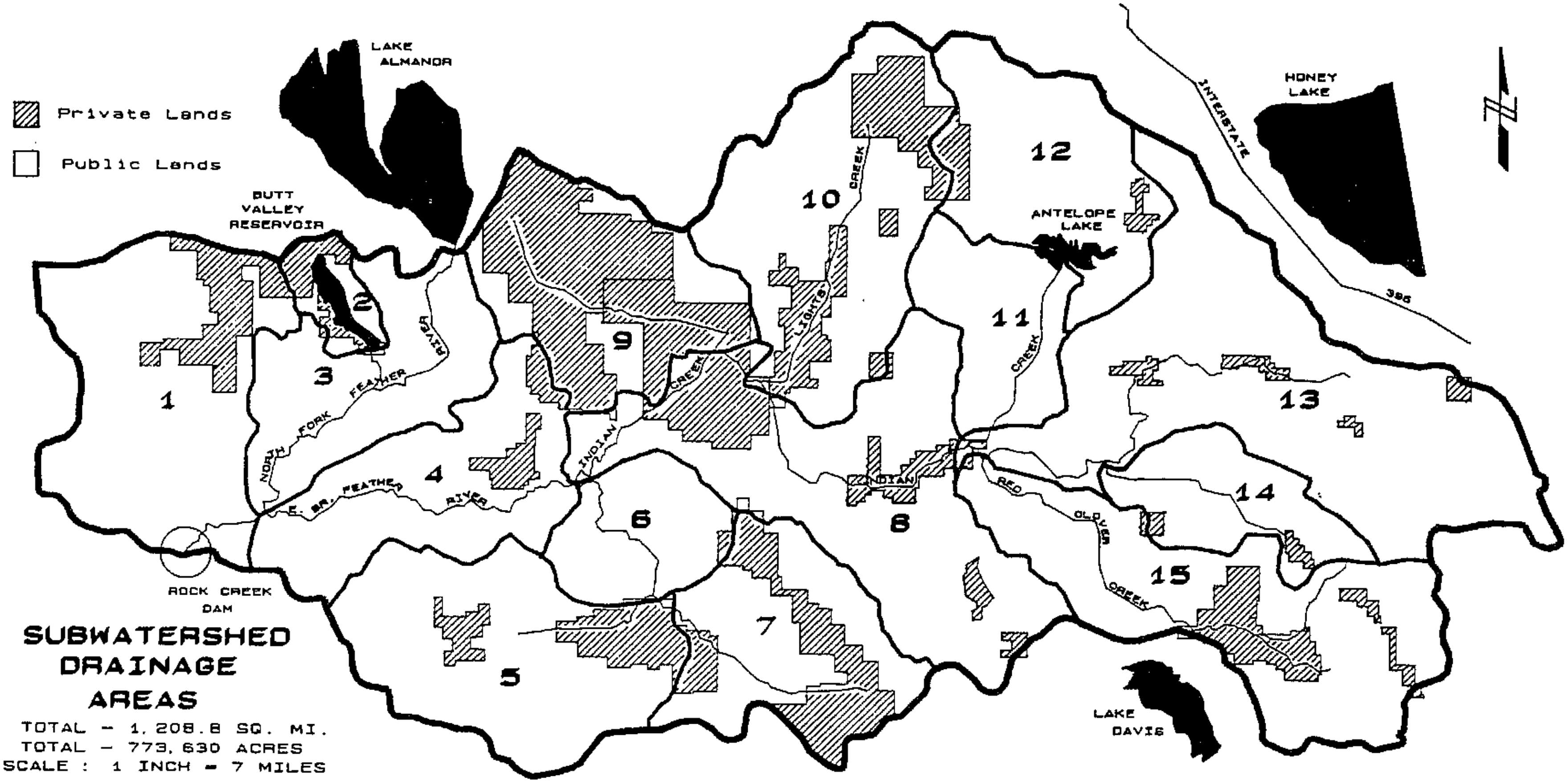
TABLE A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION INVENTORY

Relationship Between EBNFFR Subwatersheds and the National Forest System Watersheds (Plumas National Forest Subwatersheds)

Sub-watersheds	Creeks	PNF Subwatersheds #
1	Chips, Yellow Creek and Inner Gorge	9
2	Butt Valley Reservoir	11
3	N. Fork Feather River	10
4	Rush and Mill Creeks	13
5	Upper Spanish & Rock Creeks	24
6	Lower Spanish Creek	22
7	Greenhorn Creek	23
8	Little Grizzly & Hosselkus Creeks	14 A-H
9	Wolf Creek & Round Valley	15 A-C
10	Lights & Cooks Creeks	16 A-E
11	Hungary & Middle Indian Creeks	17 A-E
12	Above Antelope Lake	18 A
13	Last Chance Creek	21 A-H
14	Squaw Queen Creek	19 A-B
15	Red Clover & Dixie Creeks	20 A-E

EAST BRANCH NORTH FORK FEATHER RIVER



SUBWATERSHED DRAINAGE AREAS

TOTAL – 1,208.8 SQ. MI.
TOTAL – 773,630 ACRES
SCALE : 1 INCH = 7 MILES

Subwatershed Number	Name	Area Sq.Mi.	Area Acres	Subwatershed Number	Name	Area Sq.Mi.	Area Acres
	FOOT HILLS & CANYONS				INDIAN CREEK		
1	Chips- Yellow	105.2	67,200	8	Little Grizzly-Hosselkus	147.3	94,270
2	Butt Valley	11.2	7,170	9	Wolf-Round Valley	71.9	46,020
3	Below Lake Almanor	61.8	39,550	10	Lights-Cooks	117.4	75,140
4	Rush-Mill	76.6	49,020	11	Hungry-Middle Indian	41.2	26,370
	SPANISH CREEK			12	Above Antelope Lake	69.3	44,350
5	Upper Spanish-Rock	91.6	58,620		LAST CHANCE-RED CLOVER CRKS.		
6	Lower Spanish	34.8	22,270	13	Last Chance	116.8	74,750
7	Greenhorn	69.9	44,740	14	Squaw Queen	40.8	26,110
				15	Red Clover-Dixie	153.2	98,050

Figure 1

TOPOGRAPHY

The western slope of the Sierra Nevada rises gradually from the valley floor at a 2-6% slope in a band 50-60 miles wide. The eastern slope of the Sierra Nevada is a sharp drop to the valley floor, 2,000 to 3,000 feet in less than 10 miles.

The western portion of the study area is comprised of mountainous terrain bisected by many deep valleys with steep slopes. The North and Middle Fork of the Feather River and their tributaries have carved canyons as deep as 5,000 feet into the Sierran block. Narrow plateaus of the old erosional surface (prior to the Sierran uplift) are located between the canyons.

The eastern portion of the study area is characterized by northwest-southeast trending valleys separated or surrounded by mountains, which is characteristic of the Basin and Range Geomorphic Province. The surface features are the result of block faulting. Elevations range from about 2,100 to 7,700 feet. Slopes average 30-40 percent. Slopes less than 30 percent occur on ridge tops and valley floors. Stream gradients average 2-3 percent with the maximum perennial channel gradient being 10 percent.

The Feather River drainage is unique in that it is the only western drainage system that crosses the crest of the Sierra Nevada. This area to the east of the Sierra Nevada crest is called the Diamond Mountains by Cordell Durrell (1987).

CLIMATE

The study area is so large that it is comprised of two climatic zones. The crest of the Sierra Nevada acts as a barrier to the moisture laden air coming from the Pacific Ocean and the cold, dry air masses from the central United States in the winter. During the summer, the crest also acts as a barrier to the hot, dry air masses that develop over the central United States. This situation thus creates a high precipitation, cool summer, and mild winter climate on the western slope; and a low precipitation, hotter summer, and colder winter on the eastern slope (Ornduff 1974). Temperature decreases 1^{O}F. for every 300 feet gain in elevation.

The western Sierran portion of the study area is within the Mediterranean Climate Zone which consists of cold, wet winters and warm, dry summers. The average minimum temperature is 3.5^{O}F and the average maximum is 96.1^{O}F. Minimum temperatures occur in December to February with maximums in late July or August. The mean annual temperature is 47.1^{O}F. The average frost free period is 119 days. As one progresses up the western slope, precipitation will increase 2-4 inches for each 300 foot rise in elevation reaching a maximum at elevations of 5,000-6,000 feet and then decreases with a further increase in elevation. The average yearly precipitation at Greenville is 40.6 inches, 50

percent of which occurs as snow. There appears to be a 15 year periodicity of wet-dry cycles based on a plot of the 10 year moving averages for precipitation (PNF, unpublished report).

The eastern Sierran portion of the study area is in a "rain shadow" where little precipitation falls and desert conditions prevail. Total precipitation depends more on summer thunderstorms than winter snowfall. With the lessening of the marine influence, the temperature has a greater daily and seasonal variation. In Sierra Valley Basin, annual precipitation is 15-20 inches, while 10 miles further southeast in Long Valley the annual precipitation drops to 8-12 inches (Sketchley 1975). Temperature ranges from -30^{o}F. to 100^{o}F with the average annual temperature being 42-50^{o}F.

GEOLOGY and SOILS

The area is comprised of three different rock types: metamorphic, granitic, and sedimentary/volcanic. The oldest rocks are metamorphosed sedimentary and volcanic rocks of the Nevadian geosyncline that have been highly deformed. Massive granitic rocks form plutons that comprise the Sierra Nevada. The youngest rocks are sedimentary and Tertiary volcanic rocks that formed after the granitic intrusion. These rocks include glacial tills and sediment deposited in extinct lakes that once occupied most of the valleys in the study area. The volcanics cover a large portion of the eastern side and cap numerous peaks in the central area.

Most of the soils in the area are well drained, gravelly loams or clay loams. The productivity and manageability of the major soil types does not vary greatly. Exceptions to this are associated with rock outcrops, serpentine areas, breakland areas, and flood zones. Generally, the western slope has the more productive soils. Also, north-facing slopes have moister, deeper, and more productive soils than south-facing slopes. The erosion hazard is highest on granitic soils.

VEGETATION

For the western portion of the study area, vegetation changes depend on elevation and precipitation. The majority of the area is covered by mixed conifer timber. The most common conifers being Jeffery and ponderosa pine. Other conifers include incense cedar, white fir, red fir, Douglas fir, and sugar pine. Ceanothus and manzanita are common brush species associated with the mixed conifer forest.

For the eastern portion of the study area, the majority of the area is covered by mixed conifer timber. Major species are ponderosa pine, jeffery pine, and white fir. Incidental species are western juniper, lodgepole pine, white fir, and black oak (on disturbed sites). At elevations of 4,200-5,600 feet, pinyon

pine, Utah juniper, mountain mahogany, bitterbrush, and sagebrush can be found (Storer and Usinger 1963).

Riparian vegetation includes dogwood, grasses, sedges, willows, rushes, alders, cottonwoods, rose, ferns, and ceanothus. Willows are the most common component.

WATERSHED EROSION

The values stated for erosion and sediment yield in this report are average annual figures. The average annual figure takes into account the storm related events. The storm related events are reduced based on the frequency of the storm. Most of the damages in the study area were done by infrequent large storm events, especially streambank erosion.

The erosion by source for each subwatershed is displayed in Tables 1-15 (at the end of this report). The table number corresponds to the subwatershed number it is depicting. The erosion from Subwatershed #2, Butt Valley Reservoir, was not calculated because no sediment leaves the watershed. Therefore there is no Table 2. Table B is a summary of the data in Tables 1, 3-11, and 13-15. Table 12 is omitted from the summary because very little sediment reaches the end of the study area from above Antelope Lake. To convert tons to cubic yards, multiply the tons by a factor of 0.8. Tons were calculated from sediment volumes based upon a density of 90 pounds per cubic foot.

The largest source of erosion is from streambanks (55%). About 73% of this erosion is on smaller streams tributary to the major streams in the valleys. It appears that most of this erosion is due to a combination of increased runoff from the watersheds and the lowered base level of the larger creeks in the valleys causing headcutting, etc. The sediment yield of the major creeks in the valley floors is shown in the following table.

SEDIMENT YIELD FROM STREAMBANK EROSION
ON MAJOR CREEKS IN VALLEY FLOORS--Post 1987

Valley	Creek Miles	Erosion Rate Tons/Yr	Sediment Yield to Rock Creek Dam Tons/Yr	Tons/Mi
Genesee	6.8	31,500	28,400	4,170
Meadow	4.2	200	200	40
Indian	8.3	23,900	21,500	2,590
American	9.0	4,400	4,000	440
Thompson	0.5	100	.90	180

Table B

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
EBNFFR WATERSHED (SUBWATERSHEDS #1, 3-11, 13-15)

Type or Source of Erosion	Erosion in Study Unit		Sediment to Rock Creek Dam	
	(Tons/Yr)	(Percent)	(Tons/Yr)	(Percent)
SHEET & RILL EROSION				
Meadows	200	0.0	0	0.0
Forest	41,200	2.3	8,200	0.7
Brush	3,600	0.2	700	0.1
SUBTOTAL	45,000	2.5	8,900	0.8
Roads				
Surfaces	10,300	0.6	5,900	0.5
Cut Slopes	654,500	36.7	332,300	29.9
Fill Slopes	350,200	19.6	177,700	16.0
SUBTOTAL	1,015,000	56.9	515,900	46.5
TOTAL	1,060,000	59.4	524,800	47.3
STREAMBANKS				
Major Streams	103,600	5.8	93,400	8.4
Tributary Streams	594,100	33.3	475,500	42.8
SUBTOTAL	697,700	39.1	568,900	51.2
GULLY EROSION				
Associated w/ Streams	10,300	0.6	7,300	0.7
Associated w/ Roads	8,500	0.5	5,100	0.5
Associated w/ Uplands	8,600	0.5	4,500	0.4
SUBTOTAL	27,400	1.5	16,900	1.5
GRAND TOTAL	1,785,100	100.0	1,110,600	100.0

Table C illustrates channel changes over time. Aerial photographs, field surveys and oral histories were used to monitor changes. Based on the dimensions of abandoned channels on the valley floors, the ancestral creeks (pre-1850) in the valleys probably had capacity to carry only the 5-year flows or less. Prior to 1850, the creeks were probably choked with vegetation and most of the runoff from the hills would flood the valley floors. This would result in very little erosion.

Grazing, logging and mining from 1800 to 1900 changed the hydrology of the watersheds and the hydraulic characteristics of the creeks. Decreased cover, channel clearing, levee construction and diversions all contributed to increasing the runoff and sediment yield from the watersheds and concentrating flows into the channels on the valley floors. This caused the channel bottoms in the valleys to erode down which left the channel banks high and vertical. The corresponding drop in the water table combined with overgrazing by livestock continued to suppress the growth of the remaining riparian vegetation. The steepened banks began failing as the riparian vegetation was lost. Subsequent flows would remove the unvegetated sloughed material from the base of the banks so the banks could not stabilize at a less steep slope.

From 1900 to 1940, accelerated channel deepening and some channel widening occurred as the high, steep banks attempted to stabilize by the process of mass wasting. Aerial photo interpretation since 1940 indicates that accelerated widening has occurred with the riparian vegetation not reestablishing along the new channel banks. Figures 2 and 3 show the channel area changes for Indian Valley and Genesee Valley. It appears that the banks may be attempting to stabilize but a natural stream in soil is seldom stable until the banks become protected with vegetation. The vegetation deflects erosive flows from natural banks, accelerates sediment deposition in overbank areas, and reduces the capacity of the channel so high flows are dumped onto the flood plain where their erosive energy is dissipated.

Essentially no deepening occurred after 1940. Channel widening continued from 1941 to 1982 as the steepened banks attempted to stabilize. A major storm occurred in 1986 so a separate period from 1982 to 1987 was analyzed. Field surveys and photographs documented that Indian Creek in Indian and Genesee Valleys almost doubled in size due to widening during the 1986 storm. Channel erosion rates from 1987 into the future should decrease due to the widening. Wide, shallow flows are much less erosive than deep flows.

The increased sediment yield from the watersheds from 1800 to 1900 appears to be recorded in the channel banks of Ward Creek just above its confluence with Indian Creek. A three to four foot thick layer of recent alluvium lies over a buried soil profile at the top of the channel banks. This material appears to be a flood plain deposit but it may have been formed during

Table C   Major Valley Floor Channel Changes from pre-1850 to 2000

Channel Dimensions & Erosion Rates Pre-1850

Stream/Valley Name	Bottom Width (Feet)	Bank Height (Feet)	Tons Eroded Per Yr	Sub Wtrshd #
Dixie Creek	21	1.5	---	15
Red Clover (Main Valley)	30	1.5	---	15
Red Clover (End of Main Valley)	10.5	0.6	---	15
Total for Red Clover Valley			---	15
Last Chance (Above Squaw Queen)	22	1	---	13
Last Chance (Below Squaw Queen)	28	1.5	---	13
Total for Last Chance Creek			---	13
Squaw Queen Creek	33	1	---	14
Indian Creek (Genesee Valley)	36	2	---	8
Indian Creek (Indian Valley)	25	3	---	8
Total for indian Creek			---	8
Lights Creek	34	1.2	---	10
Spanish (Am Valley to Ind Crk)	20	1.1	---	6
Spanish (Am Valley proper)	25	5.9	---	5
Greenhorn Creek	25	1	---	7
Spanish (Upstream of Am Valley)	25	5.9	---	5
Meadow Valley	25	0.5	---	5
Thompson Valley	25	0.5	---	7
Genesee, Indian, American, Meadow & Thompson Valleys			---	
Total for other valleys			---	

("---" indicates insignificant erosion or deposition occurred.
Numbers in "()" indicate channel deposition occurred.)

Channel Dimensions & Erosion Rates 1850-1900

Stream/Valley Name	Bottom Width (Feet)	Bank Height (Feet)	Tons Eroded Per Yr	Sub Wtrshd #
Dixie Creek	21	3	1,100	15
Red Clover (Main Valley)	30	4.5	5,100	15
Red Clover (End of Main Valley)	25	4	900	15
Total for Red Clover Valley			6,000	15
Last Chance (Above Squaw Queen)	36	3	7,300	13
Last Chance (Below Squaw Queen)	28	3.5	1,400	13
Total for Last Chance Creek			8,700	13
Squaw Queen Creek	33	1	---	14
Indian Creek (Genesee Valley)	36	6	4,800	8
Indian Creek (Indian Valley)	25	5	1,900	8
Total for indian Creek			6,700	8
Lights Creek	26	1	(200)	10
Spanish (Am Valley to Ind Crk)	30	4	1,400	6
Spanish (Am Valley proper)	50	7	1,800	5
Greenhorn Creek	30	3	1,200	7
Spanish (Upstream of Am Valley)	50	7	2,300	5
Meadow Valley	25	2	300	5
Thompson Valley	25	2	100	7
Genesee, Indian, American, Meadow & Thompson Valleys			8,900	
Total for other valleys			20,500	

Table C

Table C Major Valley Floor Channel Changes from pre-1850 to 2000 (cont.)

Channel Dimensions & Erosion Rates 1901-1940

Stream/Valley Name	Bottom Width (Feet)	Bank Height (Feet)	Tons Eroded Per Yr	Sub Wtrshd #
Dixie Creek	21	5.5	2,400	15
Red Clover (Main Valley)	33	7	7,000	15
Red Clover (End of Main Valley)	46	8.2	3,500	15
Total for Red Clover Valley			10,500	15
Last Chance (Above Squaw Queen)	50	5	15,500	13
Last Chance (Below Squaw Queen)	43	7.5	7,300	13
Total for Last Chance Creek			22,800	13
Squaw Queen Creek	33	2	700	14
Indian Creek (Genesee Valley)	101	11.5	40,400	8
Indian Creek (Indian Valley)	80	8	25,400	8
Total for indian Creek			65,800	8
Lights Creek	26	11	9,100	10
Spanish (Am Valley to Ind Crk)	58	6.5	4,600	6
Spanish (Am Valley proper)	104	8.5	6,200	5
Greenhorn Creek	39	6.3	3,800	7
Spanish (Upstream of Am Valley)	104	8.5	7,600	5
Meadow Valley	25	3.9	500	5
Thompson Valley	25	3.9	100	7
Genesee, Indian, American, Meadow & Thompson Valleys			72,600	
Total for other valleys			61,500	

Channel Dimensions & Erosion Rates 1941-1982

Stream/Valley Name	Bottom Width (Feet)	Bank Height (Feet)	Tons Eroded Per Yr	Sub Wtrshd #
Dixie Creek	30	5.5	2,100	15
Red Clover (Main Valley)	40	7	3,400	15
Red Clover (End of Main Valley)	69	8.2	2,300	15
Total for Red Clover Valley			5,700	15
Last Chance (Above Squaw Queen)	75	5	13,000	13
Last Chance (Below Squaw Queen)	71	7.5	6,500	13
Total for Last Chance Creek			19,500	13
Squaw Queen Creek	58	2	1,000	14
Indian Creek (Genesee Valley)	197	11.5	41,200	8
Indian Creek (Indian Valley)	159	8	29,000	8
Total for indian Creek			70,200	8
Lights Creek	41	11	5,500	10
Spanish (Am Valley to Ind Crk)	58	6.5	---	6
Spanish (Am Valley proper)	172	8.5	6,300	5
Greenhorn Creek	64	6.3	3,600	7
Spanish (Upstream of Am Valley)	172	8.5	7,800	5
Meadow Valley	25	3.9	---	5
Thompson Valley	25	3.9	---	7
Genesee, Indian, American, Meadow & Thompson Valleys			76,500	
Total for other valleys			45,200	

("---" indicates insignificant erosion or deposition occurred.
Numbers in "()" indicate channel deposition occurred.)

Table C Major Valley Floor Channel Changes from pre-1850 to 2000 (cont.)

Stream/Valley Name	Bottom Width (Feet)	Bank Height (Feet)	Tons Eroded Per Yr	Sub Wtrshd #
Channel Dimensions & Erosion Rates 1983-1987				
Dixie Creek	33	5.5	7,500	15
Red Clover (Main Valley)	65	7	126,800	15
Red Clover (End of Main Valley)	117	8.2	50,300	15
Total for Red Clover Valley			177,100	15
Last Chance (Above Squaw Queen)	68	5	(38,100)	13
Last Chance (Below Squaw Queen)	86	7.5	36,800	13
Total for Last Chance Creek			(1,300)	13
Squaw Queen Creek	46	2	(5,000)	14
Indian Creek (Genesee Valley)	324	11.5	581,300	8
Indian Creek (Indian Valley)	294	8	538,900	8
Total for indian Creek			1,120,200	8
Lights Creek	72	11	119,100	10
Spanish (Am Valley to Ind Crk)	58	6.5	---	6
Spanish (Am Valley proper)	227	8.5	53,900	5
Greenhorn Creek	113	6.3	74,800	7
Spanish (Upstream of Am Valley)	227	8.5	66,700	5
Meadow Valley	28	3.9	1,300	5
Thompson Valley	28	3.9	400	7
Genesee, Indian, American, Meadow & Thompson Vlys.			1,175,800	
Total for other valleys			438,900	

("---" indicates insignificant erosion or deposition occurred.
Numbers in "()" indicate channel deposition occurred.)

Stream/Valley Name	Bottom Width (Feet)	Bank Height (Feet)	Tons Eroded Per Yr	Sub Wtrshd #
Channel Dimensions & Erosion Rates 1988-2000				
Dixie Creek	35	5.5	1,400	15
Red Clover (Main Valley)	69	7	6,300	15
Red Clover (End of Main Valley)	124	8.2	2,600	15
Total for Red Clover Valley			8,900	15
Last Chance (Above Squaw Queen)	72	5	7,400	13
Last Chance (Below Squaw Queen)	91	7.5	4,200	13
Total for Last Chance Creek			11,600	13
Squaw Queen Creek	48	2	300	14
Indian Creek (Genesee Valley)	345	11.5	31,500	8
Indian Creek (Indian Valley)	312	8	23,900	8
Total for indian Creek			55,400	8
Lights Creek	76	11	5,600	10
Spanish (Am Valley to Ind Crk)	61	6.5	1,300	6
Spanish (Am Valley proper)	240	8.5	4,400	5
Greenhorn Creek	120	6.3	3,500	7
Spanish (Upstream of Am Valley)	240	8.5	5,400	5
Meadow Valley	29	3.9	200	5
Thompson Valley	31	3.9	100	7
Genesee, Indian, American, Meadow & Thompson Valleys			60,100	
Total for other valleys			38,000	

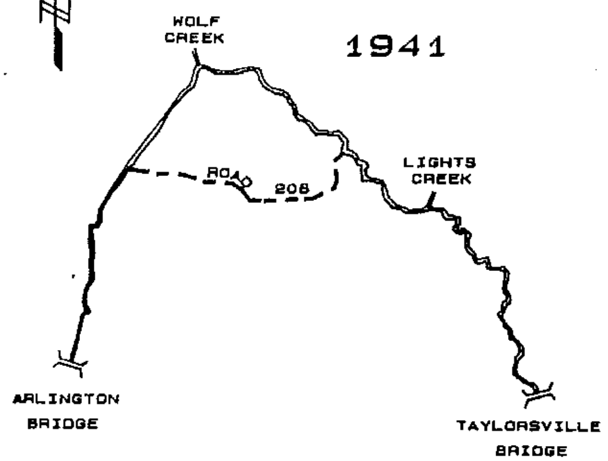
Figure 2

INDIAN CREEK
INDIAN VALLEY

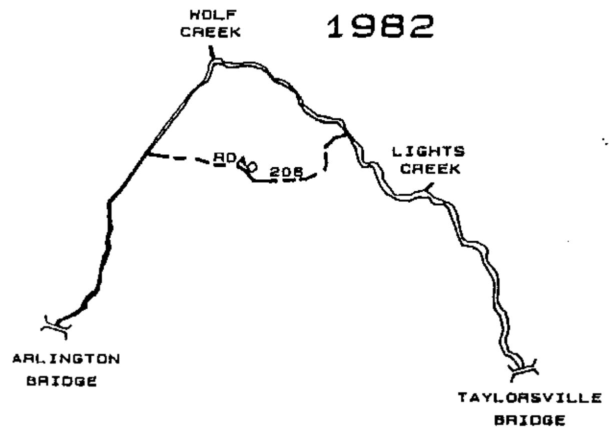
HISTORICAL PHOTO
INTERPRETATIONS

1941	TOTAL	TO RD. 208
LENGTH (Miles)	8.3	6.3
WIDTH (Feet)	80	89
CHANNEL AREA (Acres)	81	68

NOTE: ARLINGTON BRIDGE TO ROAD 208; STRAIGHTENED APPEARANCE MAY BE DUE TO PHOTO DISTORTION



1982	TOTAL	TO RD. 208
LENGTH (Miles)	8.1	6.1
WIDTH (Feet)	159	170
CHANNEL AREA (Acres)	155	126



1987	TOTAL	TO RD. 208
LENGTH (Miles)	8.4	6.3
WIDTH (Feet)	294	335
CHANNEL AREA (Acres)	300	258

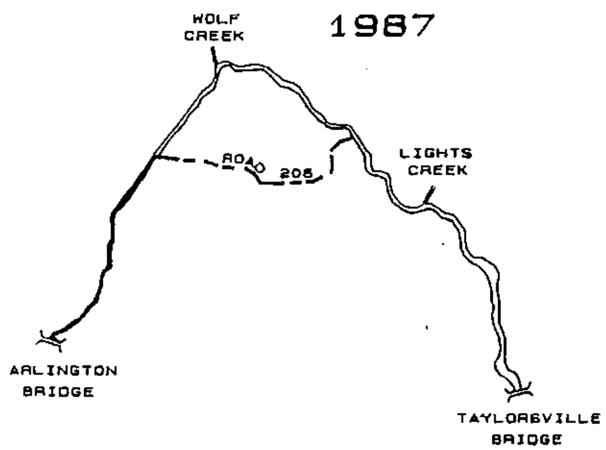
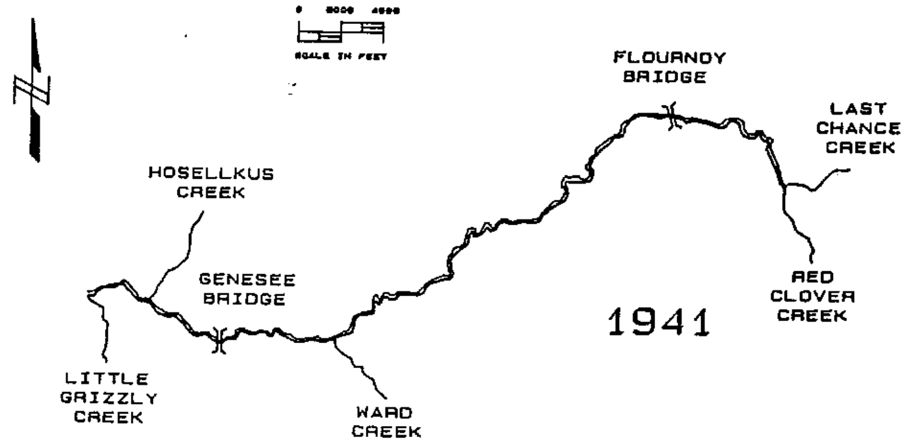
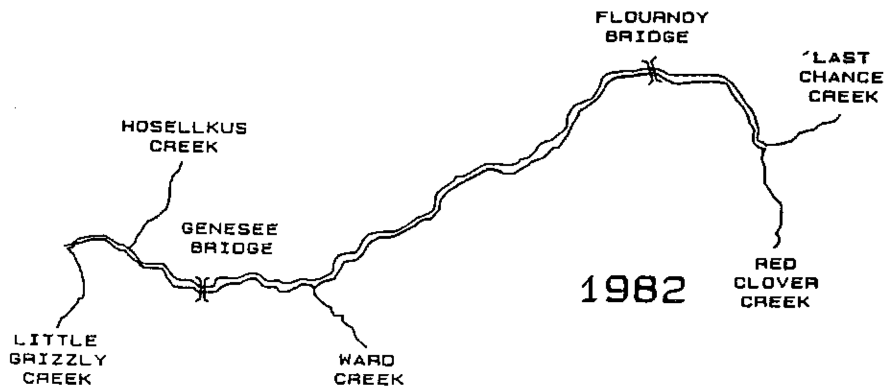


Figure 3

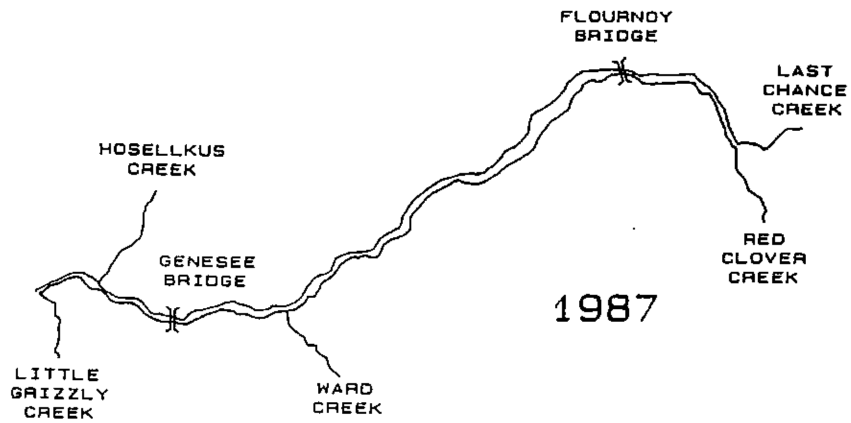
INDIAN CREEK
GENESEE VALLEY
HISTORICAL PHOTO INTERPRTATIONS



1941	
LENGTH (Miles)	7.2
WIDTH (Feet)	101
CHANNEL AREA (Acres)	68



1982	
LENGTH (Miles)	6.6
WIDTH (Feet)	197
CHANNEL AREA (Acres)	158



1987	
LENGTH (Miles)	6.7
WIDTH (Feet)	324
CHANNEL AREA (Acres)	263

the placer gold mining in the channels between 1850 and 1900. It was not uncommon to divert flow from a channel and literally excavate the entire channel area and then wash the sediment back into the excavated area during the gold dredging operation.

The second largest single source of erosion is road cut and fill slopes (43%). Road cut slopes contribute 28% and road fill slopes contribute 15% of the total erosion. Roads cause reduced forest productivity; increased runoff; accelerated surface and mass erosion; and changed streamflow rates, water quality, and channel characteristics (Megahan 1987, King and Gonsior 1980).

Megahan (1974, 1987) found that most of the accelerated surface erosion on granitic soils occurred in the first year and was reduced by the fifth year. The disturbed soil erosion rate was still higher than the undisturbed rate. On weathered granitic bedrock, the bedrock can disintegrate faster than natural stabilization can take place (Megahan 1972).

Subsoil or erodible bedrock layers are exposed in the road cuts during construction and revegetation is difficult due to the exposed cuts being steep sloped, well-drained and very low in nutrients. The FS has found that road cut slope angles of greater than 0.75H:1V are difficult to revegetate.

Road maintenance tends to keep the cuts steep due to the removal of sediment deposits from the base of the roadcut. The sediment deposits act as "toe weights" to keep the road cut from sloughing. The built-up areas at the base of the road cut also decreases dry ravel (material that rolls off the slope due to gravity). By removing this material, the base of the cut does not provide support for the slope.

The material on the road fill slope is generally waste from road construction or regrading. It is not as rich in nutrients as in-place topsoil but it is generally better vegetated than the cut slope. Water collected by the road surface often cuts rills on the fill slope as it drains from the road due to improperly placed or poorly designed culverts.

Gullies only make up about 1.5 percent of the total amount of erosion in the watershed. They are primarily caused by man's disruption of surface drainages or loss of ground cover that allows shallow sheet flows to concentrate and cut gullies. Gully systems often grow upslope from channels. This is especially true in areas where the ground cover is the poorest. The combination of a lowered base level in the channels and the increased runoff from the bare soils accelerates the gully erosion. FS soil scientists believe most of the "A" horizon (the topmost layer of soil) was eroded from the valley floor areas between 1800 and 1940. The exposed "B" horizons contribute to the poor cover and increased runoff.

Sheet and rill erosion appears to produce the least amount of erosion in the watershed. Excellent cover appears to be the primary reason for the low sheet and rill erosion rates. Forest litter, canopy cover and duff all protect the soil surface from the direct impact of raindrops. The ground cover disrupts surface sheet flows before they can become concentrated enough to cut rills. Much of the rangeland is covered with brush and grass. Many of the brushland soils are very stony. Both these factors help protect the soil surface from sheet and rill erosion. The grass cover is generally good on the meadow soils and slopes are low. These two factors reduce sheet and rill erosion in the meadows.

Over 7,500 acres per year are disturbed in the EBNFFR Watershed due to logging (Table A). At this rate, probably all the good timber stands have been cut at least twice, and some three times, over the past 140 years. Early logging using animals was not as destructive as later techniques using tractors. After environmental legislation was passed in the 1970's, logging practices were redesigned to minimize ground disturbance.

Based on field samples, it appears that logging practices increase the long-term sheet and rill erosion rates in forests by a factor of two. During the first year or two after cutting and slash removal, erosion rates may be ten or more times the rates of "undisturbed" forest. As regrowth occurs, canopy cover and ground cover gradually improve so over time the logged area returns to a more stable, erosion rate. Shultz (1978) believes it takes 35 years for a logged or burned area to return to its "pre-disturbed" vegetative cover. Megahan (1988) states that recovery is longer than 10 years.

About 1,800 acres are burned each year in the EBNFFR Watershed (Table A). Like logging, sheet and rill erosion rates are very high immediately after the fire, but as revegetation occurs, the sheet and rill erosion rate slowly returns to its "pre-disturbed" rate. Accelerated erosion also causes losses in the total nutrient pool. Nitrogen is the limiting factor for vegetative cover in the northwestern United States (Gessel 1968). On granitic based soils, the primary source of nitrogen is precipitation. Until vegetation and organic matter is restored, most of the nitrogen is leached away. Megahan (1988) states that this period of impaired productivity lasts at least 10 years. A side effect of logging and burning is that runoff generally increases so off-site channels tend to erode more due to the increased flows.

CONVERTING EROSION TO SEDIMENT YIELD TO ROCK CREEK DAM

Erosion is the process of detachment and movement of soil particles from the soil surface. Sediment yield is the amount of eroded particles that are actually removed from the eroding area and that are carried by water to a point in a stream channel where sediment yield is measured (USDA 1983). Thus sediment

yield is the gross erosion minus the sediment deposited enroute to the point of concern.

Based on a sediment survey at Rock Creek Dam made by PG&E in 1985, an average of 130,000 cubic yards or 158,000 tons per year at 90 pounds per cubic foot (pcf) of sediment has been trapped in the reservoir behind the dam. Based on a net sediment contributing area above Rock Creek Dam of 1,088 square miles, the average annual amount of sediment trapped is about 145 tons per square mile of drainage area per year. This number needs to be adjusted upwards to account for the trap efficiency of the reservoir (most of the fines reaching the dam appear to go past the dam instead of settling out) and for losses due to scour during major runoff events and maintenance dredging. For example, the record flows of February 1986 reduced the amount of sediment behind the dam by 546,000 cubic yards or 663,400 tons.

The trap efficiency of a reservoir is defined as the percentage of the sediment delivered to the reservoir that actually remains in it (USDA 1983). It is a function of detention storage time, character of the sediment, nature of the inflow, and other factors. Trap efficiency can be estimated on the basis of the ratio of the capacity of the reservoir to the average annual inflow. For Rock Creek Dam, the original storage capacity was 4,400 acre-feet with an average inflow of 1,621,400 acre-feet. Based on SCS tables (USDA 1983), these values give a trap efficiency of 25% for coarse grained material, or 10% for medium grained material. The average value of 18% was used for this study. It is realized that the original trap efficiency is no longer valid due to sediment being trapped behind the dam with time and decreasing the storage capacity. However, the dredging maintenance and scouring during flood events will raise the trap efficiency toward the original value.

A second sediment yield estimate is from US Geological Survey records at a gage on Indian Creek near Crescent Mills. The sediment sampling record indicates about 153,400 tons of sediment per year is delivered to that point in Indian Creek. By dividing the Indian Creek tons per year by the drainage area to that point, Indian Creek Watershed produces about 237 tons of sediment per square mile per year.

The Cresta, Poe, and Oroville Dams were also studied. Cresta Dam has a trap efficiency similar to Rock Creek Dam. Poe Dam has no trap efficiency. Based on the total sediment trapped divided by the appropriate trap efficiency, the total sediment yield to Rock Creek Dam is about 1,161,500 tons per year.

This report used the amount of sediment depositing in Rock Creek Dam as the control for the erosion in the study area. The USGS records at Crescent Mills were too short a time period to give a statistically reliable average value.

From 1950-1985, 2,719 acre-feet of sediment was deposited behind Rock Creek Dam. In this time period, the five highest flood peaks were in December 1955, December 1964, January 1969, January 1970, and March 1974. During the February 1986 flood flows, approximately 338 acre-feet of sediment was scoured out from behind Rock Creek Dam. It was assumed that the five flood events in the period 1950-1985 scoured the equivalent amount of sediment as three February 1986 events (1,014 acre-feet). Adding the total amount of sediment deposited and scoured together gives the total sediment deposited behind Rock Creek Dam for the 35 year time period. Dividing by the trap efficiency of the dam and then the 35 years, results in an average annual sediment yield to Rock Creek Dam of 592 acre-feet or 1,161,500 tons per year (at 90 pcf).

The amount of erosion from each source in the watershed was multiplied by a sediment delivery ratio for that source to convert erosion to sediment yield. This ratio is the percent of eroded material that actually becomes sediment yield (USDA 1983.) As eroded material deposits behind forest litter, in depressions, in road ditches and channels, the sediment delivery ratio decreases. The larger the watershed, the smaller the sediment delivery ratios are because there are more opportunities for deposition before the eroded material reaches the point in a channel where the sediment yield is measured. Eroded soils that are coarse grained have lower sediment delivery ratios than fine-grained soils. Erosion from streambanks and gullies have much higher sediment delivery ratios than sheet and rill erosion on a hillslope far removed from the drainage system.

To simplify calculations and to put each subwatershed on a more equal basis, one set of sediment delivery ratios were used throughout the watershed with the exception of the Antelope Lake Subwatershed (Tables 1, 3-15). These ratios were adjusted until the total sediment yield from the 14 subwatersheds below Antelope Lake was within ten percent of 1,161,500 tons per year. Based on this study, about 1,110,500 tons of sediment reaches the end of the study area without contributions from the Antelope Lake Subwatershed. This is about 4 percent less than the estimated amount based on measured data (1,161,500 tons per year).

Based on the summary for the EBNFFR Watershed (Table B), 43 percent of the sediment yield reaching the end of the study area is from streambank erosion on streams tributary to the major creeks in the valleys. Road cut and fill slopes contribute an additional 46 percent and streambank erosion on the major creeks in the valleys adds another 8 percent. Gullies contribute about 1.5 percent of the total sediment yield in the EBNFFR Watershed. The remaining sediment comes from sheet and rill erosion and road surfaces.

ACCELERATED VERSUS GEOLOGIC EROSION

Geologic erosion is the detachment of soil particles from soil surfaces in their natural or undisturbed condition. The geologic rate is determined by climate, parent material, soil, precipitation, topography, and vegetative cover (USDA 1983). Accelerated erosion is "erosion occurring at a rate greater than normal for the site, usually through the reduction of vegetative cover" (Roehl, 1965). This loss of vegetative cover usually is on sites disturbed by man. Geologic erosion generally occurs at much lower rates than accelerated erosion.

About 90 percent of the erosion in the EBNFFR Watershed is accelerated erosion. Similarly, about 80 percent of the sediment yield is from accelerated erosion. Since roads are installed by man, all erosion associated with roads is assumed to be accelerated erosion. About 50 percent of the sheet and rill erosion and upland gully erosion is believed to be accelerated. This is due to man-caused disturbances linked to logging, mining and some fires. Since most of the streambank erosion in the watershed occurred after man began disturbing the watershed on a large scale, it is assumed that about 75 percent of the streambank erosion is also accelerated.

FUTURE CONDITIONS

Erosion and sediment yield rates in this report are representative of today's conditions. It is assumed these rates will continue into the future.

The new Forest Plan for PNF indicates more land will be logged in the future. This increased logging should have minimal effects on todays erosion and sediment yield rates due to improved Timber-Harvesting Practices and restrictions on logging in sensitive areas.

A cloud seeding program promoted by the California Department of Water Resources may result in additional snow pack in parts of the study area in some years. Existing Environmental Impact Reports for cloud seeding in the Sierra Nevada, south of Plumas County indicate that it is almost impossible to detect increased runoff due to the cloud seeding . Natural, annual variability in runoff masks any impacts that may be associated with cloud seeding. The potential errors in estimates of erosion and sediment yield are much greater than any predicted increases in runoff due to cloud seeding.

SEDIMENT ROUTING TO LAKE OROVILLE

As a further check of the calculations in this study, sediment was routed to Lake Oroville and compared to published data. Porterfield et. al. (1978) states that the average inflow of sediment to Lake Oroville is 800 acre-feet/year or 1,568,200 tons/year. The sediment contributing drainage area of Lake Oroville is 3,015 square miles.

In order to route sediment from the end of the study area to Lake Oroville, the trap efficiency of all dams between these points must be known. The trap efficiency is the percentage of the sediment delivered to a reservoir that remains in it. There are three dams on the East Branch of the North Fork Feather River below the study area: Rock Creek, Cresta, and Poe Dams. From data supplied by PG&E and the procedures found in USDA-SCS National Engineering Handbook Section 3 Chapter 8, the trap efficiencies were calculated as 18, 12, and 0% respectively.

Routing the sediment (Table D) results in 410 acre-feet/year arriving to Lake Oroville from the study area (40% of the Lake Oroville drainage area). This is 51% of the total sediment reaching Lake Oroville. This percentage agrees with views held by PG&E and USDA-FS, Quincy (Personal Communication).

CONCLUSIONS

After the erosion and sediment yield by source were determined for each subwatershed, the total sediment yield was divided by the subwatershed drainage area to determine the rate of sediment production in each subwatershed. Table D lists the subwatersheds in numerical order. Table E lists the subwatersheds in descending order of total sediment delivered to the mouth of the study area. Table F lists the subwatersheds in descending order of sediment production per square mile.

The Antelope Lake Subwatershed actually has the highest sediment yield rate. The point of measurement, Antelope Lake, is much closer to the eroding sources in that subwatershed than Rock Creek Reservoir is to the eroding areas in the rest of the EBNFFR Watershed. This meant that higher sediment delivery ratios were used in the Antelope Lake Subwatershed than in the rest of the EBNFFR Watershed.

For total sediment yield reaching the end of the study area, the Last Chance Creek, Red Clover-Dixie Creeks, Upper Spanish-Rock Creeks, Wolf Creek-Round Valley, and Little Grizzly Creek are the top five (See Table E).

The North Fork Feather River Subwatershed (#3) is producing the most sediment per square mile of drainage area--1,760 tons per square mile. The next highest rate of sediment yield to the end of the study area is 1,650 tons per square mile from the Wolf Creek-Round Valley (Subwatershed #9). Five other subwatersheds produce sediment at a rate higher than the average for the EBNFFR Watershed, which is 1,040 tons per square mile. These are Upper Spanish Creek-Rock Creek (#5), Lower Spanish Creek (#6), Last Chance Creek (#13), Hungry-Middle Indian Creeks (#11), and Greenhorn Creek (#7).

Sheet and rill erosion on road cut/fill slopes is the major source of sediment in the study area. Streambank erosion on

Table D

SEDIMENT YIELD TO ROCK CREEK DAM FROM SUBWATERSHEDS
RANKED IN NUMERICAL ORDER BY SUBWATERSHED NUMBER
January 1989

Subwatershed Name	Subwatershed Number	Total Sediment Yield (tons)	Computed Drainage Area (Acres)	Drainage Area (Sq. Miles)	Tons per Sq. Mile Rounded	Tons per Acre Rounded
Chips-Yellow	1	63,700	67,200	105.0	610	0.9
Butt Valley Res.	2	0	7,168	11.2	0	0.0
N. Fk. Feather R.	3	108,900	39,552	61.8	1,760	2.8
Rush-Mill	4	58,400	49,024	76.6	760	1.2
U. Spanish-Rock	5	118,800	58,624	91.6	1,300	2.0
Lower Spanish	6	40,200	22,272	34.8	1,160	1.8
Greenhorn	7	73,500	44,736	69.9	1,050	1.6
Little Grizzly	8	113,100	94,272	147.3	770	1.2
Wolf-Round Valley	9	118,300	46,016	71.9	1,650	2.6
Lights-Cooks	10	86,000	75,136	117.4	730	1.1
Hungry-Mid. Indian	11	45,600	26,368	41.2	1,110	1.7
Above Antelope Lk.	12	146,800	44,352	69.3	2,120	3.3
Last Chance	13	129,600	74,752	116.8	1,110	1.7
Squaw Queen	14	27,000	26,112	40.8	660	1.0
Red Clover-Dixie	15	127,400	98,048	153.2	830	1.3

Total	1,257,300 tons/year	641.2 acre-feet/year	
Antelope Lake	(146,800)	(74.9)acre-feet/year	
	----------	----------	
To Rock Creek Dam	1,110,500 tons/year	566.4 acre-feet/year	
Deposited Rock Cr. Dam			
18.00%	(199,900)tons/year	(101.9)acre-feet/year	
	----------	----------	
To Cresta Dam	910,600 tons/year	464.4 acre-feet/year	
Deposited Cresta Dam			
12.00%	(109,300)	(55.7)acre-feet/year	
	----------	----------	
To Lake Oroville	801,300 tons/year	408.7 acre-feet/year	

Table E

SEDIMENT YIELD TO ROCK CREEK DAM FROM SUBWATERSHEDS
RANKED IN DESCENDING ORDER BY TOTAL SEDIMENT YIELD
January 1989

Subwatershed Name	Subwatershed Number	Total Sediment Yield (tons)	Computed Drainage Area (Acres)	Drainage Area (Sq. Miles)	Tons per Sq. Mile Rounded	Tons per Acre Rounded
Above Antelope Lk.	12	146,800	44,352	69.3	2,120	3.3
Last Chance	13	129,600	74,752	116.8	1,110	1.7
Red Clover-Dixie	15	127,400	98,048	153.2	830	1.3
U. Spanish-Rock	5	118,800	58,624	91.6	1,300	2.0
Wolf-Round Valley	9	118,300	46,016	71.9	1,650	2.6
Little Grizzly	8	113,100	94,272	147.3	770	1.2
N. Fk. Feather R.	3	108,900	39,552	61.8	1,760	2.8
Lights-Cooks	10	86,000	75,136	117.4	730	1.1
Greenhorn	7	73,500	44,736	69.9	1,050	1.6
Chips-Yellow	1	63,700	67,200	105.0	610	0.9
Rush-Mill	4	58,400	49,024	76.6	760	1.2
Hungry-Mid. Indian	11	45,600	26,368	41.2	1,110	1.7
Lower Spanish	6	40,200	22,272	34.8	1,160	1.8
Squaw Queen	14	27,000	26,112	40.8	660	1.0
Butt Valley Res.	2	0	7,168	11.2	0	0.0

Table F

SEDIMENT YIELD TO ROCK CREEK DAM FROM SUBWATERSHEDS
RANKED IN DESCENDING ORDER BY TONS/SQUARE MILE
January 1989

Subwatershed Name	Subwatershed Number	Total Sediment Yield (tons)	Computed Drainage Area (Acres)	Drainage Area (Sq. Miles)	Tons per Sq. Mile Rounded	Tons per Acre Rounded
Above Antelope Lk.	12	146,800	44,352	69.3	2,120	3.3
N. Fk. Feather R.	3	108,900	39,552	61.8	1,760	2.8
Wolf-Round Valley	9	118,300	46,016	71.9	1,650	2.6
U. Spanish-Rock	5	118,800	58,624	91.6	1,300	2.0
Lower Spanish	6	40,200	22,272	34.8	1,160	1.8
Last Chance	13	129,600	74,752	116.8	1,110	1.7
Hungry-Mid. Indian	11	45,600	26,368	41.2	1,110	1.7
Greenhorn	7	73,500	44,736	69.9	1,050	1.6
Red Clover-Dixie	15	127,400	98,048	153.2	830	1.3
Little Grizzly	8	113,100	94,272	147.3	770	1.2
Rush-Mill	4	58,400	49,024	76.6	760	1.2
Lights-Cooks	10	86,000	75,136	117.4	730	1.1
Squaw Queen	14	27,000	26,112	40.8	660	1.0
Chips-Yellow	1	63,700	67,200	105.0	610	0.9
Butt Valley Res.	2	0	7,168	11.2	0	0.0

tributary streams is the next major source of sediment in the study area. The one exception is Indian Creek, a major valley floor creek, which contributes the most sediment in Subwatersheds #8 and #11. The table on Page 8 shows that bank erosion in Indian Creek in Genesee Valley produces the most sediment out of the five major valleys.

Any potential erosion control work should focus on controlling tributary streambank erosion in Subwatersheds #3, 5, 6, 7, 9, 11, and 13. This could be done by controlling headcuts that are now moving up these creeks from the valley floor. Controlling runoff from the tributary stream watersheds will also help slow streambank erosion.

Controlling erosion from road cuts and fills would also significantly reduce sediment to the end of the study area.

DISCUSSION

The purpose of this study was to provide results that could be used in making an intelligent decision based on several criteria, including erosion rates, as to which subwatersheds could be prioritized for treatment. Therefore each subwatershed was not studied in detail but extrapolated from sample sites. The sediment delivery ratios were the same for each erosion source in each subwatershed. The density of roads and streams was measured and extrapolated to the whole subwatershed. The computer model used is very sensitive to these road and stream densities. This was done for expediency and should not change the relative ranking of the subwatersheds.

Some areas need to be looked at in further detail. One area to investigate would be to optimize the sediment delivery ratios for each subwatershed. Another area would be to look at the road and stream densities. The North Fork of the Feather River (#3) has a very high stream density ratio. However, most of these streams are rock lined and are not eroding at a very high rate. Therefore the percent of noneroding streams may need to be adjusted further in this subwatershed and others.

Wolf Creek-Round Valley has the next to the highest sediment yield rate. However, observations at the junction of Wolf Creek and Indian Creek did not find a sediment fan. This means that all sediment leaving the subwatershed would have to be fine silts and/or clays. Further analysis would have to be done to verify that there is enough erosion to produce all of the sediment yield in silt and clay size particles. Also, the trapping effect of Round Valley Reservoir was not taken into consideration.

In the Red Clover and Dixie Creeks subwatershed, the effect of the Red Clover Demonstration Project was not calculated. This would have to be done if this subwatershed was studied further.

REFERENCES CITED

Burroughs, Edward R. Jr. and King, John G. 1988 Reduction of Soil Erosion on Forest Roads. Unpublished Report, Intermtn Res Sta, USDA-FS.

Chapman, Donald W. 1962 Effects of Logging Upon Fish Resources of the West Coast. Jour of Forestry 60:533-537.

Duncan, S. H. and Ward, J. W. 1985 The Influence of Watershed Geology and Forest Roads on the Composition of Salmon Spawning Gravel. Northwest Sci Vol59 No. 3.

Durrell, Cordell 1987 Geologic History of the Feather River Country, California. University of California Press, Berkeley, CA.

Gessel, S. P. 1968 Progress and Needs in Tree Nutrition Research in the Northwest. In Forest Fertilization Theory and Practice: Proceedings Symposium on Forest Fertilization. TVA, National Fertilizer Development Center, Muscle Shoals, AL.

King, John G. and Burroughs, Edward R. Jr. 1988 Reduction of Soil Erosion on Forest Roads. Unpublished Report, Intermtn Res Sta, Moscow, ID.

King, John G. and Gonsior, Michael. 1980 Effects of Forest Roads on Stream Sediment. Presentation at Am Soc Civil Eng Symp Watershed Mgmt 1980, Boise, ID.

Megahan, Walter F. 1972 Sedimentation in Relation to Logging Activities in the Mountains of Central Idaho. "Present and Prospective Technology for Predicting Sediment Yields and Sources" Proc. Sediment Yield Workshop, USDA Sediment Lab, Oxford, MS.

Megahan, Walter F. 1974 Erosion Over Time on Severely Disturbed Granitic Soils: A Model. USDA-FS Res Paper INT-156, Intermtn For and Range Exp Sta, Ogden, UT.

Megahan, Walter F. 1981 Effects of Silvicultural Practices on erosion and Sedimentation in the Interior West-A Case for Sediment Budgeting. Pro/Symp Interior West watershed Management, Spokane, WA.

Megahan, Walter F. 1983 Hydrologic Effects of Clearcutting and Wildfire on Steep Granitic Slopes in Idaho. Water Resources Res V19, No 3.

Megahan, Walter F. 1987 Effect of Forest Roads on Watershed Function in Mountainous Areas. Environmental Geotechnics and Problematic Soils and Rocks, Balasubramaniam et al. (eds.), Balkema, Rotterdam.

Megahan, Walter F. 1988 Streamflow, Erosion, and Sediment responses of a Granitic Watershed to Helicopter Logging and Prescribed Burning in Central Idaho. Unpublished Report, Intermtn Res Sta, USDA-FS.

Megahan, Walter F. and Kidd, Walter J. 1972 Effect of Logging Roads on Sediment Production Rates in the Idaho Batholith. USDA-FS Res Paper INT-123, Intermtn Forest and Range Exp Sta, Ogden, UT.

Ornduff, Robert 1974 Introduction to California Plant Life. Univ CA Press, Berkeley, CA.

Porterfield, George; Busch, R. D.; and Waananen, A. O. 1978 Sediment Transport in the Feather River, Lake Oroville to Yuba City, California. USGS Wat Res Inv 78-20.

Roehl, J. W. 1965 Erosion and its Control on Agricultural Land. Fed. Inter-Agency Sediment. Conf. 1963 Proc. U.S. Dep. Agric. Misc. Publ. 970.

Schultz, Bob 1978 Unpublished Report. Vegetation Recovery Curve from Pacific Southwest Hydrologic Analysis Phase II Data, USDA-FS, Quincy, CA.

Sketchley, Harold R. 1975 Soil Survey of Sierra Valley Area, California, Parts of Sierra, Plumas, and Lassen Counties. USDA-SCS.

Storer, Tracy I. and Usinger, Robert L. 1963 Sierra Nevada Natural History. Univ CA Press, Berkeley, CA.

USDA 1983 National Engineering Handbook-Section 3, Sedimentation. USDA-SCS.

TABLE 1

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
CHIPS & YELLOW CREEKS (SUBWATERSHED #1)
(Includes PNF Watersheds #9)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	4,900	4.2	1,000	1.6
Brush	600	0.5	100	0.2
SUBTOTAL	5,500	4.7	1,100	1.7
Roads				
Surfaces	1,400	1.2	800	1.3
Cut Slopes	59,000	50.8	29,500	46.3
Fill Slopes	26,100	22.5	12,900	20.3
SUBTOTAL	86,500	74.4	43,200	67.8
TOTAL	92,000	79.2	44,300	69.5
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	23,800	20.5	19,100	30.0
SUBTOTAL	23,800	20.5	19,100	30.0
GULLY EROSION				
Associated w/ Streams	300	0.3	200	0.3
Associated w/ Roads	100	0.1	100	0.2
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	400	0.3	300	0.5
GRAND TOTAL	116,200	100.0	63,700	100.0

TABLE 3

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
NORTH FORK FEATHER RIVER BELOW LAKE ALMANOR (SUBWATERSHED #3)
(Includes PNF Watersheds #10)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	3,300	1.9	600	0.6
Brush	100	0.1	0	0.0
SUBTOTAL	3,400	2.0	600	0.6
Roads				
Surfaces	600	0.4	400	0.4
Cut Slopes	56,100	32.8	28,000	25.7
Fill Slopes	26,600	15.6	13,300	12.2
SUBTOTAL	83,300	48.7	41,700	38.3
TOTAL	86,700	50.7	42,300	38.8
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	81,100	47.4	64,900	59.6
SUBTOTAL	81,100	47.4	64,900	59.6
GULLY EROSION				
Associated w/ Streams	100	0.1	100	0.1
Associated w/ Roads	700	0.4	400	0.4
Associated w/ Uplands	2,400	1.4	1,200	1.1
SUBTOTAL	3,200	1.9	1,700	1.6
GRAND TOTAL	171,000	100.0	108,900	100.0

TABLE 4

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
RUSH & MILL CREEKS (SUBWATERSHED #4)
(Includes PNF Watersheds #13)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	3,600	3.6	700	1.2
Brush	400	0.4	100	0.2
SUBTOTAL	4,000	4.0	800	1.4
Roads				
Surfaces	500	0.5	200	0.3
Cut Slopes	37,700	37.5	18,900	32.4
Fill Slopes	23,000	22.9	10,800	18.5
SUBTOTAL	61,200	61.0	29,900	51.2
TOTAL	65,200	64.9	30,700	52.6
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	33,800	33.7	27,000	46.2
SUBTOTAL	33,800	33.7	27,000	46.2
GULLY EROSION				
Associated w/ Streams	0	0.0	0	0.0
Associated w/ Roads	400	0.4	200	0.3
Associated w/ Uplands	1,000	1.0	500	0.9
SUBTOTAL	1,400	1.4	700	1.2
GRAND TOTAL	100,400	100.0	58,400	100.0

TABLE 5

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
UPPER SPANISH & ROCK CREEKS (SUBWATERSHED #5)
(Includes PNF Watersheds #24)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	100	0.1	0	0.0
Forest	3,000	1.6	600	0.5
Brush	300	0.2	100	0.1
SUBTOTAL	3,400	1.9	700	0.6
Roads				
Surfaces	1,100	0.6	700	0.6
Cut Slopes	53,100	29.0	26,500	22.3
Fill Slopes	34,400	18.8	17,200	14.5
SUBTOTAL	88,600	48.4	44,400	37.4
TOTAL	92,000	50.2	45,100	38.0
STREAMBANKS				
Major Streams	10,000	5.5	9,000	7.6
Tributary Streams	79,400	43.3	63,500	53.5
SUBTOTAL	89,400	48.8	72,500	61.0
GULLY EROSION				
Associated w/ Streams	800	0.4	600	0.5
Associated w/ Roads	300	0.2	200	0.2
Associated w/ Uplands	700	0.4	400	0.3
SUBTOTAL	1,800	1.0	1,200	1.0
GRAND TOTAL	183,200	100.0	118,800	100.0

TABLE 6

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
LOWER SPANISH CREEK (SUBWATERSHED #6)
(Includes PNF Watersheds #22)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	1,400	2.0	300	0.7
Brush	100	0.1	0	0.0
SUBTOTAL	1,500	2.1	300	0.7
Roads				
Surfaces	700	1.0	400	1.0
Cut Slopes	32,300	45.5	16,200	40.3
Fill Slopes	19,700	27.7	9,900	24.6
SUBTOTAL	52,700	74.2	26,500	65.9
TOTAL	54,200	76.3	26,800	66.7
STREAMBANKS				
Major Streams	1,300	1.8	1,200	3.0
Tributary Streams	14,900	21.0	11,900	29.6
SUBTOTAL	16,200	22.8	13,100	32.6
GULLY EROSION				
Associated w/ Streams	100	0.1	0	0.0
Associated w/ Roads	500	0.7	300	0.7
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	600	0.8	300	0.7
GRAND TOTAL	71,000	100.0	40,200	100.0

TABLE 7

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
GREENHORN CREEK (SUBWATERSHED #7)
(Includes PNF Watersheds #23)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	2,600	2.0	500	0.7
Brush	300	0.2	100	0.1
SUBTOTAL	2,900	2.3	600	0.8
Roads				
Surfaces	1,200	0.9	700	1.0
Cut Slopes	58,100	45.2	29,100	39.6
Fill Slopes	34,000	26.4	17,000	23.1
SUBTOTAL	93,300	72.6	46,800	63.7
TOTAL	96,200	74.8	47,400	64.5
STREAMBANKS				
Major Streams	3,600	2.8	3,200	4.4
Tributary Streams	27,700	21.5	22,200	30.2
SUBTOTAL	31,300	24.3	25,400	34.6
GULLY EROSION				
Associated w/ Streams	200	0.2	100	0.1
Associated w/ Roads	900	0.7	600	0.8
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	1,100	0.9	700	1.0
GRAND TOTAL	128,600	100.0	73,500	100.0

TABLE 8

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
LITTLE GRIZZLY & HOSSELKUS CREEKS (SUBWATERSHED #8)
(Includes PNF Watersheds #8)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	100	0.1	0	0.0
Forest	6,000	3.6	1,200	1.1
Brush	300	0.2	100	0.1
SUBTOTAL	6,400	3.9	1,300	1.1
Roads				
Surfaces	800	0.5	500	0.4
Cut Slopes	44,400	27.0	22,200	19.6
Fill Slopes	22,900	13.9	11,400	10.1
SUBTOTAL	68,100	41.4	34,100	30.2
TOTAL	74,500	45.3	35,400	31.3
STREAMBANKS				
Major Streams	55,400	33.7	49,900	44.1
Tributary Streams	34,500	21.0	27,600	24.4
SUBTOTAL	89,900	54.6	77,500	68.5
GULLY EROSION				
Associated w/ Streams	100	0.1	100	0.1
Associated w/ Roads	100	0.1	100	0.1
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	200	0.1	200	0.2
GRAND TOTAL	164,600	100.0	113,100	100.0

TABLE 9

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
WOLF CREEK & ROUND VALLEY (SUBWATERSHED #9)
(Includes PNF Watersheds #15 A-C)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	3,600	1.7	700	0.6
Brush	100	0.0	0	0.0
SUBTOTAL	3,700	1.7	700	0.6
Roads				
Surfaces	900	0.4	500	0.4
Cut Slopes	109,700	50.8	54,800	46.3
Fill Slopes	62,200	28.8	31,100	26.3
SUBTOTAL	172,800	80.1	86,400	73.0
TOTAL	176,500	81.8	87,100	73.6
STREAMBANKS				
Major Streams	1,200	0.6	1,100	0.9
Tributary Streams	36,300	16.8	29,000	24.5
SUBTOTAL	37,500	17.4	30,100	25.4
GULLY EROSION				
Associated w/ Streams	100	0.0	100	0.1
Associated w/ Roads	1,700	0.8	1,000	0.8
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	1,800	0.8	1,100	0.9
GRAND TOTAL	215,800	100.0	118,300	100.0

TABLE 10

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
LIGHTS & COOKS CREEKS (SUBWATERSHED #10)
(Includes PNF Watersheds #16 A-E)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	5,800	4.0	1,200	1.4
Brush	400	0.3	0	0.0
SUBTOTAL	6,200	4.3	1,200	1.4
Roads				
Surfaces	1,100	0.8	600	0.7
Cut Slopes	62,300	43.3	32,300	37.6
Fill Slopes	27,600	19.2	14,400	16.7
SUBTOTAL	91,000	63.3	47,300	55.0
TOTAL	97,200	67.6	48,500	56.4
STREAMBANKS				
Major Streams	9,900	6.9	8,900	10.3
Tributary Streams	32,600	22.7	26,100	30.3
SUBTOTAL	42,500	29.6	35,000	40.7
GULLY EROSION				
Associated w/ Streams	1,500	1.0	1,000	1.2
Associated w/ Roads	1,700	1.2	1,000	1.2
Associated w/ Uplands	900	0.6	500	0.6
SUBTOTAL	4,100	2.9	2,500	2.9
GRAND TOTAL	143,800	100.0	86,000	100.0

TABLE 11

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
HUNGARY & MIDDLE INDIAN CREEKS (SUBWATERSHED #11)
(Includes PNF Watersheds #17 A-E)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	(Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	(Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	2,200	3.0	400	0.9
Brush	300	0.4	100	0.2
SUBTOTAL	2,500	3.5	500	1.1
Roads				
Surfaces	200	0.3	100	0.2
Cut Slopes	28,500	39.4	15,700	34.4
Fill Slopes	12,800	17.7	7,100	15.6
SUBTOTAL	41,500	57.3	22,900	50.2
TOTAL	44,000	60.8	23,400	51.3
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	26,000	35.9	20,800	45.6
SUBTOTAL	26,000	35.9	20,800	45.6
GULLY EROSION				
Associated w/ Streams	800	1.1	500	1.1
Associated w/ Roads	500	0.7	300	0.7
Associated w/ Uplands	1,100	1.5	600	1.3
SUBTOTAL	2,400	3.3	1,400	3.1
GRAND TOTAL	72,400	100.0	45,600	100.0

TABLE 12

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
ABOVE ANTELOPE LAKE (SUBWATERSHED #12)
(Includes PNF Watersheds #18 A)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	1,600	0.7	300	0.2
Brush	0	0.0	0	0.0
SUBTOTAL	1,600	0.7	300	0.2
Roads				
Surfaces	400	0.2	200	0.1
Cut Slopes	54,600	25.1	27,300	18.6
Fill Slopes	32,600	15.0	16,300	11.1
SUBTOTAL	87,600	40.2	43,800	29.8
TOTAL	89,200	40.9	44,100	30.0
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	127,400	58.5	101,900	69.4
SUBTOTAL	127,400	58.5	101,900	69.4
GULLY EROSION				
Associated w/ Streams	100	0.0	100	0.1
Associated w/ Roads	1,200	0.6	700	0.5
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	1,300	0.6	800	0.5
GRAND TOTAL	217,900	100.0	146,800	100.0

TABLE 13

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
LAST CHANCE CREEK (SUBWATERSHED #13)
(Includes PNF Watersheds #21 A-H)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	3,500	1.8	800	0.6
Brush	500	0.3	100	0.1
SUBTOTAL	4,000	2.1	900	0.7
Roads				
Surfaces	700	0.4	400	0.3
Cut Slopes	58,600	30.3	31,300	24.2
Fill Slopes	30,300	15.7	16,700	12.9
SUBTOTAL	89,600	46.3	48,400	37.3
TOTAL	93,600	48.3	49,300	38.0
STREAMBANKS				
Major Streams	11,600	6.0	10,400	8.0
Tributary Streams	82,900	42.8	66,400	51.2
SUBTOTAL	94,500	48.8	76,800	59.3
GULLY EROSION				
Associated w/ Streams	2,900	1.5	2,100	1.6
Associated w/ Roads	900	0.5	500	0.4
Associated w/ Uplands	1,700	0.9	900	0.7
SUBTOTAL	5,500	2.8	3,500	2.7
GRAND TOTAL	193,600	100.0	129,600	100.0

TABLE 14

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
SQUAW QUEEN CREEK (SUBWATERSHED #14)
(Includes PNF Watersheds #19 A-B)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	400	1.0	100	0.4
Brush	100	0.3	0	0.0
SUBTOTAL	500	1.3	100	0.4
Roads				
Surfaces	200	0.5	100	0.4
Cut Slopes	10,200	25.6	5,200	19.3
Fill Slopes	6,200	15.5	3,400	12.6
SUBTOTAL	16,600	41.6	8,700	32.2
TOTAL	17,100	42.9	8,800	32.6
STREAMBANKS				
Major Streams	300	0.8	300	1.1
Tributary Streams	21,300	53.4	17,100	63.3
SUBTOTAL	21,600	54.1	17,400	64.4
GULLY EROSION				
Associated w/ Streams	800	2.0	600	2.2
Associated w/ Roads	200	0.5	100	0.4
Associated w/ Uplands	200	0.5	100	0.4
SUBTOTAL	1,200	3.0	800	3.0
GRAND TOTAL	39,900	100.0	27,000	100.0

TABLE 15

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
RED CLOVER & DIXIE CREEKS (SUBWATERSHED #15)
(Includes PNF Watersheds #20 A-E)

Type or Source of Erosion	Erosion in Subwatershed (Tons/Yr)	Erosion in Subwatershed (Percent)	Sediment Yield to Rock Creek Dam (Tons/Yr)	Sediment Yield to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	900	0.5	100	0.1
Brush	100	0.1	0	0.0
SUBTOTAL	1,000	0.5	100	0.1
Roads				
Surfaces	900	0.5	500	0.4
Cut Slopes	44,500	24.1	22,600	17.7
Fill Slopes	24,400	13.2	12,500	9.8
SUBTOTAL	69,800	37.8	35,600	27.9
TOTAL	70,800	38.4	35,700	28.0
STREAMBANKS				
Major Streams	10,300	5.6	9,300	7.3
Tributary Streams	99,800	54.1	79,900	62.7
SUBTOTAL	110,100	59.6	89,200	70.0
GULLY EROSION				
Associated w/ Streams	2,600	1.4	1,900	1.5
Associated w/ Roads	500	0.3	300	0.2
Associated w/ Uplands	600	0.3	300	0.2
SUBTOTAL	3,700	2.0	2,500	2.0
GRAND TOTAL	184,600	100.0	127,400	100.0

EAST BRANCH OF THE NORTH FORK FEATHER RIVER EROSION INVENTORY REPORT

APPENDIX A

INVENTORY PROCEDURES

Since the watershed was too large to use a statistical sampling program, representative samples were selected by SCS and FS staff familiar with the watershed. Neither the worst or least eroding sites were sampled. The only stratification of the field samples involved trying to represent each of the major geologic and soil units, vegetation types, topography, rainfall zones and land uses (Table A1). Table A2 lists the miles and area sampled by study unit. Each field sample is marked on 7 1/2 minute topographic quadrangle maps. SCS has the original copies of all field data collected and the sample location maps. Copies of the data sheets and maps were provided to PG&E, Plumas Corporation and the FS. Diskettes with all computer files generated during data reduction and extrapolation were also provided to these same agencies.

A week was spent in the field training the field crew in the inventory procedures. They were allowed to work a week on their own and then a follow-up week of training was provided to answer questions that came up. Five people worked the first seven weeks, three people worked the next ten weeks and one person finished the field work in an additional six weeks. This totaled about 2,840 hours based on an 8-hour day and 40-hour week.

The Universal Soil Loss Equation (USLE) was used to quantify sheet and rill erosion. About 8,600 acres were sampled on the ground. Field work involved walking three or four 1,000-foot long transects across representative slopes of each sample. Ground cover, canopy cover, percent slope and slope length were noted as well as the landform and geologic parent materials at the site. Rainfall energy factors were taken from FS precipitation maps. SCS soil scientists used FS soils maps and the descriptions of the landform and geology of each site to determine the soil erodibility factor.

The direct volume method was used to estimate streambank and roadbank erosion rates. About 210 miles of streambanks and 140 miles of roadbanks were observed as field samples. The length and height of eroding areas were recorded as segments of the left and right sides of streams or the cut and fill slopes of roads. A lateral recession rate was also recorded for each segment (Tables A3 and A4). This is the amount of erosion occurring perpendicular to the face of the eroding bank in an average rainfall year. The recession rate is in units of feet per year so by multiplying the recession times the eroding area (square feet), the cubic feet of erosion per year could be estimated for every segment broken out on the data sheets. Multiplying this

Table A-1

Table A1 Physical Characteristics of the Study Units in the East Branch, North Fork Feather River

Study Unit	Major Creeks	Geology Soil Parent Material (%) Volcanics	Granitics	Metaseds	Alluvium	Veg Cover (%)[1] Forest	Brush	Meadow	Drainage Area (sq mi)	Rainfall (in/yr)	Runoff (in/yr)	Road Density (mi/sq mi)	Stream Density (mi/sq mi)	Area Disturbed Each Year Fire (acres)	Logging (acres)
1	Chips,Rock	15	45	30	10	93	6	0	104.3	65	43	1.6	1.6	210	330
2	Yellow	95	0	0	5	91	3	4	53.4	60	38	3.2	1.6	10	340
3	Rush	50	0	40	10	96	2	1	99.3	50	28	2.1	2.7	110	640
4	Low Ind,Grizz,Hossel	10	5	80	5	96	2	1	106.9	40	20	1.6	1.6	20	680
5	Wolf	35	15	30	20	97	1	1	63.7	40	20	3.2	2.6	10	410
6	Lights	5	35	45	15	97	1	1	69.8	35	16	2.0	2.1	20	450
7	Antelope Lake	15	80	0	5	93	3	2	70.9	30	10	2.2	2.1	40	450
8	Lights,Ind,RedClover LChance,Clarks	40	55	0	5	91	6	2	148.4	30	10	2.1	2.4	350	1,100
9	Red Clover	70	25	0	5	80	14	4	109.0	30	8	3.1	2.1	30	700
10	SQueen,LChance	85	10	0	5	74	21	4	148.4	25	5	2.7	2.1	660	1,240
11	Low Spanish,Grnhorn	5	0	80	15	95	3	1	107.8	45	26	3.0	2.4	210	690
12	Spanish	35	0	55	10	95	3	1	77.0	55	34	2.7	2.5	80	500
13	Indian Valley	0	0	0	100	2	2	95	--	35	16	2.5	--	--	0
	Genesee Valley	0	0	0	100	2	2	95	--	25	9	2.5	--	--	0
	American Valley	0	0	0	100	2	2	95	--	40	20	2.5	--	--	0
	Thompson Valley	0	0	0	100	2	2	95	--	40	20	2.5	--	--	0
	Meadow Valley	0	0	0	100	2	2	95	54.4[2]	50	28	2.5	--	85	0
													Total	1,835	7,530

[1] 1 to 2 percent of the area of each study unit is in the "Other" category of cover (roads, buildings, etc.)

[2] Total for all five valleys.

TABLE A2 MILES OF ROADS AND STREAMS AND ACRES OF UPLANDS SAMPLED

Study Unit	Drainage Area in Sq miles	Total Stream Miles	Total Road Miles	Tot Mi Stream Sampled	Tot Mi Roads Sampled	Total Acres Sampled	Number of Sheet & Rill Transects
1	104.3	225.2	166.8	1.07	2.37	115	2
2	53.4	85.5	192.1	6.16	5.24	190	2
3	99.3	269.2	208.6	12.18	6.57	140	3
4	106.9	168.9	171.0	16.36	14.11	705	9
5	63.7	115.3	203.8	8.34	6.65	260	5
6	69.8	148.8	139.7	10.94	12.05	560	6
7	70.9	186.5	156.0	37.94	18.62	1335	16
8	148.4	293.8	311.6	27.05	19.09	1105	14
9	109	227.7	337.8	24.28	8.16	1000	5
10	148.4	292.3	400.7	35.11	21.23	1125	12
11	107.8	120.9	223.1	10.03	9.10	880	1
12	77	264.1	323.4	20.78	13.93	30	10
13	54.4	--	--	--	--	1145	12
Total	1213.3	2398.2	2834.6	210.24	137.12	8590	97

LATERAL RECESSION RATES USED IN EAST BRANCH

NORTH FORK FEATHER RIVER EROSION INVENTORY

Table A3 Streambank and Gully Erosion

Lateral Recession Rate (ft/yr)	Category	Description
0.01-0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang. No exposed tree roots.
0.06-0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang. Some exposed tree roots but no slumps or slips.
0.3-0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads and trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and stream course or gully may be meandering.

Table A4 Roadbank Erosion

Lateral Recession Rate (ft/yr)	Category	Description
0.01-0.05	Slight	Some bare roadbank but active erosion is not readily apparent. Some rills but no vegetative overhang. Ditch bottom is grass or noneroding.
0.06-0.15	Moderate	Roadbank is bare with obvious rills and some vegetative overhang. Minor erosion or sedimentation in ditch bottom.
0.16-0.30	Severe	Roadbank is bare with rills approaching one foot in depth. Some gullies and overhanging vegetation. Active erosion or sedimentation in ditch bottom. Some fenceposts, tree roots, or culverts eroding out.
0.30+	Very Severe	Roadbank is bare with gullies, washouts, and slips. Severe vegetative overhang; fenceposts, powerlines, trees and culverts eroded out. Active erosion or sedimentation in ditch bottom.

What recession rates mean:

at 0.01 feet/year and 90 pcf = 20 tons/acre/year
at 0.05 feet/year and 90 pcf = 100 tons/acre/year
visible rills on the bank = 12 tons/acre/year

value by the density of the soil in the banks (pounds per cubic foot) and dividing by 2,000 converts the cubic feet per year to tons per year erosion.

Gully erosion was also estimated using the direct volume method on the left and right bank of each gully and on the headcut. These three values added together was the erosion for that gully. All gullies encountered in the sample areas were inventoried.

Road surface erosion was estimated visually or by using the Alutin Rill Erosion Method. If no obvious rills could be seen on the unprotected road surface, a default value of five tons per acre per year was used to represent the road surface erosion. Obvious rills would put the erosion into the ten tons per acre per year category. The Alutin Method was used to estimate erosion when rills were closely spaced or deep (approaching one foot in depth). The road length in each category and road width were recorded in the field.

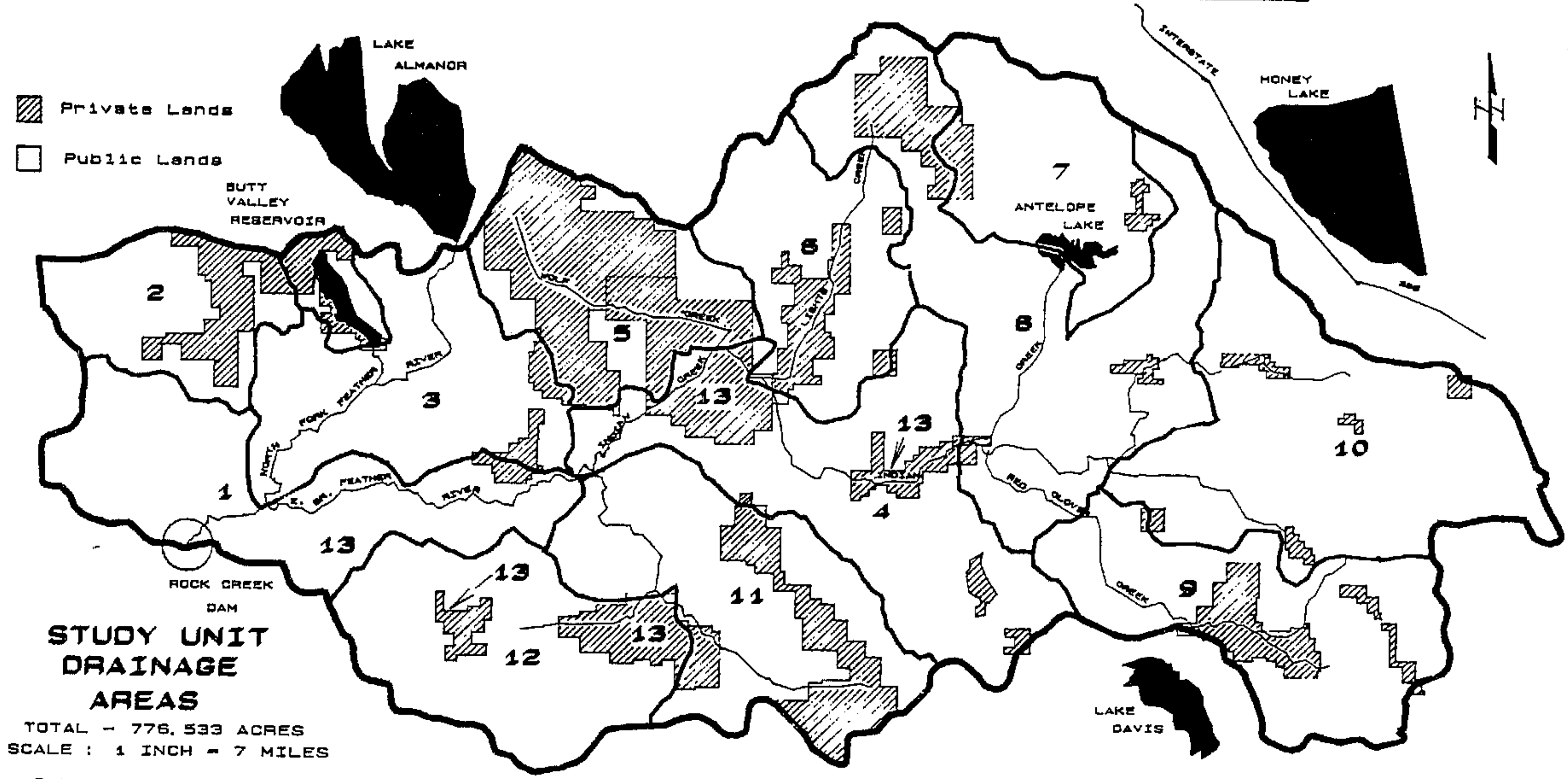
Only streams tributary to the large streams in valleys were walked. Field surveying and aerial photographs were used to determine erosion rates on the major stream in each valley. The photographs were used to estimate changes in channel widths from 1940 to 1986. The photo-interpreted areas were field surveyed in November 1987. Valley cross-sections were surveyed to record depths and widths of abandoned channels as well as the width and depth of the main channel now carrying the runoff. The lengths of the main channels that showed changes were measured using a map wheel on 7 1/2 minute topographic quadrangle maps. Changes in widths and depths of channels for six different time periods were estimated to determine the tons per year streambank and bottom erosion coming from the major streams in their valleys. The six time periods were pre-1850, 1900, 1940, 1982, 1987 and 2000.

FIELD DATA REDUCTION AND SAMPLE EXTRAPOLATION

About 300 field samples were examined. There was an average of about five data sheets for each road and stream sample and at least two sheets for each sheet and rill sample. Each of the stream and road data sheets had 20 lines of data. A line represents a segment of a cut or fill slope of a road or a left or right bank of a stream. The tons per year erosion was calculated for each line and converted to tons per bank mile per year. The tons per bank mile per year value was used to break out the categories of erosion severity. In order to be able to manipulate the data, each field sample was entered into computer files using an electronic spreadsheet template. This job took about 11 person-weeks.

The watershed was broken up into thirteen study units based on Plumas National Forest (PNF) subwatershed boundaries, geology, soils, topography and rainfall (Figure A1). Each erosion inventory sample in the Plumas National Forest subwatersheds was

EAST BRANCH NORTH FORK FEATHER RIVER



STUDY UNIT DRAINAGE AREAS

TOTAL – 776,533 ACRES
SCALE : 1 INCH = 7 MILES

Subwatershed Number	Name	Area Acres
1	Chips Cr., Rock Cr. Dam	66,739
2	Yellow Cr., Humbug Valley	34,210
3	North Fork Feather River–Rush Cr.	63,582
4	Lower Indian, Grizzly and Hosselkus Cr.	68,403
5	Wolf Cr.	40,764
6	Lights Cr.	44,706
7	Antelope Lake	45,389

Subwatershed Number	Name	Area Acres
8	E & W Branch Lights, Indian, Red Clover, Last Chance–Clarks Cr.	94,959
9	Red Clover Cr.	69,734
10	Squaw Queen–Last Chance Cr.	94,976
11	Lower Spanish–Greenhorn Cr.	69,001
12	Spanish Cr.	49,271
13	American, Meadow, Thompson Indian and Genesee Valleys	34,799

Figure A-1

assigned to one of the thirteen study units (Table A5). The "File Combine" command was then used to pull all the individual files (representing individual samples) into one big file representing a study unit. Each study unit has three of these combined files--one each for gullies, roads and streams.

Once all the field data representing an erosion source (gullies, roads, streams) was combined into one file for a study unit, the "Data Sort" command was used to rearrange each line of data (representing a gully or a segment of a road or stream) by the amount of erosion it produced. The file would then be sorted so it started with all the noneroding segments and ended with the segment or gully eroding at the highest rate (tons per mile per year or tons per year, respectively). After the data was sorted, it was easier to pick where the breaks occurred between the noneroding and slightly eroding segments, the slightly eroding and moderately eroding segments and the moderately and severely eroding segments.

The following categories were generally used for all study units. The percent of the total erosion in these categories was calculated by source for each study unit but that data was not included in this report:

For streambanks and roads:

Noneroding	0	tons/bank mile/year
Slight	1-100	"
Moderate	101-400	"
Severe	401-2000	"

For gullies:

Slight	< 5	tons/year
Moderate	5 - 10	"
Severe	> 10	"

The next step in the data reduction was to add up the lengths, heights, and recession rates of banks in each category and determine the average tons per bank mile for that category. After this, the total length in that category was divided by the total length sampled to determine the percent of the sample in that category. The drainage area of the study unit was then multiplied by the road or stream density to determine the total miles of roads or streams in the study unit. The total miles of roads or streams in the study unit were then multiplied by the percent for each category to determine the miles in the study unit in each category. By multiplying the miles of roads or streams in a category by the average erosion rate for that category, the tons per year erosion by category was calculated. All these calculations were based on bank miles which is two times the length of a road or stream.

TABLE A5

Relationship Between EBNFFR Study Units and the National Forest System Watersheds (Plumas National Forest Subwatersheds)

Study Unit #	Creeks	PNF Subwatersheds
1	Chips, Rock Creek Dam and Inner Gorge	9 A-D, 13A, 13C
2	Yellow Creek, Humbug Valley and high mountain meadows	9 E-F
3	N. Fork Feather River-Rush Creek mined areas	10 A-B, 13B, 13D
4	Lower Indian, Grizzly and Hosselkus Creeks	14
5	Wolf Creek	15
6	Lights Creek	16 A-E
7	Antelope Lake	18
8	E. and W. Branch Lights, Indian, mouth of Red Clover, Lower Last Chance-Clarks Creeks	16 F-G, 17, 20A, 21 A-C
9	Red Clover	20 B-E
10	Squaw Queen-Last Chance	19, 21 D-H
11	Lower Spanish-Greenhorn	22, 23
12	Spanish	24
13	American, Meadow, Thompson, Indian and Genesee Valleys	
14	Railroads	

Gullies were expanded in a similar manner as the roads and streams. The first sort was used to determine the number of gullies in the slight, moderate and severe category. The average tons per year per gully could then be calculated. A second sort was made to rearrange the gullies into those associated with streams, roads, and those in the upland areas away from roads and streams. The number of gullies occurring in the length of road or stream sampled was divided by that sample length to determine the number of gullies per mile. The drainage area and road and stream densities were multiplied to determine the total miles of streams or roads. The total miles were then multiplied by the gullies per mile and the tons per year per gully to get the tons per year from gullies by category and association.

The drainage area in acres was multiplied by the gullies per acre (based on the sampled area) and tons per year per gully to get the tons per year erosion from gullies in the upland areas by category.

Road surface erosion by study unit was determined in the same way as the other sources. The average annual road surface erosion rate (tons per acre per year) was multiplied by the acres of roads in each study unit to get tons per year road surface erosion.

Erosion from the major creeks was determined based on the sampled areas that were field surveyed and interpreted from aerial photographs. The erosion rates from the sampled areas were expanded to the appropriate lengths of main channels in each study unit based on local knowledge. The actual lengths were measured from 7 1/2 minute topographic quadrangle maps.

Sheet and rill erosion rates were calculated for each transect in each sample. The transect results were grouped by vegetative cover to determine an average sheet and rill erosion rate by cover type for each study unit. The Plumas National Forest database was used to extract the acres of each vegetative cover type by subwatershed. FS staff apportioned the subwatershed acres into acres by study unit. Tons per year sheet and rill erosion could then be calculated by multiplying the average annual rate by the acres. Appendix C contains the K factors used for each soil type.

The original draft report reported all values in terms of study units with the control used being the tons/square mile value from the USGS Crescent Mills gage site data. This data was revised using the average annual sedimentation at Rock Creek Dam as the control (Tables 1A to 14A). Comments received from the draft report wished the data to be in terms of subwatersheds instead of study units. Recombination of the original data and the subsequent sorting and analysis would have been too time - prohibitive. So the percentage of each study unit in each subwatershed was planimetered from digitized study area maps.

These percentages (Table A6) were used to directly recombine the study units into subwatersheds (Tables 1, 3-15 in main report).

TABLE A6 Percentages Used to Convert Study Units to Subwatersheds

Subwatershed	Conversion Formula for Study Units (SU) to Subwatersheds
1	100% SU# 2 + 52% SU# 1
2	Not Studied in Report
3	71% SU# 3
4	48% SU# 1 + 29% SU# 3
5	100% SU# 12 + 25% SU# 13
6	35% SU# 11
7	65% SU# 11 + 11% SU# 13
8	100% SU# 4 + 40% SU# 13
9	100% SU# 5 + 24% SU# 13
10	100% SU# 6 + 23% SU # 8
11	28% SU# 8
12	100% SU# 7
13	38% SU# 8 + 71% SU# 10
14	29% SU#10 + 2% SU# 8
15	100% SU# 9 + 9% SU# 8

TABLE 1 A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
CHIPS CREEK, ROCK CREEK DAM & INNER GORGE (STUDY UNIT #1)
(Includes PNF Watersheds 9A, 9B, 9C, 9D, 13A, 13C)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	4800	21.9	400	17.4
Brush	800	3.7	100	4.3
SUBTOTAL	5600	25.6	500	21.7
Roads				
Surfaces	400	1.8	100	4.3
Cut Slopes	9900	45.2	1000	43.5
Fill Slopes	5300	24.2	300	13.0
SUBTOTAL	15600	71.2	1400	60.9
TOTAL	21200	96.8	1900	82.6
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	700	3.2	400	17.4
SUBTOTAL	700	3.2	400	17.4
GULLY EROSION				
Associated w/ Streams	0	0.0	0	0.0
Associated w/ Roads	0	0.0	0	0.0
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	0	0.0	0	0.0
GRAND TOTAL	21900	100.0	2300	100.0

3/30/88

Table 2A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
YELLOW CREEK, HUMBUG VALLEY & HIGH MOUNTAIN MEADOWS (STUDY UNIT #2)
(Includes PNF Watersheds 9E, 9F)

Type or Source of Erosion	Erosion in Study Unit		Sediment to Rock Creek Dam	
	(Tons/Yr)	(Percent)	(Tons/Yr)	(Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	2400	3.2	200	1.7
Brush	200	0.3	0	0.0
SUBTOTAL	2600	3.4	200	1.7
Roads				
Surfaces	1200	1.6	200	1.7
Cut Slopes	44100	58.0	4400	38.3
Fill Slopes	16200	21.3	800	7.0
SUBTOTAL	61500	80.9	5400	47.0
TOTAL	64100	84.3	5600	48.7
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	11500	15.1	5800	50.4
SUBTOTAL	11500	15.1	5800	50.4
GULLY EROSION				
Associated w/ Streams	300	0.4	100	0.9
Associated w/ Roads	100	0.1	0	0.0
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	400	0.5	100	0.9
GRAND TOTAL	76000	100.0	11500	100.0

3/30/88

TABLE 3 A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
NORTH FORK FEATHER-RUSH CREEK MINED AREAS (STUDY UNIT #3)
(Includes PNF Watersheds 10A, 10B, 13B, 13D)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	4600	4.7	400	1.9
Brush	200	0.2	0	0.0
SUBTOTAL	4800	4.9	400	1.9
Roads				
Surfaces	900	0.9	200	1.0
Cut Slopes	39600	40.8	4000	19.2
Fill Slopes	18700	19.3	900	4.3
SUBTOTAL	59200	61.0	5100	24.5
TOTAL	64000	66.0	5500	26.4
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	28500	29.4	14300	68.8
SUBTOTAL	28500	29.4	14300	68.8
GULLY EROSION				
Associated w/ Streams	100	0.1	0	0.0
Associated w/ Roads	1000	1.0	300	1.4
Associated w/ Uplands	3400	3.5	700	3.4
SUBTOTAL	4500	4.6	1000	4.8
GRAND TOTAL	97000	100.0	20800	100.0

3/30/88

Table 4A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
LOWER INDIAN, GRIZZLY, & HOSSELKUS CREEKS (STUDY UNIT #4)
(Includes PNF Watersheds 14A, 14B, 14C, 14D
14E Upper, 14E Lower, 14F, 14G, 14H)

Type or Source of Erosion	Erosion in Study Unit		Sediment to Rock Creek Dam	
	(Tons/Yr)	(Percent)	(Tons/Yr)	(Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	6000	12.6	600	7.8
Brush	300	0.6	0	0.0
SUBTOTAL	6300	13.3	600	7.8
Roads				
Surfaces	800	1.7	200	2.6
Cut Slopes	21300	44.8	2100	27.3
Fill Slopes	10300	21.7	500	6.5
SUBTOTAL	32400	68.2	2800	36.4
TOTAL	38700	81.5	3400	44.2
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	8600	18.1	4300	55.8
SUBTOTAL	8600	18.1	4300	55.8
GULLY EROSION				
Associated w/ Streams	100	0.2	0	0.0
Associated w/ Roads	100	0.2	0	0.0
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	200	0.4	0	0.0
GRAND TOTAL	47500	100.0	7700	100.0

3/30/88

TABLE 5A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
WOLF CREEK (STUDY UNIT #5)
(Includes PNF Watersheds 15A, 15B, 15C)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	3600	3.4	400	2.4
Brush	100	0.1	0	0.0
SUBTOTAL	3700	3.5	400	2.4
Roads				
Surfaces	900	0.9	200	1.2
Cut Slopes	52400	50.1	5200	31.0
Fill Slopes	27800	26.6	1400	8.3
SUBTOTAL	81100	77.5	6800	40.5
TOTAL	84800	81.1	7200	42.9
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	18100	17.3	9100	54.2
SUBTOTAL	18100	17.3	9100	54.2
GULLY EROSION				
Associated w/ Streams	100	0.1	0	0.0
Associated w/ Roads	1600	1.5	500	3.0
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	1700	1.6	500	3.0
GRAND TOTAL	104600	100.0	16800	100.0

3/30/88

Table 6A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
LIGHTS CREEK (STUDY UNIT #6)
(Includes PNF Watersheds 16A, 16B, 16C, 16D, 16E)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	4000	6.8	400	3.3
Brush	100	0.2	0	0.0
SUBTOTAL	4100	7.0	400	3.3
Roads				
Surfaces	900	1.5	200	1.7
Cut Slopes	27200	46.2	2700	22.5
Fill Slopes	12000	20.4	600	5.0
SUBTOTAL	40100	68.1	3500	29.2
TOTAL	44200	75.0	3900	32.5
STREAMBANKS				
Major Streams	4000	6.8	3000	25.0
Tributary Streams	8500	14.4	4300	35.8
SUBTOTAL	12500	21.2	7300	60.8
GULLY EROSION				
Associated w/ Streams	900	1.5	400	3.3
Associated w/ Roads	1300	2.2	400	3.3
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	2200	3.7	800	6.7
GRAND TOTAL	58900	100.0	12000	100.0

3/30/88

TABLE 7A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
ANTELOPE LAKE (STUDY UNIT #7)
(Includes PNF Watersheds 18)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Antelope Lake (Tons/Yr)	Sediment to Antelope Lake (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	1600	0.9	400	0.5
Brush	0	0.0	0	0.0
SUBTOTAL	1600	0.9	400	0.5
Roads				
Surfaces	400	0.2	200	0.2
Cut Slopes	49200	28.8	14800	16.7
Fill Slopes	29300	17.2	5900	6.7
SUBTOTAL	78900	46.2	20900	23.6
TOTAL	80500	47.2	21300	24.1
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	88900	52.1	66700	75.4
SUBTOTAL	88900	52.1	66700	75.4
GULLY EROSION				
Associated w/ Streams	100	0.1	0	0.0
Associated w/ Roads	1200	0.7	500	0.6
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	1300	0.8	500	0.6
GRAND TOTAL	170700	100.0	88500	100.0

3/30/88

Table 8A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
E & W BRANCH LIGHTS, INDIAN, MOUTH OF RED CLOVER,
LOWER LAST CHANCE-CLARKS CREEKS (STUDY UNIT #8)
(Includes PNF Watersheds 16F-G, 17A-E, 20A, 21A-C)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	7800	4.2	800	1.7
Brush	1100	0.6	100	0.2
SUBTOTAL	8900	4.7	900	1.9
Roads				
Surfaces	700	0.4	100	0.2
Cut Slopes	71800	38.2	7200	15.4
Fill Slopes	31700	16.9	1600	3.4
SUBTOTAL	104200	55.5	8900	19.1
TOTAL	113100	60.2	9800	21.0
STREAMBANKS				
Major Streams	1500	0.8	1100	2.4
Tributary Streams	65000	34.6	32500	69.6
SUBTOTAL	66500	35.4	33600	71.9
GULLY EROSION				
Associated w/ Streams	2700	1.4	2000	4.3
Associated w/ Roads	1700	0.9	500	1.1
Associated w/ Uplands	3900	2.1	800	1.7
SUBTOTAL	8300	4.4	3300	7.1
GRAND TOTAL	187900	100.0	46700	100.0

3/30/88

TABLE 9A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
RED CLOVER CREEK (STUDY UNIT #9)
(Includes PNF Watersheds 20B, 20C, 20D, 20E)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	200	0.2	0	0.0
Brush	0	0.0	0	0.0
SUBTOTAL	200	0.2	0	0.0
Roads				
Surfaces	800	0.8	200	0.6
Cut Slopes	28300	27.6	2800	8.2
Fill Slopes	16200	15.8	800	2.3
SUBTOTAL	45300	44.2	3800	11.1
TOTAL	45500	44.3	3800	11.1
STREAMBANKS				
Major Streams	8500	8.3	6400	18.7
Tributary Streams	45700	44.5	22900	67.0
SUBTOTAL	54200	52.8	29300	85.7
GULLY EROSION				
Associated w/ Streams	2400	2.3	1000	2.9
Associated w/ Roads	300	0.3	100	0.3
Associated w/ Uplands	200	0.2	0	0.0
SUBTOTAL	2900	2.8	1100	3.2
GRAND TOTAL	102600	100.0	34200	100.0

3/30/88

Table 10A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
SQUAW QUEEN-LAST CHANCE CREEKS (STUDY UNIT #10)
(Includes PNF Watersheds 19A, 19B, 21D, 21E, 21F, 21G, 21H)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	800	1.1	0	0.0
Brush	100	0.1	0	0.0
SUBTOTAL	900	1.2	0	0.0
Roads				
Surfaces	600	0.8	100	0.4
Cut Slopes	14000	19.3	1400	5.1
Fill Slopes	9100	12.6	500	1.8
SUBTOTAL	23700	32.7	2000	7.3
TOTAL	24600	34.0	2000	7.3
STREAMBANKS				
Major Streams	4000	5.5	3000	10.9
Tributary Streams	40400	55.8	20200	73.7
SUBTOTAL	44400	61.3	23200	84.7
GULLY EROSION				
Associated w/ Streams	2700	3.7	2000	7.3
Associated w/ Roads	400	0.6	100	0.4
Associated w/ Uplands	300	0.4	100	0.4
SUBTOTAL	3400	4.7	2200	8.0
GRAND TOTAL	72400	100.0	27400	100.0

3/30/88

TABLE 11A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
LOWER SPANISH-GREENHORN CREEKS (STUDY UNIT #11)
(Includes PNF Watersheds 22, 23A, 23B, 23C)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	4000	3.6	400	2.3
Brush	400	0.4	0	0.0
SUBTOTAL	4400	3.9	400	2.3
Roads				
Surfaces	1900	1.7	400	2.3
Cut Slopes	43000	38.4	4300	24.4
Fill Slopes	41500	37.1	2100	11.9
SUBTOTAL	86400	77.1	6800	38.6
TOTAL	90800	81.1	7200	40.9
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	19700	17.6	9900	56.3
SUBTOTAL	19700	17.6	9900	56.3
GULLY EROSION				
Associated w/ Streams	200	0.2	100	0.6
Associated w/ Roads	1300	1.2	400	2.3
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	1500	1.3	500	2.8
GRAND TOTAL	112000	100.0	17600	100.0

3/30/88

Table 12A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
SPANISH CREEK (STUDY UNIT #12)
(Includes PNF Watersheds 24A, 24B, 24C, 24D, 24E)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	3000	2.3	400	1.2
Brush	300	0.2	0	0.0
SUBTOTAL	3300	2.5	400	1.2
Roads				
Surfaces	1100	0.8	200	0.6
Cut Slopes	43800	32.9	4400	12.7
Fill Slopes	27700	20.8	1400	4.0
SUBTOTAL	72600	54.5	6000	17.3
TOTAL	75900	56.9	6400	18.4
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	55600	41.7	27800	80.1
SUBTOTAL	55600	41.7	27800	80.1
GULLY EROSION				
Associated w/ Streams	800	0.6	300	0.9
Associated w/ Roads	300	0.2	100	0.3
Associated w/ Uplands	700	0.5	100	0.3
SUBTOTAL	1800	1.4	500	1.4
GRAND TOTAL	133300	100.0	34700	100.0

3/30/88

TABLE 13 A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
AMERICAN, MEADOW, THOMPSON, INDIAN, & GENESEE VALLEYS
(STUDY UNIT #13)
(Includes PNF Watersheds 14B, 14G, 15A, 16A, 24E)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	200	0.7	0	0.0
Forest	0	0.0	0	0.0
Brush	100	0.3	0	0.0
SUBTOTAL	300	1.0	0	0.0
Roads				
Surfaces	0	0.0	0	0.0
Cut Slopes	0	0.0	0	0.0
Fill Slopes	0	0.0	0	0.0
SUBTOTAL	0	0.0	0	0.0
TOTAL	300	1.0	0	0.0
STREAMBANKS				
Major Streams	29500	99.0	22100	100.0
Tributary Streams	0	0.0	0	0.0
SUBTOTAL	29500	99.0	22100	100.0
GULLY EROSION				
Associated w/ Streams	0	0.0	0	0.0
Associated w/ Roads	0	0.0	0	0.0
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	0	0.0	0	0.0
GRAND TOTAL	29800	100.0	22100	100.0

3/30/88

Table 14A

EAST BRANCH NORTH FORK FEATHER RIVER EROSION & SEDIMENT INVENTORY
RAILROAD EROSION IN WOLF, INDIAN, & SPANISH CREEK WATERSHEDS
(Includes PNF Watersheds 9A, 13A, 13C, 14A, 14B, 15A, 15B, 22)

Type or Source of Erosion	Erosion in Study Unit (Tons/Yr)	Erosion in Study Unit (Percent)	Sediment to Rock Creek Dam (Tons/Yr)	Sediment to Rock Creek Dam (Percent)
SHEET & RILL EROSION				
Meadows	0	0.0	0	0.0
Forest	0	0.0	0	0.0
Brush	0	0.0	0	0.0
SUBTOTAL	0	0.0	0	0.0
Roads				
Surfaces	0	0.0	0	0.0
Cut Slopes	23200	42.5	2300	57.5
Fill Slopes	31100	57.0	1600	40.0
SUBTOTAL	54300	99.5	3900	97.5
TOTAL	54300	99.5	3900	97.5
STREAMBANKS				
Major Streams	0	0.0	0	0.0
Tributary Streams	0	0.0	0	0.0
SUBTOTAL	0	0.0	0	0.0
GULLY EROSION				
Associated w/ Streams	0	0.0	0	0.0
Associated w/ Roads	300	0.5	100	2.5
Associated w/ Uplands	0	0.0	0	0.0
SUBTOTAL	300	0.5	100	2.5
GRAND TOTAL	54600	100.0	4000	100.0

3/30/88

APPENDIX B

WAYS TO MINIMIZE ROAD EROSION

1. Avoid construction in high erosion hazard areas.
2. Minimize the amount of disturbance by controlling the total mileage and areal extent of the roads.
3. Minimize erosion on areas that are disturbed by using practices to control erosion (King and Burroughs 1988).
4. Minimize offsite effects of erosion.
5. For midslope and lower slope locations, design roads to accommodate additional flow from the interception of the subsurface flow zone (Megahan, 1983).
6. Maximum results occur if erosion control measures are applied immediately after construction. Treatments protect the soil until vegetation is established, and installation of downslope barriers are used to delay and reduce downslope soil movement (Megahan and Kidd 1972).

APPENDIX C

SOIL K FACTORS

The PNF Soil Survey Report was used to determine the K Factors. The soil mapping in the PNF report is at an Order 3 level in which families (F), complexes of families and undifferentiated units are described. In many cases, it was difficult to determine which component of a complex a particular transect occurred. Determinations were made by comparing information on transect sheets and information in the soil survey report.

In the valleys of Plumas County an Order 2 soil survey was available at the Susanville Soil Survey Office. The soils in this report were described to the series level (S).

The K factors in the report did not appear to be corrected for rock fragments. Table 603-5 of the USDA-SCS National Soils Handbook (NSH) was used to adjust the K values (attached). Where rock fragments are present in the surface, the K values were reduced in proportion to the amount of rock fragments.

QUAD	PLOT	SOIL MAP SYMBOL	TRAN-SECT	SOIL	TEXTURE	K
ALMANOR NE (CANYON DAM)	219	KwF	1-3	KINKLE (F)	GRV-L	0.20
ANTELOPE LK.	83	XiF	1-3	LITHIC XEROCHREPTS (F)	GR-LS	0.17
		HqF	1-3	WAPI (F)	GR-LS	0.10
BUCKS LK.	280	SdF	1-3	AIKEN (F)	GR-L	0.20
	283	SdF	1-3	KISTRIN (F)	GRV-L	0.12
	284	SdF	1-3	AIKEN (F)	GR-L	0.20
	2	BdG	1-3	SKALEN (F)	CB-L	0.17
	4	SdF	1-3	KISTREN (F)	GRV-L	0.14
	3	XcF	1-3	TYPIC HAPLOXERULTS (F)	L	0.32
		XbF	1-3	ULTIC PALEXERALFS (F)	SL	0.28

QUAD	PLOT	SOIL MAP SYMBOL	TRAN-SECT	SOIL	TEXTURE	K
	8	XbF	1-4	ULTIC PALEXERALFS (F)	SL	0.28
	19	NO WORKSHEET AVAILABLE				
BABCOCK PK.	237	GwE	1-2	SATTLEY (F)	GR-L	0.15
		GwE	3-4	FRANKTOWN (F)	CBV-L	0.14
	80	RxF	1-2	CAGWIN (F)	GR-LS	0.17
		RxF	3	LITHIC XEROCHREPTS (F)	GR-LS	0.17
	79	RxF	1-3	CAGWIN (F)	GR-LS	0.17
	75	XiF	1-2	CAGWIN (F)	GR-LS	0.17
		XiF	3	LITHIC XEROCHREPTS (F)	GR-LS	0.17
	76	CqF	1-3	CHAIX (F)	SL	0.22
CROCKER MTN	246	AhSE	1-2	FRANKTON (F)	CBV-L	0.14
		AhSE	3	FOPIANO (F)	CB-SL	0.15
	90	SbE	1-2	SATTLEY (F)	CBV-L	0.11
		AqVE	3-4	FRANKTON (F)	CBV-L	0.14
	89	SfE	1-3	FRANKTON (F)	CBV-L	0.14
DIAMOND MTN	232	RxF	1-3	LITHIC XEROCHREPTS (F)	GR-LS	0.17
DIXIE MTN	250	ShF	1-3	SHEPAN (F)	GRV-SIL	0.12
FERRIS CR.	267	SwG	1-3	SWITCHBACK	GR-SL	0.20
	275	WgF	1-3	SHEPAN	GRV-SIL	0.12
	272	GwF	1-3	POLECREEK	GR-SCL	0.20
GENESEE VALLEY	61	KwF	1-3	KINKLE (F)	GRV-L	0.15
	72	CqF	1-3	WAPI (F)	COSL	0.19
	73	RxF	1 & 3	LITHIC XEROCHREPTS (F)	GR-LS	0.28
		RxF	2	CAGWIN (F)	GR-LS	0.17

QUAD	PLOT	SOIL MAP SYMBOL	TRAN-SECT	SOIL	TEXTURE	K
GREENVILLE NE	9	30	1-4	MASSACK (F)	FSL	0.32
	57	KwG	1-3	KINKEL	GRV-L	0.12
	32	BdG	1-3	SKALAN	CB-L	0.15
GREENVILLE NW	40	KwF	1-2	DEADWOOD (F)	GR-SIL	0.23
	38	BoG	1-2	HOLLAND (F)	GR-L	0.23
		BoF	1-2	HOLLAND (F)	GR-L	0.23
	11	20	1	GANSER (S)	SIL	0.37
		24	2-3	KEDDIE (S)	L	0.32
	12	24	1	KEDDIE (S)	L	0.32
	32	KwG	1	KINKLE (F)	GRV-L	0.32
		KwG	2	KINKLE (F)	GRV-L	0.12
		LjF	3	YAHNE (F)	CBV-L	0.12
GREENVILLE SE	24	DfOH	1-2	DEADWOOD (F)	GR-L	0.23
	21	HkE	1-4	SKALAN (F)	GRV-SL	0.09
	1	25	1-2 & 4	KEDDIE (S)	L	0.32
		22	3	GREENHORN (S)	S	0.10
	21A	BdF	1-4	KISTIRN (F)	GRV-SIL	0.12
	22	BdF	1-4	KISTIRN (F)	GRV-SIL	0.12
	7A	24	1-2	KEDDIE (S)	L	0.32
		30	3	MASSACK (S)	GR-L	0.20
GREENVILLE SW	30	KwG	1-2	DEADWOOD (F)	GR-L	0.23
	5A	24	1-4	KEDDIE (S)	L	0.32
	6B	24	1-3	KEDDIE (S)	L	0.32
GRIZZLY VALLEY	244	GwE	1-3	POLECREEK (F)	GR-SCL	0.20
	205	TfF	1-3	TROJAN (F)	L	0.32
KETTLE ROCK	42	HsF	1-3	HAYPRESS (F)	STV-LS	0.10
		RxF	1-3	CAGWIN (F)	GR-LS	0.17
		RxF	1-3	CAGWIN (F)	GR-LS	0.17

QUAD	PLOT	SOIL MAP SYMBOL	TRAN-SECT	SOIL	TEXTURE	K
		CgF	1-3	CHAIX (F)	SL	0.24
MT. INGALLS	209	WvF	1-4	WOODSEYE (F)	GRV-L	0.12
QUINCY	16	28	1-3	KEDDIE (S)	L	0.32
	13T	23	1-3	GREENHORN (S)	GR-L	0.20
	17	NO MAP LOCATION PROVIDED				
SPRING GARDEN	6	LjF	1-4	YAHNE (F)	CB-L	0.17
		LjF	5	INVILLE (F)	GRV-L	0.17
SQUAW VALLEY PEAK	264.	SbE	1-3	SATTLEY (F)	GR-L	0.17
	101	SqSF	1-3	SATTLEY (F)	GR-L	0.17
	253T	GwE	1	FRANKTOWN (F)	CBV-L	0.14
		563E	2-4	FRANKTOWN (F)	CBV-L	0.14
	259	MaE	1-2	FRANKTOWN (F)	CBV-L	0.14
	261	BcE	1-3	BULLNELL (F)	SL	0.24
	100	AhE	1-3	FOPIANO (F)	GR-SL	0.15
	93	SfE	1-3	SATTLEY (F)	GR-SL	0.17
STONY RIDGE	97T.	TfE	1	SATTLEY (F)	CBV-L	0.11
			2-4	TROJAN (F)	L	0.32
WESTWOOD SE	50T.	EwE	1-3	ETCHEN (F)	GR-L	0.20