MIDDLE FORK EEL RIVER
SEDIMENT TMDL

SMALL SEDIMENT SOURCE SURVEY

Mendocino National Forest
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This report is divided into an introduction, and for each sediment source that sources' project design, sampling protocol and findings. Sediment sources were roads, gullies caused by roads, erosion from timber harvest unit skid trails and landings, and streambank erosion.

INTRODUCTION

In late February 2002, representatives from the EPA and Forest Service (Regional Office, PSW Research, Klamath and Mendocino National Forests) met to discuss the Forest Service conducting a sediment survey for the Middle Fork Eel River TMDL. An interagency agreement was made for EPA to fund the Mendocino National Forest to conduct a small and large source sediment survey for the Middle Fork Eel River, including private land from the Forest boundary to the confluence with the main Eel River near Dos Rios.

The small source survey would measure sediment from roads, man induced gullies in grassland/hardwood vegetation types, skid trails and landings from timber sale areas that entered streams and streambanks. The large source survey would measure active landslide contributions to the sediment budget of the Middle Fork Eel River.

An agreement was made with the Round Valley Indian Tribe, to collect field data for the small sediment source survey. The Forest Hydrologist provided training and oversight of their work. The purpose of the training was to give tribal members training and development in field surveys and to collect needed information for the TMDL. The Tribe provided a three person crew, vehicle, crew supervisor and data manager for the project.

Klamath N.F. Forest Geologist (Juan de la Fuente), was requested to measure landslide sedimentation. He developed a protocol to measure the contribution of sediment to the stream system from active landslides. Juan and another geologist (Bill Snavely) did aerial photograph analysis and field calculations of material from landslides entering a stream.

SMALL SEDIMENT SOURCE SURVEY

By May, the Forest Hydrologist (Bob Faust) had developed protocols for measuring sediment derived from roads at stream crossings, gullies and timber harvest areas. A field test of the road and gully forms was conducted in May with assistance from West

Zone Hydrologist (Peter Adams).

Forest Service statistician (Jack Lewis) provided information on sample size and review of the data analysis. GIS was used to produce maps that labeled locations where roads crossed streams and labeled locations of roads that passed through grasslands or woodlands. Timber harvest units were identified using cutover maps with potential sediment source areas (skid trails or landings) near streams identified with aerial photographs.

In June, the Forest Hydrologist began training individuals from the Round Valley Indian Tribe on the sampling procedures outlined in the protocols. Field checking of work was done in July, September and October.

Data synthesis was done by the Tribe in late October. Report preparation was done in early 2003.

The Tribe did most of the field work in three watersheds. Hydrologist Adams did survey work in Elk Creek. Hydrologist Faust conducted some timber harvest surveys in the Black Butte River watershed.

The Middle Fork Eel watershed was divided into four subwatersheds to reflect differences in logging and road construction history, vegetation types, geology and other physiographic features. The four 5^{th} field subwatersheds were Upper Middle Fork Eel River, Black Butte River Elk Creek and Williams/Thatcher Creeks.

ROADS

Survey work on National Forest System roads was conducted inside the Forest boundary. Roads on private land, either within or outside the Forest boundary were not sampled.

<u>Roads on National Forest System (NFS) land</u>

<u>Sample Protocol</u>

<u>Road Prism Survey</u>

Since roads receive differing amounts of road maintenance, they were separated into four maintenance types. Level 1 roads are in custodial care and may be closed, level 2 roads are maintained for high clearance vehicles, while passenger cars can drive on level 3 roads and level 4 roads with a moderate degree of user comfort for all vehicle types.

Roads were further segregated by surface type, native (dirt) surface, rocked and asphalt. Length of road by maintenance level and surface type was measured in GIS. Along each road, road/stream crossings were numbered.

Funding determined the sample size. The number of days to work in a watershed was based on the number of road miles in that watershed. Within a watershed, the number of days to sample roads by maintenance level was also based on total length. For example, the miles of road within the Upper Middle Fork Eel watershed represented 26% of the total miles of the four watersheds. It was determined that funding to do the field survey would equate to forty-four days. The percent of miles and available days to survey roads in the Upper Middle Fork Eel River would be 12 days. In the Upper Middle Fork Eel River, 37% of the road miles are in maintenance level 1. This percent of 12 days available equates to 4 days to sample level 1 roads. In a days time, it was estimated that two roads could be sampled per day. On each road two to three road/stream crossings could be sampled per day or four to six road/stream crossings per day. Forty-four days were allotted to sample road/stream crossings.

The road to be sampled was determined by adding the length of all roads in each maintenance level class and by surface type. Random numbers were used to select a length which was compared to the running miles; this gives weight to long roads.
The road number within the mileage range was the selected road. For example, road 20N107 was the first road listed for the Black Butte River watershed. Length of road 20N107 went from 0.0 to 0.70, road 20N111 from 0.71 to 1.50, road 20N113 from 1.51 to 1.60, etc. for all the maintenance level 1 roads with native surface. If random number 1.12 was selected, this number would fall in the range of road 20N111 miles of 0.71 and 1.50, thus 20N111 was the selected road.

Road/stream crossings were identified in GIS. For the selected roads, the crossings were numbered and a random table was used to select the number of road/stream crossings to be sampled in a watershed.

For example, road 25N18 has seventeen road/stream crossings and road 24N81 has two crossings. Each of the crossings was consecutively numbered, and a random number selected to represent the crossing. Table 1 lists the miles of road in each watershed by maintenance level and road surface type. The Black Butte River watershed had the most miles followed by the Upper Middle Fork Eel River watershed. Elk Creek and Williams/Thatcher watersheds had the least road miles.

Some streams designated on the GIS topographic map did not exist in the field. If a stream was not present at the GIS designated location, a coin was flipped to determine which way (up or down the road) to travel to the next stream crossing. This situation only happened a few times.

In order for a road parameter to be measured on a road, the sediment source (parameter) had to directly contribute sediment to a stream. Parameters measured on the road were road surface, cutbanks, inside ditches, cut and fill slopes only if they contributed sediment to the stream.

Table 1: Length of Road by Maintenance Level and Surface Type

		Miles of road by surface type					
	Maintenance						
Watershed	Level	NAT	IMP	AGG	AC	BST	Total
Middle Fork Eel	1	44	0	0	0	0	44
	2	53	0	0	0	0	53
	3	13	27	0	0	1	41
	4	0	0	0	0	10	10
							148
Black Butte River	1	120	0	0	0	0	120
	2	84	0	0	0	0	84
	3	3	20	3	0	0	26
	5	0	0	0	0.1	0	0.1
							230
	Maintenance						
Elk Creek	Level	NAT	IMP	AGG	AC	BST	Total
	1	33	5	0	0	0	38
	2	7	4	0	0	0	11
	3		6				6
							55
Williams/Thatcher							
	Maintenance						
	Level	NAT	IMP	AGG	AC	BST	Total
	1	13	0	0	0	0	13
	2	17	3	0	0	0	20
	3	3	11		0.2		14.2
							47.2

Field Survey:
At the designated crossing on the GIS map, the existence of a stream was determined. If a stream (ephemeral, intermittent, perennial) existed, field data was collected. Measurements were made on 1) road surface length and width that contributed runoff into a stream, 2) the dimensions of a cut slope contributing sediment to a stream either by direct discharge or by a ditch/berm and 3) stream crossing embankment (fill) rilling or slumps that eroded into the channel. Road sediment draining into litter was not considered to be a discharge to the stream. Slope steepness was measured with a clinometer while ground cover was ocularlly estimated.

Photographs were taken at the sample sites. These photos are useful in visualizing the site and understanding the collected data.

Table 2 in the Appendix displays the amount of sediment measured at the randomly chosen road/stream crossings. Sediment is displayed as cubic feet, not cubic yards as in other tables.

Sediment Calculations

Road sediment calculations for the road prism were determined by using the WEPP model. (http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/wr/wepproad.pl)
Data to run the model were climate (Willits 1NE CA), soil texture (clay loam), and road design (insloped, bare ditch). This model calculates pounds of sediment produced. Conversion of pounds to cubic feet was based on a cubic yard of soil weighing 3000 pounds. The typical soil type is sheetiron, which has a basic soil erosion rate of 0.32 inches/year. Cut/fill slope soil erosion on a 45% slope with 30% cover yields a soil loss of 0.06 inches/year. The same data but with 70% cover gives a soil erosion rate = 0.006 inches/year.

Findings

Field measurements at road/stream crossings were tabulated by 5th field watershed. Soil introduction to streams at road/stream crossings was tabulated by road maintenance level and road surface type. There was surprisingly only a few road/stream crossings that were contributing sediment to the stream. Compared to a decade or more ago, the roads have very few outside berms, roads are mostly outsloped, drainage across an embankment rarely drains onto the slope, fill slopes are heavily vegetated and cutslopes are moderately covered with vegetation and litter.

Of the parameters measured, roads in the Black Butte River had erosion from the road bed and very little from cut banks. In contrast, roads in the Upper Middle Fork Eel watershed had erosion from various sources, eg. cutbank and inside ditch. See Appendix table 3.

Statistical analysis was used to estimate sediment production from all road/stream crossings. Table 4 shows the amount of erosion in each watershed by road maintenance level and surface type. In cases where no data was collected for a specific maintenance level or surface type, it was estimated from data collected in another watershed. In the Upper Middle Fork Eel watershed, maintenance level 3 roads with an improved surface yielded the highest sediment rate. Whereas in the other three watersheds, maintenance level 1 and 2 roads with a native surface yielded the highest sediment rates.

Table 4. Total number of crossings by maintenance level and surface type.

Watershed – Upper Middle Fork Eel

Mntce Level	Surface Type	Total # Crossings	#Sampled	# with Erosion	Cu. Yards
1	NAT	116	9	4	32
2	NAT	167	9	1	5
3	NAT	43	3	3	13
	IMP	99	7	3	352
	BST	9	0	--	32
4	NAT	3	0	--	29
	BST	48	3	2	52

Watershed - Black Butte River

Mntce Level	Surface Type	Total # Crossings	#Sampled	# with Erosion	Estimated Cu. Yards
1	NAT	326	14	4	82
2	NAT	267	19	4	67
3	AGG	7	0	0	25
	IMP	27	7	2	1
	NAT	7	5	2	25
5	AC	1	0	0	4

Watershed - Elk Creek

Mntce Level	Surface Type	Total # Crossings	#Sampled	# with Erosion	Estimated Cu. Yards
1	NAT	71	3	2	24
	IMP	17	1	0	6
2	NAT	19	0	0	8
	IMP	23	1	1	9
3	IMP	2	2	1	2

Watershed - Williams/Thatcher

Mntce Level	Surface Type	Total # Crossings	#Sampled	# with Erosion	Estimated Cu. Yards
1	NAT	54	0	0	18
2	NAT	104	2	1	24
	IMP	6	1	0	2
3	NAT	19	0	0	18
	IMP	3	0	0	3
	AC	2	0	0	2

System and Non-System Roads

Forest Service system roads are those that have been identified by the Forest as roads to keep and maintain. Non-system roads are typically narrow roads created by off road vehicles. These roads receive no funds for maintenance. Thus, they may have chronic erosion problems.

The Forest engineering department does not have an accurate accounting of these roads but does have an estimate. Of the total miles of system roads in the Upper Middle Fork Eel (see table 1), an additional 1.5 miles (or less than 1%) are not documented on the system. In the Black Butte River watershed, there are about five more miles (2%) of non-system roads; in the Elk Creek watershed, less than 1% of the roads (0.5 miles) are non-system; in Williams/Thatcher there is about an additional 2.5 miles (5%) that are non-system roads. (B. Egly, B. Conner, pers. communication).

More non-system roads are thought to exist in Williams/Thatcher watershed due to the openness of the countryside. The Elk Creek watershed has private land and brushfields that limit off highway travel. The Black Butte River watershed has more open area and less steepness than the Upper Middle Fork Eel River for off-highway vehicle use.

Road Failure Surveys

Two kinds of road failures were examined. Large failures (a) that were repaired with storm damage funds and (b) small failures that were repaired with road maintenance funds.

a. Besides measuring road parameters, an attempt was made to determine the amount of material eroded from large storm damage sites. Most of the sites had been repaired and were difficult to locate due to vegetative growth.

b. Quantification of small storm damage sites was also difficult because not every winter produces culvert washouts or slumps.

Sample Design

a. The Forest engineering department keeps general information on the location of large road failures. Road failures range from settling roadbeds, to small slumps, to cutbank or fill failures to landslides. These failures are in a variety of sizes. Road failures from 1995 to 2002 were identified on a Forest map. Effort was made to find these sites to determine the amount of soil leaving the site and being deposited in a stream.

b. Small failure site estimates were done by the Covelo Ranger District Engineer (Conner). For many years he has repaired or opened plugged or washed out culverts in these watersheds.

No storm damage road repair survey was done on non-National Forest System roads.

Sediment Calculations

a. Since the road failures were repaired, it was difficult to locate exactly where they occurred. However, two identifiable road failures were located in the upper Black Butte watershed. Dimensions of the failures were made by tape and ocular estimate. One site near Umbrella Creek (Black Butte River) was a road bed failure that deposited roughly 7,800 cubic yards of soil into the stream. Another nearby site at Skidmore Creek yielded about 170 cubic yards of material originating from an unstable cutbank and fill slope. Other sites in the Black Butte River drainage ranged in estimated size from 20 cubic yards to 900 cubic yards. (B. Egly personal communication).

b. Based on past road maintenance experience, the Ranger District Engineer estimated the number of road/stream crossings and the volume of sediment moved downstream in the four watersheds. (B. Conner pers. Communication).

Findings

a. Volume of sediment produced by each large site was estimated based on contracts and recollection by the engineering department (B. Egly).

Between 1995 and 2002 (7 years) the following volume estimates of sediment to streams were:

Upper Middle Fork Eel River – 6,420 cubic yards was produced from 16 sites. Average volume per site was about 400 cubic yards. Over a 3 to 4 year period, 3 to 4 road failures would be expected to develop or one per year producing 400 cubic yards.

Black Butte River – 11,275 cubic yards was produced from 18 sites. Average volume per site was about 630 cubic yards. Over a five year period, one to two sites would be expected to develop or 250 cubic yards per year.

Williams/Thatcher – 40 cubic yards was produced from two sites. Average volume per site was about 20 cubic yards. During a five year period, one or two failures are estimated to occur or 8 cubic yards/year.

Elk Creek – 4,400 cubic yards was produced from 9 sites. Average volume per site was about 490 cubic yards. During a five year period, 3 or 4 road failures would be expected to develop or 390 cubic yards/year.

b. In the Upper Middle Fork Eel River watershed, the Espee Slide road crossing moves every year. Roughly 200 cubic yards of material moves down slope towards Howard Lake. The lake captures nearly all of the material. Roughly 25 road/stream crossings in this watershed contribute about 165 cubic yards of material a year.

In the Black Butte River watershed, about 17 road/stream crossings contribute 80 cubic yards per year. Elk Creek watershed has one or two road/stream crossings that contribute about five cubic yards per year while in Williams/Thatcher watershed four to five sites contribute about 40 cubic yards per year.

Roads

Roads located on Non-National Forest System Land

Sediment analysis attempted to document erosion occurring from roads not under control of the Forest Service.

Sample Design

The simplest way to make this road sediment determination was to conduct a map exercise examining roads on private land within the Forest boundary and roads outside of the Forest boundary. No direct measurements of sediment to streams was made on these roads.

GIS was used to tabulate road/stream crossings on private land within the Forest boundary. These roads are typically native surface and serve as access to residences or for timber removal. Since no measurements were taken on these crossings nor an effort to estimate a maintenance level, an average erosion rate between a Forest Service maintenance level 2 and 3 was used. Using the Black Butte River measurements, this rate was eleven cubic feet per crossing.

Sediment Calculations

Sediment to streams on non-National Forest System land was estimated using the same average soil delivery amount as that on National Forest System land per road/stream crossing. This assumption may produce low sediment production as private roads are often insloped with long distances between cross drains. Also, they may receive less maintenance and have rutting.

Non-National Forest System road stream crossings were determined by highlighting roads on a 1:24000 topographic map. Streams crossing roads were determined by the stream crenulation method. Streams were marked crossing a road if the topographic lines made a “V” shape of roughly 120 degrees or less.

For outside the Forest boundary, the number of road/streams crossings were tabulated by paved roads (Highway 162), improved roads (Pookiney, Mina, etc.) and native surface roads.

Lack of data precluded any estimate of roads damaged by storm damage.

Findings

Table 5 shows the estimated amount of soil deposited into streams from roads that are not National Forest System responsibility. As mentioned above, these roads may have a different road prism and road location that may or may not contribute similar amounts of sediment to streams as those roads on National Forest System land.

Table 5. Deposition from road/stream crossings on Non-National Forest System lands by Maintenance Level.

Level 1 and 2 roads

Watershed	Deposition Rate (cu.ft.)*	Number of Crossings	Total (cu.yd.) Deposition
ROUND	7	299	78
ELK	7	298	77
W/T	7	549	142
	11	23	9
MFE	11	8	3
BBR	11	208	88

*Erosion rate for roads inside Forest boundary are higher than outside as terrain is steeper and soils more erosive.

Level 3 roads**

Watershed	Deposition Rate (cu.ft.)	Number of Crossings	Total Deposition (cu.ft)	Total (cu.yd.) Deposition
ROUND	28	34	952	35
W/T	28	56	1568	58

**Level 3 roads – Poonkinny, Mina, Short, Simmerly Flat, Dingman, Doghouse, Pedro Ridge.

Level 4 roads**

Watershed	Deposition Rate (cu.ft.)	Number of Crossings	Total Deposition (cu.ft)	Total (cu.yd.) Deposition
ROUND	87	9	783	29
W/T	87	61	5307	197

** Level 4 road - Highway 162

Elk – included in outside Forest boundary

TIMBER HARVEST

Timber harvest units were examined to determine if any erosion occurring from skid trails and landings was being deposited in streamcourses.

Sample Pool

Like roads, the watershed was divided into four subwatersheds for sampling of timber sales. Some subwatersheds had more timber harvest than others and during different time periods. Timber sales from 1980 to present were in the sample pool. See Appendix table 12. This year was the beginning of formal implementation of watershed best management practices.

This study only measured erosion reaching a streamcourse. A random number table was used to select harvest units for field survey. The number of units selected by subwatershed was based on the total number of units. For instance, the Black Butte River had the most harvest units (43%), followed by the Upper Middle Fork Eel River (31%), Elk Creek (16%) and Williams-Thatcher (10%). Thirty timber harvest tractor units were sampled. Skyline logging units were not part of the sample pool as this logging method requires suspension over the streamcourses, which has been validated through the BMP Effectiveness Program, and skyline landings are located away from streams and closer to ridges for better log suspension.

Selected units were examined on aerial photographs that occurred most recently after logging. For the selected units, all skid trails that crossed streamcourses or landings near streams, as seen on the air photo, were selected for field survey. These older photographs were valuable in locating the sites in the field as over a 10-15 year period vegetation regrowth covered disturbed areas.

Sediment Calculations

Field survey consisted of measuring erosion on skid trail (running surface, cut/fill) approaches to stream crossings. The length of trail (surface, cut and fill) contributing runoff to the stream was measured. Three cross sections of this length measured or estimated the amount of erosion, normally one to two millimeters.

Landings were examined to determine if surface runoff would reach a stream. For landings, the erosion rate was based on the soils basic erosion rate with 10% ground cover and 5% slope. This produced an average 0.001 inches/year soil loss.

Soil loss numbers for surface erosion on landings and skid trails was extremely low. See

Appendix table 13. Measurements in the crossing made up most of the erosion. These measurements included the length, width and depth of soil that was eroded from the crossing. Some crossings were very well removed while others had some soil remaining.

Findings

The Upper Middle Fork Eel had the highest sediment yield from timber harvest, but only from one sample which had erosion. Whereas the Black Butte River watershed had several samples with erosion but smaller sediment yields. See table 6.

There have been high amounts of timber harvest on private lands in the Cold Creek and Spanish Creek subwatersheds of the Black Butte River. No sediment calculations were made for private land timber harvesting.

Table 6: Erosion from Timber Harvest Units

Watershed	Erosion (cu yds)
Upper Middle Fork Eel	23
Black Butte River	13
Williams/Thatcher	0
Elk Creek	NK*

*Not known as area not surveyed. However, the timber sales are Mendenhall fire salvage sales from about 1989. Nearly all of the disturbed area has recovered with brush.

GRASSLAND GULLY SURVEY

Areas that contain road related gullies are located in grasslands and hardwood stands. For this study only road caused gullies that entered streams were measured. This excluded channels where road water added flow to an existing stream and where road drainage gullies dissipated on the slope.

Sample Design

For each subwatershed, the total miles of road in the grass and hardwood vegetation types were summed. Sample size in each subwatershed was based on the amount of miles on these vegetation types. The Black Butte River subwatershed had 44% of the miles, followed by Williams/Thatcher at 34%, Upper Middle Fork Eel River (14%) and Elk Creek (8%).

As with selecting road/stream crossings, the cumulative length of road in a subwatershed was totaled. Random table numbers were used to select a length. The length was matched with the cumulative road segments and selected. Twenty days were allotted to gully survey. Road gullies on non-National Forest System land occur along some roads but are not extensive. These gullies were not measured.

Sediment Calculations

Only the active eroding channel in the bottom of the gully was measured. This channel corresponded to bankfull flows that occur within a 2-5 year time period. Banks above the bankfull channel were measured for height, slope and ground cover.

The gully was measured at three locations (20 feet below outlet, mid-point and 20 feet above confluence) and data tabulated data in three segments. For statistical analysis, all road runoff related gullies were ocularly measured for depth, width and length. The gullies were numbered and one randomly chosen to be measured with a tape.

Data analysis compared the measured gully dimensions with the ocular dimensions. For streambank erosion, the soil erosion rate was adjusted for slope and ground cover. Statistical analysis was used to extrapolate that data to the other ocular estimated gullies in that road segment. For the watershed, data from individual road segments (segments with and without gullies) was computed to give total gully erosion in the watershed. See table 7.

Table 7: Road Gully Erosion in the Watersheds

Watershed	Estimated Total
Black Butte	36
Upper Middle Fork Eel	9
Elk Creek	78
Williams/Thatcher	48

Findings

Measurements of gully channel dimensions assumed an annual rate where in reality the observable dimensions may have occurred over several years. Surprisingly there is more road gully erosion in Elk Creek watershed than Williams/Thatcher as there is less road mileage in this watershed. However, two of the four randomly selected sites contained erosive channels that delivered sediment to a stream. Williams/Thatcher contains much grassland and road associated gullies.

STREAMBANK

The 1970 Forest Service River Basin group calculated erosion rates of various size streams in the Middle Fork Eel River watershed. Since no watershed map is with the study, an assumption was made that the river basin wilderness watershed was Middle Fork Eel River above Eel River Station and that the Black Butte and Elk Creek watersheds commenced at the confluence with the Middle Fork Eel River.

These scientists used aerial photography (1941 and 1965) and an Abrahms height finder to measure height of streambank erosion. Erosion rates were tabulated by stream order. An annual rate calculated for this time period included two large flood years, 1956 and 1964.

The Mendocino Forest made a terse field study to validate the river basin erosion rates. The time period of measured erosion was assumed to be from the last large water flow year, 1998.

Sample Design

Streambank erosion was measured along short reaches of Estell Creek, Spanish Creek and the Black Butte River located in the upper watershed. The Forest stream channel stability rating evaluation form was used to determine the condition of streambanks, specifically the bank cutting parameter. Channel reaches measured were in excellent, good, fair or poor condition. Factors evaluated in this parameter were amount of raw banks, root mat overhangs and sloughing. Only streambank cutting and failures to 50 feet high were measured. Larger stream landslides were evaluated in the large sediment source analysis.

Forest Stream Sediment Calculations

Length of channel erosion was measured by hip chain, tape measure and ocular estimate. Assumption was that the most recent bank erosion occurred during bankfull discharges which occurred within the last five years.

The size of the stream at the sample points were as follows: Estell Creek stream order 6, Spanish Creek stream order 5, Black Butte River stream order 6. Even though Estell Creek is a smaller watershed than Spanish Creek, it has a higher stream density which allows merging streams to grow faster.

Findings

From Forest stream surveys in the Black Butte river and its tributaries, streambank cutting ranged from medium fair to low good. Table 8 shows the measured bank cutting along various reaches of stream channel. Converting to an annual rate of erosion, the values in the table would need to be divided by 5 years. This rate of erosion would be less than the River Basin study which is reasonable as that study measured streambank erosion after two floods (1956 and 1964) and landslides to 200 feet high.

Table 8. Forest Measured Stream Bank Erosion.

Unit of Measure is cubic feet/foot of stream over 5 year period.

Stream Name	Excellent Condition	Good Condition	Fair Condition	Poor Condition
Estell Creek	0.2	0.4	4.0 (0.47 AF/mi/)	166.0
Spanish Creek	0.1	4.0	---	2250.0
Black Butte R.	---	1.25	---	----

Sediment Calculations

The 1970 River Basin Study listed the Black Butte River order 2 stream length of 302 miles producing 137 AF/year. This is equivalent to 3.7 cuft./ft of stream; order 3 had 76 miles of stream that produced 38 AF/year which is equivalent to 4.1 cuft/ft of stream; order 4 had 18 miles of stream producing 14AF which is equivalent to 6.4 cuft./ft of stream; Order 5 had 14 miles of stream producing 16AF which is equivalent to about 9.4 cuft./ft of stream. Note how sediment yield increases exponentially as stream condition deteriorates. In the river basin study, total length of stream was 410 miles that produced 205 AF of sediment. This is equivalent to 4.1 cuft/ft of stream length.

Since the River Basin study included 200 feet high landslides in their streambank erosion rates, other studies were sought that excluded large landslides. Otherwise, landslide rates in this study would be included twice as landslide mapping delineated fifty feet or higher slides. Mary Raines, in the sediment study on the South Fork Trinity River, listed streambank erosion rates by several watersheds and by stream orders.

The Klamath Forest Geologist (de la Fuente) determined that the Grouse Creek watershed in the South Fork Trinity report had similar Franciscan geology as the watersheds in this study area. Thus, these streambank erosion rates were used instead of the River Basin

Streambank measurements made by the Forest were assumed to occur over a five year period. With the measured rate of 4.0 AF for Estell Creek converted to a yearly basis is 0.9 AF/mi/yr. This closely resembles findings by Raines. Since Raines is the most complete information available, her erosion rates for Grouse Creek were used for all watersheds in this study. Table 9 in the appendix presents streambank erosion rates by watershed while table 10 summarizes the data.

Table 10. Summary of streambank erosion by watershed.

Watershed Name	Streambank Erosion in cubic yards
Upper Middle Fork Eel	64,520
Black Butte River	51,616
Elk Creek	54,842
Williams/Thatcher	111,297
Round Valley	20,969
Total Streambank Erosion	303,244 cubic yards

Channel Comparisons

Aerial photographs from 1961 and 1993 were used to make a terse look at channel conditions on the Middle Fork Eel River and Black Butte River above their confluence. The Middle Fork near Buck Creek appears to look nearly the same in 1993 as in 1961. There are the same landslides, gravel bars, riparian vegetation and stream meander pattern. However, the 1993 air photos of Black Butte River near Nebo Creek show less riparian vegetation, wider gravel bars and more stream meander. From these quick observations, one may be able to say that the Middle Fork Eel River has nearly recovered from the 1956 and 1964 floods and current sedimentation influxes are transported through the system. In contrast, the Black Butte River has more sediment than it can transport. This can be seen on the aerial photographs as wider gravel bars, more meandering due to less channel gradient and less riparian vegetation. Channel meandering during high flows probably removes the vegetation.

Channel Length

Other figures needing validation were length of streams. The River Basin study listed miles of stream in a watershed by stream order. The River Basin group used a coarser delineation than the Forest Service. For instance, a River Basin order 2 stream is the same as a Forest Service order 3.

In the early 1980's, stream mapping for the Forest was done by hand using the Maxwell stream crenulation method. With this method, a stream begins when the angle of the contour line is less than 120 degrees, "like a U", on a 40 foot 1:24000 scale contour map. Last year a contractor was used to check the angles of the contours using GIS. This analysis resulted in many less streams. These streams were presumed to be intermittent and perennial. Streams with arcs greater than 120 degrees were presumed to be ephemeral. The contractor validated streams for all watersheds except Round Valley are used in this study and they exceed the length of streams in the River Basin study. Since Round Valley watershed was outside of the Forest Boundary, it was not previously crenulated. This watershed was hand crenulated and length of stream order measured by planimeter.

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APPENDIX

ROADS

Appendix - Table 2: TMDL Road/Stream Crossing Statistical Data
(Crossing abbreviated xing)

Upper Middle Fork Eel Watershed

Xing Number	Mntce Level	Surface Type	Erosion (Cu Ft)
966	1	NAT	7.9
1136			31.9
1138			22.0
1030			5.5
Total			67.3

Number of Xings sampled with no erosion = 5 Xing Number 1206, 1192, 1118, 1349, 1133

Number of crossings in watershed =116

Xing Number	Mntce Level	Surface Type	Erosion (Cu Ft)
997	2	NAT	7.0

Number of Xings sampled with no erosion = 8 Xing number 1075, 1130, 1222, 975, 1174, 1124, 1104, 942

Number of crossings in watershed = 167

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
1372	3	NAT	14.1
1375			2.0
1376			7.9
Total			24.0

Number of Xings sampled with no erosion = 0
Number of Crossings in watershed = 43

Upper Middle Fork Eel Watershed (continued)

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
980	3	IMP	438.0
1005			232.1
917			2.2
Total			

Number of Xings sampled with no erosion = 4   Xing number 935, 1020, 1022, 999

Number of crossings in watershed = 99

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
--------	3	BST	-------

No crossings in this category sampled

Number of crossings in watershed = 9

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
1324	4	BST	85.5
1331			1.6
Total			87.1

Number of Xings sampled with no erosion = 1 Xing number 1335

Number of crossings in watershed = 48

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
---------	4	NAT	--------

No crossings in this category sampled

Number of crossings in watershed = 3

Black Butte River Watershed (Table 2 continued)

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
429	1	NAT	7.40
453			38.98
415			33.99
581			1.94
306			12.60

Number of Xings samples with no erosion = 9
Number of crossings in watershed = 326

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
120	2	NAT	27.51
206			35.8
226			29.4
698			29.8

Number of Xings sampled with no erosion = 14
Number of crossings in watershed = 267

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
78	3	IMP	9.36
346			0.60

Number of Xings sampled with no erosion = 3
Number of crossings in watershed = 27

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	3	AGG	-------

Number of Xings sampled with no erosion = 2
Number of crossings in watershed = 7

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	3	NAT	-------

Number of Xings sampled = 0
Number of crossings in watershed = 7

Table 2 Black Butte River (continued).

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	5	AC	-------

Number of Xings sampled = 0
Number of crossings in watershed = 1

Table 2. **Williams/Thatcher Watershed**

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	1	NAT	-------

Number of Xings sampled with no erosion = 3
Number of crossings in watershed = 54

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
1623	2	NAT	12.7

Number of Xings sampled with no erosion = 2
Number of crossings in watershed = 104

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	2	IMP	-------

Number of crossings sampled = 0
Number of crossings in watershed = 6

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	3	AC	-------

Number of crossings sampled = 0
Number of crossings in watershed = 2

Table 2. Williams/Thatcher (continued)

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	3	IMP	-------

Number of crossings sampled = 0
Number of crossings in watershed = 3

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	3	NAT	-------

Number of crossings sampled = 0
Number of crossings in watershed = 19

Table 2. **Elk Creek Watershed**

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
810	1	NAT	16.05
834			1.98
871			11.0

Number of Xings sampled with no erosion = 2
Number of crossings in watershed = 71

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	1	IMP	-------

Number of Xings sampled = 0
Number of crossings in watershed = 17

Xing Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	2	IMP	-------

Number of Xings sampled = 0
Number of crossings in watershed = 23

Xings Number	Mntce Level	Surface Type	Erosion (Cu ft)
-------	2	NAT	-------

Number of Xings sampled = 0
Number of crossings in watershed = 19

Xings Number	Mntce Level	Surface Type	Erosion (Cu ft)
751	3	IMP	25.01

Number of Xings with no erosion = 0
Number of crossings in watershed = 2

Roads (continued)

Appendix Table 3. Sources of Sediment from the Road Prism.
(Bold face watershed abbreviation is data for that watershed – Upper Middle Fork Eel River)

TMDL Road Data
Calculations

Watershed		**UMFE**	BBR	Elk Crk	Williams/Thatcher								
				Cubic Feet									
		Mntce			Roadbed	Erosion		Ditch			Fill		
Road	Xing #	Level	Surface	Roadbed	Cutbank	Rill	Ditch	Berm	Slump	Fill	Rill	Slump	Total
24N63	966	1	NAT	0.5	4		3.4						7.9
24N52	1136				4.4		5.1			22.4			31.9
	1138							22					22
24N26	1030			1.2		4.1				0.1	0.1		5.5
												Total	67.3
24N21	997	2	NAT		2.8		4.4					Total	7.2
24N21	1372	3	NAT		1.6		12.5						14.1
	1375						2						2
	1376					7.9							7.9
												Total	24
M21	980	3	IMP		81		136				4	217	438
	1005				29		3.1						32.1
M1	917										2.2		2.2
												Total	472.3
M1	1324	4	BST								13.5	72	85.5
	1331										1.6		1.6
												Total	87.1

Appendix Table 3. Sources of Sediment from the Road Prism.
(Bold face watershed abbreviation is data for that watershed – Black Butte River)

TMDL Road Data
Calculations

Watershed MFE **BBR** Elk Crk Williams/Thatcher

Cubic Feet

Road	Xing #	Mntce Level	Surface	Roadbed	Roadbed Cutbank	Erosion Rill	Ditch	Ditch Berm	Slump	Fill	Fill Rill	Slump	Total
21N06	429	1	NAT	1.5							5.9		7.4
	453			29.7							9.24		38.94
	415			5.9							21.7		27.6
20N29	581	1	NAT	1.9									1.9
												Total	75.84
22N11	120	2	NAT	24.1						1.6	1.8		27.5
	206			35.8									35.8
20N09	698	2	NAT	17.5						115.4	2.7		135.6
22N29	226	2	NAT		30.8		25.6						56.4
												Total	255.3
M1	78	3	IMP				9.4						9.4
	346	3	IMP								0.6		0.6
												Total	10

TMDL Road Data Calculations

Watershed MFE BBR **Elk Crk** Williams/Thatcher

Cubic Feet

Road	Xing #	Mntce Level	Surface	Roadbed	Roadbed Cutbank	Erosion Rill	Ditch	Ditch Berm	Slump	Fill	Fill Rill	Slump	Total
20N04	810	1	NAT							1.15	6	9	16.15
20N03	834	1	NAT		1.8	0.18							1.98
20N01	871	2	IMP							6.5	4.5		11
M1	751	3	IMP				23.9			1.9	0.3		26.1

TMDL Road Data Calculations

Watershed MFE BBR Elk Crk **Williams/Thatcher**

Cubic Feet

Road	Xing #	Mntce Level	Surface	Roadbed	Roadbed Cutbank	Erosion Rill	Ditch	Ditch Berm	Slump	Fill	Fill Rill	Slump	Total
21N08	1623	2	NAT				12.7						12.7

GULLY

Appendix Table 11. Road Segments Randomly Selected for Gully Erosion Measurement.

Watershed	Segments with Erosion	Segments without Erosion
U. Middle Fork Eel	30, 902, 1300	36, 1235, 1298
Black Butte River	596, 724, 712, 524	716, 721, 789, 476, 1188, 780, 147
Elk Creek	800, 91	561, 1105
Williams/Thatcher	47, 61, 389, 392, 399	55, 396, 1009, 1116, 1127

STREAMBANK

Table 9. Streambank Erosion Rates by Stream Order in the Middle Fork Eel River. Based on Grouse Creek study by Mary Raines.

Watershed – Upper Middle Fork Eel River

FS Stream Order	Length (mi)	Raines Erosion Rate AF/mi	Total Erosion AF
1	712	0.006	4
2	249	0.05	12
3	130	0.05	7
4	65	0.06	4
5	45	0.08	4
6	24	0.39	9
			40
			= 64,520 cu.yds

Watershed - Black Butte River

FS Stream Order	Length (mi)	Raines Erosion Rate AF/mi	Total Erosion AF
1	563	0.006	3
2	208	0.05	10
3	97	0.05	5
4	55	0.06	3
5	22	0.08	2
6	24	0.39	9
			32
			= 51,616 cu.yds.

Table 9. Streambank Erosion Inside/Outside the Forest Boundary

Watershed- Elk Creek

USFS Stream Order	Stream Length	Raines Erosion Rate	Total
1	667	0.006	4
2	227	0.05	11
3	105	0.05	5
4	51	0.06	3
5	28	0.08	2
6	21	0.39	8
7	2	0.29	1
		Total	34
			= 54,842 cu. yds.

Table 9. Streambank Erosion Rates - Outside of the Forest Boundary

Watershed - Williams/Thatcher

River Basin Stream Order	Stream Length (mi)	Raines Erosion Rate (AF/MI)		Total (AF)	
1	1122	0.006		7	
2	370	0.05		19	
3	168	0.05		8	
4	71	0.06		4	
5	25	0.08		2	
6	13	0.39		5	
7	20	0.29		6	
8	17	1.05		18	
			Total	69	= 111,297 cu yds

Watershed – Round Valley

River Basin Stream Order	Stream Length (mi)	Raines Erosion Rate (AF/MI)		Total (AF)	
1	378	0.006		2	
2	125	0.05		6	
3	44	0.05		2	
4	17	0.06		1	
5	16	0.08		1	
6	3	0.39		1	
			Total	13	= 20,969 cu yds.

TIMBER HARVEST

Appendix Table 12. Timber Sales in Timber Harvest Unit Sample Pool.

Middle Fork Eel River

Devils, Trinity, Lazyman, Cedar Blowdown, Doe, Lazyman Salvage, Beaver, Greenhouse 88.

Total units were 63 or 31% of all units in the Upper Middle Fork Eel River watershed. It took 30 random units to produce 9 units with landings/skid trails next to streams.

Black Butte River

Nosbig buyout, Snow, Jenks, Ocean, Hunter resale, Spanish Ridge II, Clear, Boardtree, Kneecap, Wallow, Atchison, Ridge, Mississippi, Umbrella, Horn.

Total units were 87 or 43% of all units in the Middle Fork Eel study watershed. It took 36 units to get 14 units.

Elk Creek

Island, Smokehouse fire salvage, Crocker fire salvage, Sanhedrin fire salvage.

Total units were 32 or 16% of all units in the Middle Fork Eel study watershed. It took 15 random units to produce 3 units with landings/skid trails next to streams.

Williams/Thatcher

Hayden, Coyote salvage, Thatcher, Camp.

Total units were 21 or 10% of all units in the Middle Fork Eel study watershed. It took 10 random units to pick 4 to sample.

TIMBER HARVEST

Appendix Table 13. Timber Harvest Unit Erosion Amounts

Upper Middle Fork Eel Watershed

Name	Number	(cuft)	(cuft)
Beaver	5	0	0
Cedar	10	0	0
Doe	4	0	0
	15	0	0
	20	0	0
	21	0	0
Devils	1	0	0
	8	0	0
Trinity	9	0	87.8

Black Butte River Watershed

Timber Sale Name	Unit Number	Landing (cuft)	Skid Trail (cuft)	
Boardtree	4	0	0	
Jenks	1	0	0	
	3	0	0.24	
Horn	3	0	0.03	
	5	3.5	0.20	
	6	0.03	0.22	Past 75.7 cuft
Nosbig	1	0.01	0	Past 13.5 cuft
Umbrella	3	3.2	0	
	14	0	40.0	
	7	0	0	
	9	1.6	0	
	10	0	0	

Appendix Table 13: Timber Harvest Unit Erosion Amounts (continued)

Williams/Thatcher Watershed

Timber Sale Name	Unit Number	Landing (cuft)	Skid Trail (cuft)
Camp	1	0	0
Hayden	1	0	0
	4	0	0
	10	0	0

Elk Watershed

Timber Sale Name	Unit Number	Landing (cuft)	Skid Trail (cuft)

No sales surveyed. Assigned person on fire assignment.