INVESTIGATION OF WATER QUALITY PROBLEMS ON PLUMAS COUNTY ROADS TRAVERSING U.S.F.S. ADMINISTERED PUBLIC LANDS WITHIN THE SPANISH CREEK WATERSHED

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PREPARED FOR:
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AND THE
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Introduction:

This report is a continuation of studies carried out by the Feather River Coordinated Resource Management (CRM) group in the region since 1985. The CRM is a multi-agency organization that has carried out numerous erosion control studies and projects since 1985. The first such study; East Branch North Fork Feather Erosion Inventory Report (SCS, 1989) noted that the Spanish Creek watershed contributed significant amounts of sediment to the East Branch, North Fork, Feather River (EBNFFR). A follow up study; EBNFFR Spanish and Last Chance Creek Non-Point Source Water Pollution Study, Section 205(J)(2), Clean Water Act (PCCDC and Plumas Corp., 1992) which began in 1989 and was completed in 1992 concluded that roads were a major contributor of sediment within the Spanish Creek watershed.

In 1990 the Plumas National Forest, in cooperation with the Feather River Coordinated Resource Management group sought and received State and Federal funding to conduct inventories of sediment sources associated with roads within the East Branch, North Fork, Feather River drainage, which includes the Spanish Creek Watershed. During the establishment of project guidelines it was decided to include all locatable roads within the watersheds to be investigated, this included State, and County roads as well as Plumas National Forest access roads. One of the 1990 project goals was to develop a data base of road related water quality problems and sediment sources. In addition, the basic data gathered was analyzed to determined the most common sediment producing problems within the study area. Close to 600 miles of road and road like structures (skid trails and log landings) were investigated. This type of information is being used in conjunction with other watershed condition information to rank potential restoration areas within the Spanish Creek watershed. The Plumas County Road Department is seeking to better document, define and prioritize erosion problems and sediment sources occurring on County roads investigated during the original study. To accomplish this, data on sediment sources from County roads was retrieved from the data files compiled in 1990-91. Each sediment source from County roads was revisited in 1994-95 to update the information (see Appendix B, Water Quality Investigation Procedures). The updated information presented in this report can be used by the Plumas County Road Department to develop maintenance projects toward remediating these problems in subsequent annual work plans. This remediation work will be at the direction of, and primarily by the Road Department directly, although some projects may require further involvement by the CRM.

Historical Aspect

Road construction and maintenance activities have been major contributors of sediment and riparian area loss over the years. Early roads followed historical patterns of travel and commerce in the County. These travelways often started as pack animal trails then evolved into wagon routes which often followed stream corridors because riparian areas offered gentler terrain as well as forage and water for livestock.

Although many of the early travelways were later upgraded to carry more traffic at higher speeds they were often constructed on the same routes due to historical use and less expense in using an established roadway. These early County roads, many which still exist as active routes today, were constructed using traditional engineering practices during a time when the consideration of environmental effects of road design, placement and drainage was not a common practice. Early drainage and maintenance practices were designed simply to move water away from the road in order to keep the road surface and subsurface dry. Often large drainage structures involving extensive ditching was preferred over numerous smaller structures to save initial effort and expense. These early practices commonly rerouted drainage water into stream courses for rapid removal. This was a benefit to the road but caused unintentional harm to other resources, primarily the adjacent riparian area and water quality of the stream course. The result has been the loss or significant degradation in riparian areas, with corresponding changes in stream channels and water quality due to increased sedimentation, turbidity, water temperature, and decreases in dissolved oxygen concentration and important aquatic biota, such as trout. Road engineering and maintenance practices have undergone extensive evolution since the early 1950. This is also true of our understanding of the importance of the aquatic and riparian environment, yet many similar erosion and sedimentation problems exist on both County and Forest Service roads within the Spanish Creek watershed.

Results

Table 1 lists each of the eleven County roads by number, name and miles investigated for water quality problems in 1994-5.

Table 1: LIST OF PLUMAS COUNTY ROADS SURVEYED AND MILES INVESTIGATED		
Road Number	**Road Name**	**Miles Surveyed**
PC423	Big Creek Road	5.0
PC411	Bucks Lake Road	6.1
PC422	Snake Lake Road	2.5
PC406A	Oakland Camp Road	1.5
PC417	Butterfly Valley Road	3.0
PC420	Little Blackhawk Creek Road	1.5
PC511	Quincy-LaPorte Road	5.3
PC403	Mt. Hough Road	9.1
PC508	Greenhorn Ranch Road	3.0
PC402	(At Massack)	0.2
PC401	Squirrel Creek Road	2.0
	TOTAL	39.2

Table 2 displays the cumulative results of each of the eleven County roads surveyed originally in 1990 when a concerted effort was made to survey all locatable roads within the Spanish Creek Watershed. The 1990 inventory records were then used to relocate problem sites in 1994-5 that were causing water quality or riparian degradation and to update the site records and gather photographs of sediment delivery sites on each of the eleven County roads investigated. This new resurvey was limited to only County roads that traversed Plumas National Forest administered lands. County roads, and some segments of County roads that passed through private contains road problem descriptions by mile post with data forms, photographs and maps for each of the eleven roads investigated).

Table 2: TOTAL WATER QUALITY PROBLEMS BY TYPE AND SEVERITY FOR INVESTIGATED COUNTY ROADS WITHIN THE SPANISH CREEK WATERSHED			
ROAD PRISM			
PROBLEM TYPE	**MODERATE**	**SEVERE**	**TOTAL**
Location/Alignment	6	15	21
Road Cut Slope	4	6	10
Road Surface	3	2	5
Road Fill Slope	4	14	18
Road Drainage Structures	9	15	24
TOTAL	**26**	**52**	**78**

CHANNEL CROSSINGS			
PROBLEM TYPE	**MODERATE**	**SEVERE**	**TOTALS**
Crossing Approaches	29	35	64 *
Channel Above Crossing	30	17	47 *
Channel Below Crossing	12	11	23
Crossing	3	0	3
TOTAL	**74**	**63**	**137**

Most recurring problems that contribute to sediment delivery to channels on County roads traversing Plumas National Forest administered lands (see Appendix A. Procedure for Water Quality Assessment of County Roads within the Spanish Creek Watershed).

Common Road Problems

The two most common road problems found during the investigation are 1. problems related to erosion of road drainage structures, and 2. Location/Alignment, or the placement of roads in close proximity to stream channels.

The majority of the County roads investigated are insloped with inside ditches and ditch relief culverts. The most common problems related to the road drainage system, are erosion in the inside ditch and the use of channel crossing culverts as a ditch relief culvert. The result of using runoff is a change in the channel hydrograph and direct introduction of off site sediment to the channel. Examples of this problem type are most evident on The Big Creek Road (PC 423) and the Quincy-La Porte Road (PC 511), (See Appendix C., for a problem description and photographs by mile post for each of these roads). Each of these roads are also good examples of the second most common road related problem; Location/Alignment, where the majority of the road is in close proximity to a perennial channel. Both also have road sections where the fill slope is directly eroding into the channel.

Road Drainage Structures

Erosion, sediment production and delivery occurring within road drainage structure represent 31% of all moderate and severe road related water quality problems on County roads surveyed during this project. The most common problems encountered are erosion of the inside ditch and use of channel crossing culverts to function as ditch relief culverts.

Several factors may account for erosion to the inside ditch. These include precipitation and runoff amounts for the given geographic area and its elevation and aspect, erosiveness of the soil, steepness of the road, and spacing of ditch relief culverts. Of each of these factors spacing of ditch relief culverts is the most critical. There are four basic indicators of inadequate relief drain spacing: 1) gullying of the inside ditch, 2) gullying or sliding of the slope below the culvert outlet of the cross drain, 3) direct transport of sediment along an inside ditch to a watercourse, or 4) loss of capacity of culvert cross drains due to filling with sediment (Weaver and Hagans, 1994). The most common indicator found is the use of a channel crossing culvert as a ditch relief cross drain (For an example see Appendix C, Big Creek Road (PC 423), Site #6, Photographs # 423-12 and 13 at mile post 1.65). Ditch flow needs to be culverted across the road and discharged into a vegetative buffer that can filter the runoff before it reaches a stream channel.

Road Location and Alignment

As discussed above, many roads were historically located near watercourses for ease of travel. Many of these routes are still in use today as modern County roads. Location and Alignment problems account for 27% of all moderate and severe sediment delivery sites related to County roads investigated during the project. The most severe location and alignment problems occur when the toe of the road fill material actually enters the channel or the channel has been shoved against the opposite hill slope to provide enough room for the road prism (for an example see Appendix C, Big Creek Road (PC 423) Site # 8, Photographs # 423-18,19, and 20, mile post 2.7. Also See Butterfly Valley Road (PC 417), Site # 1, Photographs # 417-1,2,3, mile post 0.2). In most, if not all cases relocating the road away form the channel influence zone is not an option. In cases such as this, fill slope stabilization and attention to road drainage become the important factors in reducing sediment input to the watercourse.

Common Channel Crossing Problems

The two most common water quality problems related to channel crossings involve the crossing approaches and the condition of the channel above the

Crossing Approaches

Water quality problems related to crossing approaches accounted of 47% of all crossing related problems investigated during this project. In most cases these crossings have a high diversion potential which occur when the road climbs through the crossing and one approach slopes away from the crossing. This is also known as a "positive" approach. If the culvert becomes obstructed and is overtopped by high flows the approach that slopes away from the crossing will capture the flow. On most paved roads the overflow travels down the inside ditch until it can reenter its natural channel. Often this causes additional erosion of the inside ditch and can also cause erosion to the fill material as the flood flows cross the road and spill over the fill material (for an example see Appendix C, Quincy-La Porte Road (PC 511), Site # 3, Photographs # 511-5,6,7,8,9,10, mile post 3.7). On unsurfaced roads large amounts of sediment can be generated during a road capture when the crossing becomes obstructed.

Crossing approaches that are “negative” or slope down to the crossing present less potential for large amounts of sediment delivery because when the culvert is overtopped the high flows flow onto the road surface, over the fill and back into the channel. The fill may be washed-out, but the streamflow is not diverted down the road and across the unprotected fill slope. All stream crossings are designed to fail at some flood recurrence interval. The majority of culverts cannot tolerate much more than a 25-year flow event with out failure. The chance of a 25-year flow event is about 34 percent in 10 years and 70 percent on 30 years. This is an economic balancing act that all road engineers encounter. Stream crossings design needs to take failure into account and minimize the amount of material that would be added to the channel when the crossing fails during large flood events.

Condition Of The Stream Channel Above The Crossing

Stream channel bed and bank scour and erosion above culvert crossings accounts for 34% of moderate and severe water quality problems related to stream crossings inventoried for this report. One of the causes of upstream gully formation above a culvert is the way most culverts are installed. During installation most culvert seats are commonly excavated so that the culvert bottom rests on mineral soil below the natural grade of the stream bottom. Excavated culverts keep the road dry and provide excellent bedding for the pipe; however, they also lead to upstream and sometimes even downstream erosion of the channel bed and banks. If the culvert head is seated below channel grade, water flowing into the culvert has to drop into the culvert inlet, even a small drop caused the flowing water to pick up velocity, this increased velocity removes soil from the channel bottom as it drops into the culvert, this causes upstream scour of the channel bottom as the channel readjusts to a new base-level defined by the seated culvert (see Appendix C, Snake Lake Road (PC 422) Site #5, Photographs # 422-8,9,10, mile post 0.6).

Other problems associated with the channel above the crossing deal with the deposition of material above the crossing which may lead to a partial or complete obstruction of the culvert. Often organic matter may become lodged at the culvert inlet, slowing and ponding water. As flowing water enters the area of ponded water the water velocity decreased causing the bedload the channel is moving to drop out and deposit just upstream of the culvert. Over time as this deposit builds the stream channel will be forced to move around the deposit. This often causes channel bank erosion which adds sediment to the channel but may also result in a alignment problems between the channel and culvert (see Appendix C, Snake Lake Road (PC 422) Site #6, Photographs # 422-11, 12, mile post 0.85).

Conclusions

Of the many different problem types and sites located on the eleven County roads investigated during the study it becomes apparent that the single most important factor in limiting sediment generation and delivery to watercourses is the original design and location of the road. This, more than any other factor sets the stage for cause and effect where water quality is concerned. Maintenance plays an important role, but is often limited by the original road design.

Of the eleven County roads investigated, three stand out as high sediment producers: the Big Creek Road (PC 423), Squirrel Creek Road (PC 401) and Quincy-La Port Road (PC 511). Each of these three are located in close proximity to watercourses and exhibit the four main problem types discussed above. Solutions to these problems are, of course, site specific but need to concentrate on stabilization of fill material and limiting sediment inputs to watercourses from the road drainage structures.

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Appendix A

Procedure for Water Quality Assessment of County Roads Within Spanish Creek Watershed

Investigation Purpose

To identify and assess sediment sources associated with Plumas County roads traversing Plumas National Forest administered public land causing water quality and riparian area degradation within the Spanish Creek watershed.

Procedure

For each road, five basic road components were assessed. 1) Facility location and/or alignment, 2) Road cut slope, 3) Road surface, 4) Road fill slope, and 5) Road drainage structures. Before these components could be assessed a primary problem indicator had to be present at the site. The primary problem indicator is defined as: The presence and/or movement of sediment from a road into a channel or to within 100 feet of a channel. The presence of this indicator at any site dictated the need to inventory the cause of the sediment movement. Investigations within the EBNFFR drainage indicate that many streamside buffer zones lack the ability to trap off-site sediment. Therefore, most sediment deposited within 100 feet of a channel can be expected to enter the channel system at some point in time. Sediment that was successfully channeled into a natural or artificial filter strip more than 100 feet away from a channel was considered an insignificant threat to water quality.

Problem Assessment Components

At each site where a primary problem indicator was present the following components were assessed.

1. Facility location and/or alignment

Describes the proximity of the road to a channel or channel area. No distinction was made between ephemeral, intermittent or perennial channels because once sediment reaches a channel of any kind it is only a matter of time before it works its way down into the main channel system. Location and alignment is defined as: The extent of road located in a streamside area or along a meadow edge. The closer the road is to a channel the greater the possibility of sediment contribution and possible destruction of the natural filter strip that protects the channel from off-site sedimentation.

Road location/alignment impact rating

A severe impact is described as more than a 1000 feet road parallels a stream channel and is within 100 feet of the channel, or most of the fill slope is actively eroding into the stream channel. A moderate impact has less than a 1000 feet of road paralleling a channel or is more than 100 feet, but less than 200 feet away from the channel. Light impacts are generally those sites that are small and insignificant, and are not a substantial threat to water quality.

2. Road cut slope

Only one indicator, cut slope failure, was used to assess the condition of cut slopes, although several processes contribute to its erosion. Because most road cut slopes remain over-steepened, they are subject to rain-splash, sheet, rill, gully and ravel erosion. However, these erosion process usually result in the deposition of sediment on the road surface or in the road drainage structures and is accounted for when these components are assessed. This leaves the presence, size class and abundance of slumping and slope failure the primary concern.

Road cut slope impact rating

Severe cut slope impacts consist of 3 or more slope failures or slumps per mile, or less than 3 per mile if they are greater than 25 feet in width. Moderate cut slope impacts are slope failures or slumps fewer than 3 per mile and less than 25 feet in width. Light impacts are those judged to be small and not a significant threat to water quality.

3. Road surface
There are three basic types of road surfaces on the forest: paved, rocked or graveled, and dirt. Paved road surfaces exhibit no erosion, while rock or gravel surfaces generally show only small amounts, dirt road surfaces, on the other hand, are the main road surface related sediment source within the drainage. Road surfaces were assessed for the presence, size class, and abundance of gullies. It was assumed that gully formation was the end result in the erosion processes. Road surface impact rating Severe impacts on the road surface is indicated by the presence of gullies with a top width of 1 foot or greater. Moderate impacts are gullies with a top width less than 1 foot. Light impacts to the road surface are those sites which are small and insignificant to water quality concerns.

4. Road fill slope
The fill slope was treated in much the same way as the cut slope with one addition. Because of the relative steepness and looseness of fill material it is subject to slumping and slope failure as on the cut slope but it is also subject to gullying. Gullies that form on the road surface will often continue onto the fill material.

Road fill slope impact rating
Severe impacts on the fill slope are indicated by the presence of gullies with a top width of 1 foot or greater and/or slope failures greater then 25 feet in width.

Moderate impacts are indicated by the presence of gullies with a top width of less than 1 foot and/or the presence of slope failures less than 25 feet in width.

Light impacts are erosion occurrence that are small and not judged to be a significant threat to water quality.

5.Road drainage structures
Drainage structures such as waterbars, rolling dips, inside ditches, cross drains, outsloped surface, berms, and overside drains are all designed to remove surface water from the road prism. When properly designed and maintained road drainage removes surface water before it has a chance to damage the road prism.

Road drainage structure impact rating
Severe impacts to drainage structures are: active erosion occurring to the structure. The inside ditch is greater then 18 inches deep and/or waterbars washed out or cross drained clogged with sediment and/or the presence of gullies below drainage structures with a top width greater than 1 foot.

Moderate impacts include active erosion to structures, inside ditch is eroding but is less than 18 inches deep, sediment has accumulated in cross drains and gullies have formed below drainage structures but have a top width less than 1 foot.

Light impacts are generally small, site specific and not a significant threat to water quality.

Procedure for Evaluating Stream and Meadow Crossings on Plumas County Roads Within the Spanish Creek Watershed

Introduction

In addition to being subject to the same erosive forces that effect roads, stream and meadow crossings are subject to stream channel forces. Any natural stream that has flowing water at some point in the season is subject to water pressure, velocity, and centrifugal forces. Depending upon the amount of flow, the slope and sinuosity of the channel, these forces can be significant and result in the dynamic interplay of erosion, sedimentation and debris movement. Inserting a crossing into this dynamic environment requires special attention to the effects of the crossing on the channel as well as the effects of the channel on the crossing. Three basic types of crossing occur on streams and across meadows in the Spanish Creek Watershed: Bridge crossings, culvert crossings and low water crossings with and without culverts. Only culvert and low water crossings were inventoried.

Every stream and meadow crossing have three general impacts: local impacts, upstream impacts and downstream impacts. Crossings can disrupt channel stability forcing the channel to adjust its bed and banks to the presence of the crossing. Culvert outlets may cause the formation of scour holes, culvert inlets set lower than the channel bed may cause headcutting which can impact upstream areas. Channel crossings are often used as crossdrains to remove water and sediment from a road surface. The increased flow and sediment inputs can impact the channel locally as well as downstream of the crossing. Crossings can also act as obstructions to debris and bedload movement in the channel. The accumulation of debris above the crossing can cause the channel to move laterally seeking a path around the obstruction. This can result in accelerated bank and crossing fill erosion and downstream sediment problems. Erosion originating on the crossing approaches and crossing fill material often enter the channel directly adding to local and downstream sediment accumulations.

Meadow crossings represent an additional set of potential problems. Many smaller meadows do not have well defined channels; instead water moves down the meadow, both across the surface and below the surface. Roads that cross a meadow tend to interrupt the hydrology of the site. The placement of a culvert and road fill material on a meadow tends to concentrate water movement. This often results in the formation of discontinuous gully systems above the culvert and gullies that confine the channel below the crossing.

Procedure

During the process of investigating road related sediment sources each stream and meadow crossing encountered was also assessed using the same primary problem indicator used to inventory roads (sediment movement to a channel or channel area). If the primary problem indicator existed four basic components of the crossing were assessed; 1. The condition of the crossing approaches, 2. the condition of the stream channel above the crossing, 3. the condition of the stream channel below the crossing and, 4. the type and overall condition of the 4 crossing.

Problem Assessment Components

1. Crossing Approaches. Crossing approaches consist of the crossing fill material and the road prism (cut slope, road surface, and fill slope) on both sides of the crossing to the extent where the road no longer drains toward, or away from the crossing. This is the extent of road effecting and affected by the channel, usually a distance of 50 to 100 feet ether side of the crossing. Crossing approaches were assessed for angle of approach, positive or negative, and the presence of rilling, gullying, slope failure of cut and fill slopes, and erosion of drainage structures.

2. Stream channel above the crossing. The condition of the channel above the crossing was assessed for three main conditions.

A. Scour and erosion: The presence and size class of headcutting, channel bed and bank erosion.

B. Ponding: The presence and abundance of depositional material above the crossing created by debris movement and the inability of the culvert to handle large flows or past blockage of the culvert. Evidence that the road has been topped by flows or has developed the potential to be topped.

C. Obstructions: The extent of partial blockage of the culvert or channel due to depositional material, both organic and inorganic, or the potential for development.

High flows often pickup woody debris and transport it downstream where it can become hung-up at the culvert inlet reducing culvert capacity. The resulting constriction causes water to pond above the culvert. As stream flow enters the ponded water area stream velocity decreases. The sediment load normally carried by the channel drops out to settle on the channel bottom. This creates layer upon layer of accumulated bedload at the culvert inlet creating a potential culvert blockage.

Stream channel below the crossing: The condition of the stream channel below the crossing was assessed for two main conditions.

A. Scour at the culvert outfall: The presence and size class of an active scour hole at the culvert outfall.

B. Bed and bank scour and erosion: The presence and size class of bed and bank scour and erosion downstream from the culvert.

Scour in the vicinity of the culvert outfall can be classified into two separate types. The first is local scour and is typified by a scour hole. This is caused by a combination of high exit velocities and the lack of energy dissipating features. Course material scoured from the hole is deposited immediately downstream, often in the form of a low bar. Finer material is transported further downstream causing sediment damage. The second type of scour is general bed and bank channel scour. This scour type tends to extend further along the stream channel and is not localized around a particular obstruction. General channel scour can involve a gradual, fairly uniform degradation or lowering of the channel bed. Improper culvert placement is one of the causes of this process.

Condition of the crossing: Evaluation of the type of crossing, culvert present or low water crossing with no culvert, or culvert has been washed out.

Stream and Meadow Crossing Rating System
Each of the four problem assessments components were rated "severe","moderate", and "light" as were road conditions.

1. Crossing Approaches

Severe impacts are those crossings which have a "positive,, grade. This is an approach which drops downhill away from the crossing. If the crossing is overtopped by high flows the road will capture the flow. Eventually the flow returns to the channel after traveling down the roadway picking up additional sediment and causing damage to the road prism. Other indicators of severe impacts on the crossing approaches are the presence of many rills and/or gullies with a top width greater than 1 foot or slope failures on cut and fill material with a width greater than 25 feet or erosion of the inside ditch to a depth of 1 foot or more, or water bars washed out.

Moderate impacts on approaches are: level approach grades, some rilling present, gullies with a top width less than 1 foot, slope failures less than 25 feet in width, and minor erosion to the inside ditch and water bars.

Light impacts are those judged to be small, insignificant and not a threat to water quality.

2. Stream Channel Above the Crossing

Severe impacts to the upstream channel are significant bed and bank scour such as headcutting greater than 24 inches deep and/or bank erosion greater than 24 inches high. Evidence that ponding has occurred above the crossing causing the roadway to be topped or the potential for topping to occur. The presence of obstructions, such as mass drift (the accumulation of large amounts of debris) severely restricting channel or culvert area, or a high potential for this development.

Moderate impacts are headcutting or bank erosion less than 24 inches deep, the presence of depositional material above the crossing and/or the partial blockage of channel or culvert area or a moderate potential for this development.

Light impacts are those judged to be not a threat to water quality.

3. Stream Channel Below the Crossing

Severe impacts below the crossing are indicated by the presence of an active scour hole greater than 24 inches deep, and/or significant bed and bank scour, headcutting greater than 12 inches deep and bank erosion greater than 24 inches high.

Moderate impacts are indicated by the presence of an active scour hole less than 24 inches deep and moderate bed scour, headcutting less than 12 inches deep and/or bank erosion less than 24 inches high.

Light impacts are judged to be insignificant and not a threat to water quality.

4. The Crossing Evaluation

Severe impacts occur when the crossing has been washed out.

Moderate impacts are associated with crossings that have no culvert (low water crossings) where the water flows over the roadway, or if the culvert is in place, evidence that the crossing has been washed out or overtopped in the past.

Light impacts are those judged to be insignificant and not a threat to water quality.

APPENDIX B

ROAD AND STREAM CROSSING BIBLIOGRAPHY

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