PINE CREEK WATERSHED ASSESSMENT REPORT

A Plan of Action for Erosion Prevention and Erosion Control in the Pine Creek Watershed, Hoopa, California

Summary for Management

The Pine Creek watershed assessment project was undertaken to develop a practical, action-oriented plan for proactive erosion prevention and erosion control on Hoopa Tribal lands in the Pine Creek basin. Implementation of recommended projects over the next several years is aimed at accelerating the long-term, permanent recovery of anadromous, fish-bearing stream channels in the Pine Creek basin.

Selected stream channels, slopes and over 100 miles of active and abandoned roads in the watershed were mapped and/or inventoried for existing and potential erosion problems that threaten to damage fisheries resources, including spawning and rearing habitat. A database of 445 sites was developed, with each site identified and described in detail. Over 113,000 yds^3 of measured erosion (and over 102,000 yds^3 of sediment yield to stream channels) was documented to have originated from the hillslopes of Pine Creek. Most of this erosion was closely associated with past landuse.

Detailed watershed assessment work at each site has lead to the development of recommended projects at 150 different work locations on nine large treatment areas. Recommendations for these work sites include descriptions of appropriate erosion prevention techniques and cost estimates for performing the treatments.

In the next logical step, skilled equipment operators and erosion control specialists can immediately implement those projects that have been identified as the most cost-effective and most beneficial to long term watershed stabilization and recovery. A prioritized list and description of these treatment areas is included at the end of this report.

Treatment of all 150 sites is expected to prevent at least 45,000 yds^3 of sediment from entering streams and being delivered to Pine Creek. Total cost is expected to be approximately \$200,000, or \$4.45/yds^3. Erosion prevention and erosion control work at the highest priority of the nine treatment areas will be accomplished for approximately \$3.50 per yds^3.

Physical treatment of high priority work sites that would otherwise directly threaten fisheries resources is a useful and necessary step in watershed stabilization. It is one of two complimentary methods for "erosion-proofing" a watershed. The second, and perhaps the most cost-effective tool for reducing future sediment contributions to fish-

Pacific Watershed Associates
Geomorphic Studies • Erosion & Sedimentation Processes • Wildland Hydrology • Erosion Control
P.O. Box 4433 • Arcata, California • 95521 • 707-839-5130

bearing streams in these highly erodible, steepland drainage basins, is the utilization of preventive landuse practices.

Based on observations at hundreds of sites throughout the basin, this report also includes suggestions for altering some landuse practices to help protect fisheries resources (especially from damage which occurs during infrequent floods), while still encouraging forestry operations. These recommendations (some of which may already be in practice) include general suggestions for 1) road location and planning, 2) road construction, 3) road maintenance, repair and upgrading practices and 4) road abandonment techniques.

Generally, suggestions for road location include the avoidance of steep inner gorge locations; steep, wet headwater swale areas and the steep stream-side slopes of high order, incised tributary streams. These are all sites where tremendous volumes of sediment have been released to the stream system following road building in the past.

For road construction practices, recommendations have been made to 1) encourage endhauling and limit sidecasting on steep inner gorge and stream-side slopes, 2) reduce sidecasting during construction and reconstruction of stream crossings of incised stream channels, and 3) encourage the practice of constructing stream crossings with no diversion potential. Employing this latter technique can assist in preventing the development of large gully systems and the delivery of thousands of cubic yards of sediment to Pine Creek and its tributaries.

In road maintenance practices, recommendations have been made to encourage the increased use of trash barriers to prevent culvert plugging and downspouts to reduce erosion at culvert outfalls. These are especially important during infrequent, large magnitude floods. In addition, it is suggested that culverts throughout the watershed be "sensitivity" coded and marked in the field to allow for rapid assessment and identification of annual and storm-period maintenance needs. Problem culverts can then be quickly checked.

Finally, and perhaps most importantly, specific provisions for the proactive abandonment of unneeded logging roads are spelled out in detail to both protect the physical resource of the roadbed, as well as to eliminate unnecessary inputs of sediment to the local streams. The large volume of eroded sediment which is contributed from stream crossings and unstable fill slopes along abandoned roads could be almost entirely prevented through the implementation of straight forward, inexpensive road closure techniques when old roads are no longer needed for near-term forest management.

PACIFIC WATERSHED ASSOCIATES

PINE CREEK WATERSHED ASSESSMENT REPORT:

A Plan of Action for Erosion Prevention and Erosion Control in the Pine Creek Watershed, Hoopa, California

prepared for

THE HOOPA VALLEY BUSINESS COUNCIL, TRIBAL FISHERIES DEPARTMENT

by

PACIFIC WATERSHED ASSOCIATES
P.O. BOX 4433, ARCATA, CALIFORNIA, 95521
(707) 839-5130
DECEMBER, 1990

PACIFIC
WATERSHED
ASSOCIATES

PINE CREEK WATERSHED ASSESSMENT REPORT

A Plan of Action for Erosion Prevention and Erosion Control in the Pine Creek Watershed, Hoopa, California

Summary for Management

The Pine Creek watershed assessment project was undertaken to develop a practical, action-oriented plan for proactive erosion prevention and erosion control on Hoopa Tribal lands in the Pine Creek basin. Implementation of recommended projects over the next several years is aimed at accelerating the long-term, permanent recovery of anadromous, fish-bearing stream channels in the Pine Creek basin.

Selected stream channels, slopes and over 100 miles of active and abandoned roads in the watershed were mapped and/or inventoried for existing and potential erosion problems that threaten to damage fisheries resources, including spawning and rearing habitat. A database of 445 sites was developed, with each site identified and described in detail. Over 113,000 yds^3 of measured erosion (and over 102,000 yds^3 of sediment yield to stream channels) was documented to have originated from the hillslopes of Pine Creek. Most of this erosion was closely associated with past landuse.

Detailed watershed assessment work at each site has lead to the development of recommended projects at 150 different work locations on nine large treatment areas. Recommendations for these work sites include descriptions of appropriate erosion prevention techniques and cost estimates for performing the treatments.

In the next logical step, skilled equipment operators and erosion control specialists can immediately implement those projects that have been identified as the most cost-effective and most beneficial to long term watershed stabilization and recovery. A prioritized list and description of these treatment areas is included at the end of this report.

Treatment of all 150 sites is expected to prevent at least 45,000 yds^3 of sediment from entering streams and being delivered to Pine Creek. Total cost is expected to be approximately $200,000, or $4.45/$yds^3$. Erosion prevention and erosion control work at the highest priority of the nine treatment areas will be accomplished for approximately $3.50 per yds^3.

Physical treatment of high priority work sites that would otherwise directly threaten fisheries resources is a useful and necessary step in watershed stabilization. It is one of two complimentary methods for "erosion-proofing" a watershed. The second, and perhaps the most cost-effective tool for reducing future sediment contributions to fish-

Geomorphic Studies• Erosion & Sedimentation Processes• Wildland Hydrology• Erosion Control
P.O. Box 4433• Arcata, California• 95521• 707-839-5130

bearing streams in these highly erodible, steepland drainage basins, is the utilization of preventive landuse practices.

Based on observations at hundreds of sites throughout the basin, this report also includes suggestions for altering some landuse practices to help protect fisheries resources (especially from damage which occurs during infrequent floods), while still encouraging forestry operations. These recommendations (some of which may already be in practice) include general suggestions for 1) road location and planning, 2) road construction, 3) road maintenance, repair and upgrading practices and 4) road abandonment techniques.

Generally, suggestions for road location include the avoidance of steep inner gorge locations; steep, wet headwater swale areas and the steep stream-side slopes of high order, incised tributary streams. These are all sites where tremendous volumes of sediment have been released to the stream system following road building in the past.

For road construction practices, recommendations have been made to 1) encourage endhauling and limit sidecasting on steep inner gorge and stream-side slopes, 2) reduce sidecasting during construction and reconstruction of stream crossings of incised stream channels, and 3) encourage the practice of constructing stream crossings with no diversion potential. Employing this latter technique can assist in preventing the development of large gully systems and the delivery of thousands of cubic yards of sediment to Pine Creek and its tributaries.

In road maintenance practices, recommendations have been made to encourage the increased use of trash barriers to prevent culvert plugging and downspouts to reduce erosion at culvert outfalls. These are especially important during infrequent, large magnitude floods. In addition, it is suggested that culverts throughout the watershed be "sensitivity" coded and marked in the field to allow for rapid assessment and identification of annual and storm-period maintenance needs. Problem culverts can then be quickly checked.

Finally, and perhaps most importantly, specific provisions for the proactive abandonment of unneeded logging roads are spelled out in detail to both protect the physical resource of the roadbed, as well as to eliminate unnecessary inputs of sediment to the local streams. The large volume of eroded sediment which is contributed from stream crossings and unstable fill slopes along abandoned roads could be almost entirely prevented through the implementation of straight forward, inexpensive road closure techniques when old roads are no longer needed for near-term forest management.

PINE CREEK WATERSHED ASSESSMENT REPORT

Table of Contents — *Page*

Appendices | ***Page***

List of Tables

List of Tables (continued) | *Page*

List of Maps

List of Plates

NOTE: These plates are available for review at the U.S. Fish & Wildlife Service Klamath River Fishery Resource Office, Yreka, California.

PINE CREEK WATERSHED ASSESSMENT REPORT

A Plan of Action for Erosion Prevention and Erosion Control in the Pine Creek Watershed, Hoopa, California

I. Introduction to Watershed Assessments

A watershed analysis and erosion control planning project entails the delineation of treatable, persistent sources of eroded sediment which contribute or threaten to deliver large quantities of sediment to fish bearing streams. The focus of such an inventory must necessarily be limited to the identification and prioritization of potential sources of erosion and sediment yield that are amenable to treatment. Sources of past sedimentation are of interest only in what they tell us about similar areas that may yield sediment in the future.

Because fish-bearing watersheds are often many square miles in size, comprehensive field inventories of all possible sources of sediment may not always be feasible within existing fiscal constraints. Yet, because of a basin's existing or potential value as an anadromous fish resource area, it may be important to identify and treat those significant sources of sediment that threaten to further impact fish spawning and rearing habitat. Assessment projects are implemented to identify and prioritize the major, cost-effectively treatable sources of sediment that are most likely to directly impact fish bearing streams if left unattended.

In this analysis, wildland roads are initially singled out in the analysis both because the road network provides ready access for heavy equipment to reach potential work sites, and because roads often represent serious sediment sources themselves. Studies throughout steeplands of northern California and the Pacific Northwest have found roads to be the primary, landuse-related contributor to on-site erosion and downstream sediment yield that impact fish bearing streams.

Stream crossings and log landings on abandoned (unmaintained) roads located low on the hillslope are prime locations where preventable, cost-effective erosion prevention projects can keep large quantities of sediment from entering perennial streams and being transported to important spawning and rearing areas. An accurate, prioritized list of such treatable areas is, therefore, important in determining potential work sites for watershed stabilization.

As the first step in the assessment process, an air photo analysis of the watershed is conducted to help reveal the location of sensitive roads and other high priority areas for further field mapping, analysis and potential treatment. Major, potentially treatable or preventable sources of erosion and sediment yield are then identified and prioritized for treatment during detailed field mapping and analysis of each road and each site.

Geomorphic Studies• Erosion & Sedimentation Processes• Wildland Hydrology• Erosion Control
P.O. Box 4433• Arcata, California• 95521• 707-839-5130

Once sites are identified and prioritized, general prescriptions for erosion control and erosion prevention are developed for each major source of treatable erosion that, if left untreated, would likely result in sediment yield to fish-bearing streams. Generalized prescriptions, such as those listed at the end of this report, describe the types of heavy equipment needed, general labor intensive treatments required and rough costs for each work site.

In the final step of the assessment, a report is developed which outlines recommendations and pinpoints areas within each watershed which would benefit most from cost-effective erosion control and erosion prevention work. To accomplish this, criteria are developed to prioritize possible work sites based on their potential for future, preventable sediment yield, their proximity to important fish habitat areas, and the cost-effectiveness of the proposed treatments. Finally, and of equal importance to physical treatments of existing problems, recommendations are made on how on-going landuse practices in the watershed might be modified to reduce the threat of future erosion and sediment yield from continued management activities.

III. Objectives of the Pine Creek Watershed Assessment

The general objective of the Pine Creek watershed assessment project is to develop a practical, fact-based, prioritized listing of cost-effective erosion control and erosion prevention projects. These projects are aimed at accelerating the long-term, permanent recovery of anadromous, fish-bearing stream channels in the Pine Creek basin.

Over the last four decades, severe aggradation in the main channel of Pine Creek (and the loss of important fisheries resources) has been a consequence of 1) tributary debris torrenting, which delivered excess quantities of debris to lower gradient reaches, 2) the sudden influx and accumulation of large quantities of sediment from diffuse hillslope sources, and 3) localized but numerous streamside landslides. As of 1990, main channel conditions appear to be improving as large accumulations of stored sediment in the channel are flushed downstream and out of the system.

Preventing substantial, additional influxes of coarse sediment to the main channel and its tributaries during future flood events will allow for continued or accelerated channel recovery during the next several decades. The premise is that if the supply of newly eroded sediment from the hillslopes is diminished, available stream power in the main channel and its tributaries will continue or accelerate the process of channel scouring and recovery.

Erosion control and erosion prevention works prescribed in this assessment report are focused on treating potential sites located in accessible hillslope locations, along low order stream channels and in steep headwater swales. They are designed to significantly diminish watershed sediment inputs to the channel system during the next major flood event.

For Pine Creek, watershed assessment work has lead to the development of generalized recommendations, techniques and costs needed to perform erosion prevention treatments on permanent, seasonal and abandoned roads throughout each of nine watershed treatment areas. Provisions for the proactive abandonment of unneeded logging roads are spelled out in detail to both protect the physical resource of the roadbed as well as eliminating unnecessary inputs of sediment to the local streams. Treated, abandoned, road prisms are stabilized until they are again needed to provide access to second growth timber resources.

A variety of simple, straight forward, procedures described in this report provide the basis for stabilizing and actively promoting long term reductions in accelerated erosion and sediment yield and a permanent improvement in fisheries habitat. This report outlines appropriate treatments designed to remedy existing and potential erosion problems in the most cost-effective manner possible. Only those sites expected to deliver significant quantities of sediment to Pine Creek or its tributaries are singled out for possible treatment.

In the next logical step, skilled equipment operators and erosion control specialists can immediately implement those projects deemed most cost-effective and most beneficial to long term watershed stabilization and recovery. A list of these treatment areas is included at the end of this report.

Results described in this watershed assessment report are categorized under the following basic components:

a. construction history and current maintenance status of roads in the watershed, as identified in the field and on sequential aerial photographs,

b. erosion history of mass movement and fluvial erosion features identified during the air photo analysis of the basin,

c. tabulation and discussion of existing and potential erosion problems, including estimated erosion potential, estimated sediment yield and causes of erosion, along all roads in the basin,

d. a listing of prioritized sites recommended for erosion control or erosion prevention treatment, including generalized prescriptions and cost estimates for sites judged to be of highest priority,

e. generalized prescriptions, techniques and costs to perform erosion prevention treatments on both maintained, abandoned and unmaintained (but driveable) roads, including general equipment and labor needs and estimated costs, and

f. recommendations regarding on-going and future landuse practices, including road construction, road maintenance and road abandonment practices, which might be altered or improved to lessen watershed impacts from future landuse activities.

A. Pine Creek Watershed Assessment Project

The Pine Creek watershed assessment project, funded by the Trinity River Task Force, administered by the Hoopa Tribal Council, and supervised through the Hoopa Tribal Fisheries Department, was undertaken with the ultimate goal of fisheries improvement and protection. This watershed assessment represents the first of two phases of drainage basin work that will logically conclude with the application of specific, cost-effective watershed improvement projects aimed at reducing or preventing additional sedimentation and damage to Pine Creek and its fish bearing tributaries.

The Pine Creek assessment work focused on that portion of the Pine Creek watershed located within the Hoopa Reservation. Field surveys were conducted to quantitatively inventory sites which displayed past or future potential for sediment production and yield, and to assess and prioritize each candidate site for cost-effective erosion prevention and control.

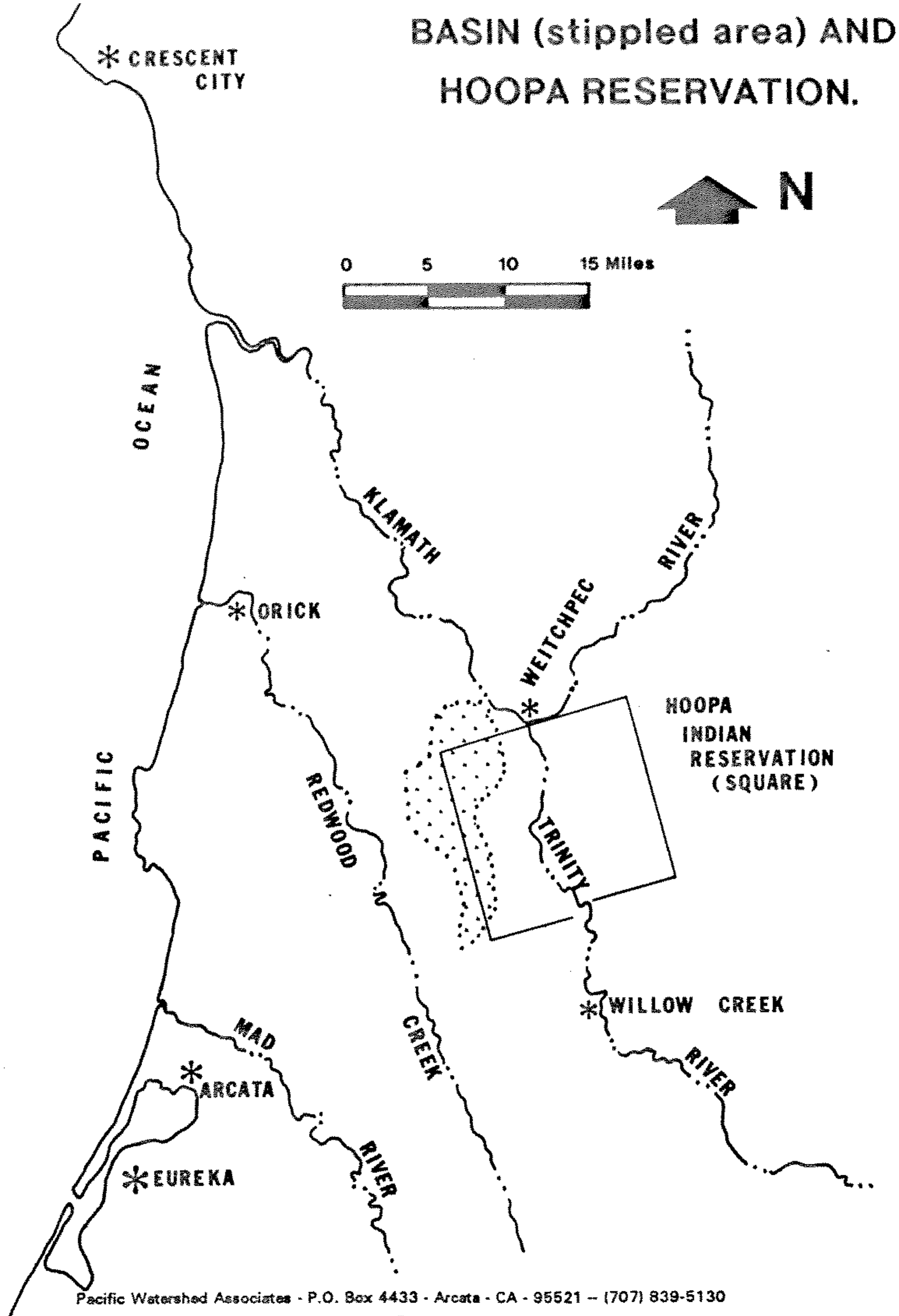
The ultimate goal of the Pine Creek watershed assessment, and of subsequent watershed improvement projects on the ground, is the restoration, enhancement and protection of the basin's fisheries.
The immediate purpose of the inventory was to identify sites where ongoing and future watershed improvement projects could cost-effectively reduce sediment production and sediment yield to anadromous fish bearing streams, including Pine Creek and its tributaries.

B. Study Area

The Pine Creek watershed is a 49 mi^2 basin that drains the Coast Ranges of Northern California and discharges into the Klamath River 2.9 miles downstream from the town of Weitchpec (the confluence of the Klamath and Trinity Rivers)(Map 1). The eastern portion of the basin, east of and including the main stem of Pine Creek, lies within the Hoopa Reservation. Much of the western side of the basin, as well as the lower basin near its confluence with the Klamath River, lies outside the reservation boundaries and is privately owned and managed by industrial timber companies.

Approximately 21 mi^2 (43%) of the basin is included within the reservation and forms the land base for this watershed assessment and analysis. The remaining 28 mi^2 (57%) lies outside the reservation but drains eastward and into the main stem of Pine Creek, thereby affecting Tribal fisheries and riparian resources within the channel corridor.

MAP 1. LOCATION OF PINE CREEK DRAINAGE BASIN (stippled area) AND HOOPA RESERVATION.



C. Private Lands Tributary to the Study Area

Private lands, tributary to Pine Creek but located outside the study area, were harvested largely between 1960 and 1980 using clearcutting and tractor logging techniques common to that era. As is evident on historic aerial photographs, ground disturbance from tractor yarding was severe and lower order streams were heavily impacted. Virtually all logging roads were abandoned immediately following the cessation of timber operations and subsequent stream crossing washouts and fillslope failures are ubiquitous.

The largest storms and floods of the period (1964, 1972, 1975) triggered substantial erosion along poorly constructed and unmaintained logging roads. Numerous debris slides and debris torrents originated from the failure of unstable fill slopes, landings and poorly built stream crossings constructed on steep slopes. These torrents and sediment laden flows travelled great distances down first, second and third order channel systems stripping them of their remaining riparian vegetation, organic debris and channel structure.

Thus, immense quantities of sediment have been delivered to the main channel of Pine Creek from erosion and sediment production originating on private forest lands tributary to the reservation. These private lands will continue to contribute sediment to Pine Creek in the future, albeit at rates diminished from past levels when unstable fillslopes and stream crossings were still intact.

IV. Background

Watershed management in northern California has not historically been sensitive to fisheries values. Yet logging and road construction need not be at odds with the restoration and maintenance of highly productive anadromous fish-bearing streams. Improved landuse practices, conducted in concert with directed erosion control and erosion prevention work on existing disturbed areas, can lead to long term watershed stabilization and the coexistence of both landuse and native fisheries resources. Recommendations aimed to this dual purpose, and specifically directed to land areas in the Pine Creek watershed, is the essence of this watershed assessment project.

There is recent, growing recognition that effective fisheries restoration and long term recovery of gravel-bedded anadromous fish streams is directly dependent on the recovery and healing of eroding hillslopes and tributary streams in the upland watershed areas of a drainage basin. Until those sources of aggravated erosion and sediment production are treated and effectively eliminated, there is little that can be done in the channel to provide for long term improvements in spawning and rearing environments.

A concentrated effort of watershed restoration (erosion prevention and erosion control) in the upper portion of watersheds will be of greater long-term benefit to the aquatic environment than in-stream or channel structure work. Structures constructed or placed in once productive spawning channels have been found to be highly subject to storm damage and only locally effective in providing temporary improvement in habitat. It is now generally recognized that if upper watershed areas are managed properly, streams and creeks will recover to a self sustaining, productive condition.

Once erosion prevention work has been selected as a means of promoting drainage basin recovery, it is imperative that a helter-skelter approach to watershed stabilization and the treatment of existing erosion problems be strictly avoided. To be both effective and cost-effective, problems within a proposed treatment area (a drainage basin with an impacted anadromous resource) must first be identified and then listed and categorized according to magnitude and treatability of each erosion source.

Lastly, a cost-effectiveness analysis must be employed to accurately prioritize each proposed treatment site relative to the others. The erosion potential (likelihood of erosion) of each feature is determined through field analysis. Then, the volume of sediment expected to be eroded or delivered to the channel system is determined. Finally, the predicted cost of treating the feature is closely estimated. With these three factors (likelihood of erosion, delivery volume and treatment cost), all sites can be compared and evaluated against each other.

The sites with the greatest probability of delivering large quantities of sediment to fish bearing streams, will rank high on the list of potential work sites if they can be treated at a low cost-effectiveness value. The cost-effectiveness of treating a work site is defined as the average amount of money spent to prevent one cubic yard of sediment from entering or being delivered to the stream system.

Without first following each of these steps, it is unlikely that erosion control work will treat those sources of sediment that could most effectively be controlled for the least amount of money.

Effective watershed stabilization entails both erosion control and erosion prevention. ***Erosion control*** practices for steep forested lands impacted by logging and road building have been thoroughly tested and evaluated and are applicable for most areas in northern California (Weaver and Sonnevil, 1984; Weaver and others, 1987). The application of these techniques to controlling erosion from selected, disturbed lands in tributary watersheds would be straight forward. Only the most cost-effectively treatable sources of erosion need be attacked with aggressive erosion control.

Projects which provide for ***erosion prevention*** are by far the most cost-effective means of ensuring suitable habitat for anadromous fish production. Erosion prevention entails the recognition and treatment of potential erosion sources before they become contributors to sediment yield. This is accomplished through field inventories which identify both existing potential sites of erosion, as well as on-going landuse practices that continue to develop new sites of potential erosion.

Finally, simple and inexpensive changes in common ***landuse practices*** (such as road construction or road maintenance techniques) employed by landowners in a watershed can often go a long way to preventing unnecessary, accelerated erosion in the future. Likewise, for example, inexpensive, preventive treatments to existing roads can often be performed to "erosion proof" them before the next major storm.

V. Procedure

A. Sequence of Work Tasks and Data Collection

The analysis of watershed conditions in Pine Creek involved several discrete steps or stages. These steps were a necessary precursor to on-the-ground watershed rehabilitation work which is to be undertaken in the future. They ensure that only the most cost-effective of fisheries-related projects in the basin are undertaken.

1. Phase 1

The first step was to assemble historic aerial photographs and relevant literature available for the drainage basin, in order to construct accurate road maps, a road construction history and an erosion history. Climatological data and flow records for nearby watersheds were also investigated to determine the information on historical floods.

For Pine Creek, a 1977, rectified, USGS orthophoto quad was used as the small scale base map for general mapping of the location of all roads in the study area. This has served as the base for several maps contained in this report. The main photographs used for field mapping were 1:12,000 scale, true color, 9"x9" vertical aerial photographs flown in May, 1990. They were commissioned by and flown for the Hoopa Valley Business Council.

Frosted mylar overlays were attached to each photo and used to record site information as it was collected in the field. Information recorded on these overlays includes road location, site number and location, type or classification of site, erosional features (stream-side landslides, debris torrents, gullies and gullied stream channels, washed out stream crossings, etc), stream channels, stream crossings and culvert locations. The location and area of coverage for relevant 1990 mapping photographs in the Pine Creek study area is shown on Plate 3.

Aerial photographs for the years 1944, 1962, 1965, 1972, 1977 and 1990 were analyzed to determine the location and timing of erosional events, and road construction and harvesting histories for areas within the basin. These years were chosen to bracket, as closely as possible, known north coastal California regional floods which occurred in 1955, 1964, 1972, and 1975. In this way, the effects of extreme hydrologic events can be associated with the resultant erosional processes in areas with and without the added, complicating influence of landuse.

2. Phase 2

In the second stage, an extensive analysis of aerial photos was conducted to detail the following information:

a. road locations and road construction history,
b. landslide locations and mass movement history,
c. "road-related" erosion (stream crossing washouts, gullies and landslides, where visible) and
d. expected locations of all stream crossings.

Air photo analysis was used to delineate the worst existing erosion sources, and to provide evidence of how landuse, road construction and road maintenance history, and storms (floods) have each influenced erosion processes in Pine Creek and its tributaries. The photo analysis was also used to directly point to those areas of the watershed where more detail field inventories of erosion problems were judged to be useful in delineating existing and potential, treatable erosion sources.

Not all areas in the basin were expected to contain potentially significant sediment sources. For example, roadless areas, remote (inaccessible) streamside zones and low gradient upland areas were far less likely to display serious, treatable, erosion problems. Such areas were sampled for problems and investigated in greater detail only where photographic analysis suggested the presence of significant, potentially treatable erosion problems. As a safeguard, and regardless of their location, all roads crossing upland areas were field inventoried for stream crossings and instabilities because of their likely association with landuse-related erosion.

Substantially more field time was eventually allocated to middle and lower hillslope areas where steep, dissected slopes are crossed by active or abandoned roads. This is the location where most active and potentially active, treatable, erosion problems were found.

3. Phase 3

Phase three of the Pine Creek project involved the conduct of field inventories and site analyses. This was the most time consuming element of the project. Significant existing and potential erosion problems were identified and described along virtually every existing road in the watershed assessment area. All active roads, as well as all abandoned alignments were mapped and surveyed on the ground. These analyses covered sensitive roads (those where sites are common and often have a high likelihood of contributing sediment directly into perennial streams or fish bearing watercourses), as well as road alignments farther removed from fish-bearing streams where potentially important work sites are less common.

A variety of data was collected for each field site. Appendix B shows a copy of the 3 page, computer data sheet that was filled-in for each of the 445 sites identified during the field inventory. Appendix B also contains a complete listing of the definitions of the 192 separate questions contained on this data sheet. Depending on the classification of a site (stream crossing, debris slide, gully, etc), different portions of the form were filled in with the relevant information.

Site numbers were logically ordered to go with road systems in the basin. The road system and site number ordering is as follows:

Site Numbers	Location of Sites
0 - 100	Pine "J" & 100-Acre Prairie Roads (East of Pine Ck)
100's, 200's	No. 2 Road (east and west side of Pine Ck)
300's	No. 2 Road Spurs
500's	No. 201 Road (west side Pine Ck; Little Pine Ck)
600's	Bald Hill West (west from Pine Creek bridge)
700's	Bald Hill East (east from Pine Creek bridge)
800's	Snow Camp, Pine "G", and Bloody Camp Roads

Basic information was collected for every site, including an assigned site number, date of mapping, site location, air photo identification, access information and a brief descriptive summary of the site's characteristics. In addition, one of the last of the general questions (#20) on this first page of the data sheet requested information on how the site was classified; *Sheet 1 and 4*, or *Sheet 1 (alone)*, or *Sheet 2* or *Sheet 3*.

Figure 1: EROSION PREVENTION AND EROSION CONTROL DATA SHEET
PINE CREEK WATERSHED ASSESSMENT AREA

1. Site No.: 2. Mileage:
3. Major?: 4. Minor?:
5. Date Mapped: 6. Mapped by:
7. Photos taken:

8. Watershed: 9. Ownership:
10 Map Sheet: 11. Air Photo:
12. Air Photo Date: 13. Air photo scale:
14. Road Name: 15. Abandoned (Y,N):
16. Driveable (Y,N): 17. Minor rebuild (Y,N):
18. Major Rebuild (Y,N): 19. Built by (yr):

20. Sheet (1,2,3): 20.5 Treat?(Y,N): 21. Sketch present (Y,N):
22. Summary Comments:

Sheet #1

******* I. EROSION WITH PROBABLE SEDIMENT DELIVERY TO STREAMS *******

23. Existing debris slide (Y,N): 24. Potential debris slide (Y,N):
25. Deep seated slide (Y,N): 25A. Landslide site (Y,N):
26Lnd: 27Sw: 28RdF: 29Cks: 30Sca: 31Range: 32AvgFT:
33Evac: 34WVg: 35H2O: 36:LnTres: 37Other:
38. Gully (Y,N): 39. Rilling/surface (Y,N): 40. Stream/channel (Y,N):
41. Stream crossing (Y,N):
42. CMP, Bridge, Humboldt, Fill (C,B,H,F):
43. CMP dia (in):
44. High dp? (Y,N): 45.<50 or >50: 46. Rd slope (%):
47. High fp? (Y,N): 48. Check cmp size? (Y,N):
49. Xing history (D,W,N,U):
50. Plug potential (H,M,L): 51. % Plugged:
52. Sed Transport (H,M,L): 53. Ch Gradient (%):
54. CMP Plug cause (W,S,V):
55. Now diverted (Y,N): 56. Pct. Washed out (%):
57. Comment:

58. Natural (Y,N): 59. Cutblock (Y,N): 60. Road related (Y,N):
61. Other:

62. Active (Y,N): 63. Waiting (Y,N): 64. Inactive (Y,N):
65. % veged: 66. Describe slide surface:

67. Slope above (%): 68. Slope below (%): 69. Springs (Y,N):

70. Bedrock:
71. Soil(ft): 72.FewRx: 73.Coh: 74.Dg: 75.Mot: 76.DpColl:

77.IG: 78.BIS: 79.HwS: 80.(U,M,L,S): 81.(Conv,Pl,Diverg):
82. Other:
83. Comments:

Figure 1 (continued)

84. Past erosion (yds): 85. Delivery (%):
86. (WxLxD):

87. Erosion potential (H,M,L): 88. Erode in normal winter (Y,M,N):
89. Move in big storm (Y,M,L): 90. St. Divers.yd3 (<100,<500,>500):
91. Future erosion (yds): 92. (WxLxD):
93. Comment:

94. Future delivery (Y,N): 95. Delivery percent (%):
96. Can control erosion? (Y,N): 97. How?(E,H,B):
98. Correct diversion potential? (Y,N): 99. How?(E,H,B):
Past vol (yds): Future Vol (yds):
100. Treatment Immediacy (H,M,L):
101. None: 102. Replace CMP: 103. Larger CMP:
104. Add CMP: 105. Clean ditch/CMP: 106. Rolling dip:
107. Add TR/DS: 108. Pull Xing: 109. Pull fill:
110. Other:
111. Pot extreme eros.(Y,N): 112.Vol(yd): 113.Comment:

Sheet #2

114. STEEP COLLUVIAL SWALE, POTENTIAL DEBRIS SLIDE LOCATION? (Y,N):
********** II. NO PROBLEM RX, NO DP RX, & ALL DITCH RELIEF CMP'S **********
115. Ditch (Y,N): 115b. Stream (Y,N): 115c. Spring (Y,N):

116. CMP,Humboldt,Fill (C,H,F): 117. CMP Dia.(in): 118. T.R.? (Y,N):

119. FP? (Y,N): 120. Check CMP size? (Y,N): 121. Fill vol (YDS):

122. Plug potential (H,M,L): 123. How? (S,W,V):

124.Past eros: 125.Vol (yds): 126.Type:
127.Fut. eros: 128.Vol (yds): 129.Type:

130. repair/replace (Y,N): 131. install cmp/larger cmp (Y,N):
132. install TR (Y,N): 133. install ED or DS (Y,N):
134. clean CMP (Y,N): 135. clean ditch (Y,N):
136. install rolling dip (Y,N): 137. none (Y,N):
138. Other tmt:
139. Comment:

Sheet #3

************* III. SLIDES AND EROSION WITH NO DELIVERY ****************
140. Existing debris slide (Y,N): 141. Potential debris slide (Y,N):
142. Deep seated slide (Y,N): 143. Other (Y,N):

144. Landing (Y,N): 145. Road fill (Y,N): 146. Other (Y,N):

147. Active (Y,N): 148. Waiting (Y,N): 149. Inactive (Y,N):

150. Slope (%): 151. Springs (Y,N):
152. Bedrock:
153. Inner gorge (Y,N): 154. BIS (Y,N): 155. Steep swale (Y,N):
156. Other:
157. Past erosion (yds): 158. (WxLxD):
159. Erosion potential (H,M,L):
160. Storm dependent (Y,N):
161. Future erosion (yds): 162. (WxLxD):
163. No tmt: 164. Pull fill: 165. Other:
166. Comment:

Figure 1 (continued)

Sheet #4

VOL SAVED: *********** TREATMENTS ************ TREAT THIS SITE?:
167. TREATMENT TYPE IPOS: EOS: IPRX: ERX: XRD: RD: OTHER:
168. COMMENT:

***************************** FILLSLOPES ******************************
VOLUME GENERATED PER FOOT OF ROAD (YDS): TOTAL EXCAVATED VOL (YDS):
AVAILABLE STORAGE VOLUME (YDS):
COMMENT:

***************************** CROSSINGS *******************************
ESTIMATED VOLUME OF FILL CROSSING (YDS): IS LOCAL STORAGE AVAILABLE?:
COMMENT:

***************************** LOGISTICS *******************************
POST TMT EXPOSED AREA (FT2): LABOR TMT NEEDED...STRAW?: GRASS?:
COMMENT:

EQPT NEEDED EXC?: CAT?: OTHER?: TIME EST (HRS) EXC: CAT:
COMMENT:

Sheet 1 sites include all those that have delivered, or threaten to deliver, over 50 yds^3 of eroded sediment to stream channels. Within this category are those sites that delivered sediment to streams in the past, usually in response to a large storm or flood. Also included as Sheet 1 sites are those sites that are expected to erode and deliver over 50 yds^3 of sediment to streams in the future. For sites where there is a potential for cost-effective erosion control or erosion prevention work in the future, *Sheet 4* (the treatment sheet) was also prepared.

Sheet 2 sites and *Sheet 3* sites describe locations where there is potential for erosion (or where there was past erosion), but there will be (or was) little or no significant sediment delivery to streams. *Sheet 2* sites consist of stream crossings that are unlikely to ever fail (washout) and where there is no potential for stream diversion. Also included in Sheet 2 sites are ditch relief culverts that display no significant potential for future erosion. Many *Sheet 2* (and *Sheet 3*) sites are characterized by past or future erosion with little or no sediment delivery to local stream channels.

Sheet 3 sites include all past (existing) and potential (predicted) landslides (debris slides, fill failures, deep seated landslides), as well as gullies and surface erosion sites, *where there is no significant sediment delivered, or to be delivered, to stream channels.* Erosion at these sites caused, or could cause, local hillslope damage, but will not significantly impact fish-bearing streams.

Special attention was paid to all major stream crossings, all stream crossings with a high diversion potential (DP) and stream crossings with a high failure potential (FP) [all represented as *Sheet 1* sites], particularly on roads that are abandoned and no longer maintained. Erosion and failure of every stream crossing on abandoned roads is almost certain to eventually occur. Most wash out during large storms. Once initiated, sediment eroded at these locations will be delivered directly into low order stream channels and begin its irreversible journey toward fish-bearing watercourses.

Visibly unstable fillslopes, unstable log landings and unstable hillslopes crossed by either abandoned or maintained logging roads were also closely described, especially if they threatened to deliver sediment to a downslope stream channel (*Sheet 1* sites). To be visibly unstable, the site must have contained cracks or scarps or other visible evidence of past or pending slope failure.

The erosion potential and potential for sediment delivery was estimated for each major problem site or potential problem site. Importantly, the past and future expected volume of sediment to be eroded, and the volume to be delivered to streams, was estimated for each site. The data tells not only how much has been eroded and delivered from existing sites, it also provides estimates on how much will be eroded and delivered in the future, if no erosion control or erosion prevention work is performed.

4. Phase 4
During the field inventory of existing and potential erosion sources, a more detailed analysis of each significant site was performed. This step included an analysis of the most effective and cost-effective erosion prevention and/or erosion control work that could be applied to each of the highest priority sites. This analysis included generalized heavy equipment and labor-intensive prescriptions, as well as procedures, cost estimates and equipment times needed for effective treatment. The sites selected for eventual treatment are the ones that are expected to generate the most cost-effective reduction in sediment delivery to the drainage network and the mainstem channel.

B. Assessing Treatment Priorities
Basic treatment priorities and prescriptions were formulated concurrent with the identification, description and mapping of past and potential sources of road-related erosion and sediment yield. Treatment priorities were evaluated on the basis of several factors and conditions associated with and noted for each potential site.

1. Sheet 1, 2 or 3 (Question #20) - Sheet 1 sites involved either past or potential future delivery of sediment to stream channels and, eventually, to the main stem of Pine Creek. While all sites recommended for treatment come from the *Sheet 1* category of sites, not all the *Sheet 1* sites merit expenditures for erosion prevention or erosion control.

Erosion at *Sheet 2* and *Sheet 3* sites, by definition, did not (and will not) result in the contribution of eroded sediment to local streams. Although neither of these two categories of sites are expected to contribute significant volumes of sediment to fish-bearing streams, a number of them still represent large erosion sources. To prevent damage to regeneration or failure of sections of existing roads, general treatment recommendations have been included to control or prevent erosion on several *Sheet 2* and *Sheet 3* sites.

2. Future Erosion and Delivery (Questions #91 & 95) - The volume of sediment expected to enter stream channels from future erosion at the site played a significant role in determining the treatment priority. Most of the sites mapped in the field were limited to those where past or future erosion (or sediment delivery) was determined to be greater than 50 cubic yards. The larger the potential future contribution of sediment to streams, the more important it became to closely evaluate its potential for cost-effective treatment.

3. *Erosion Potential (Question 87)* - The erosion potential of a site is a subjective evaluation of the likelihood that future erosion will occur. Erosion potential is evaluated as high, moderate or low. This is an estimated potential for additional erosion, based on local site conditions and observations. Thus, it is a probability estimate, and not an estimate of how much erosion is likely to occur. A 50 yd^3 feature can have a high erosion potential while a nearby 500 yd^3 potential debris slide may be classified as having a low erosion potential if it is unlikely it will ever fail and move downslope.

4. *Treatment Immediacy (Question 100)* - Treatment immediacy is a subjective evaluation of how important it is to quickly perform erosion control or erosion prevention work. It is defined as High, Moderate or Low. An evaluation of *treatment immediacy* considers erosion potential, future erosion and delivery volumes, and treatability. If failure or sediment delivery is imminent, even in an average winter, then treatment may need to be performed as soon as possible and treatment immediacy might be judged "high." On the other hand, an erosion feature that threatens to delivery large quantities of sediment to a stream in the near future might have a "low" treatment immediacy if it is judged impossible to control or prevent the expected erosion. Treatment immediacy is a summary, subjective measure or assessment of a site's need for rapid treatment.

5. *Access (Questions 15, 16, 17 & 18)* - One factor influencing a site's treatment priority is the difficulty (cost and environmental impact) of reaching the site with the necessary equipment to effectively treat the potential erosion. Many identified sites were found on abandoned roads which would require brushing and tree removal to access the site(s). Other abandoned roads would require minor or major rebuilding of washed out stream crossings and/or existing landslides in order to reach potential work sites further out the alignment. Road reconstruction adds to the overall cost of erosion control work and reduces project cost-effectiveness. Potential work sites with lower cost-effectiveness, in turn, will be of relatively lower priority.

6. *Recommended Treatment Prescriptions, Logistics and Costs (Questions 101-110 and Sheet 4)* - General treatments are cataloged in questions 101-110, and the specifics of the recommended treatments, as well as costs and logistics (eg., equipment types, excavation volumes, equipment hours, etc) are outlined on Sheet 4. Sheet four information has been filled out for all 220 sites having a high, moderate or low rating for Treatment Immediacy.

Treatment priorities were developed in consideration of these factors, as well as an evaluation of the estimated cost-effectiveness of the erosion control or erosion prevention treatment. Cost-effectiveness was determined by dividing the cost

($) of accessing and treating a site by the volume of sediment prevented from being delivered to local stream channels. For example, if it would cost $2000 to access and treat an eroding stream crossing that would have delivered 500 yds^3 (had it been left to erode), the predicted cost-effectiveness would be $\$4/yd^3$.

To be considered for priority treatment, a site must 1) have potential for significant sediment delivery to a stream channel (with the potential for transport to a fish-bearing stream), 2) have been cataloged with a high or moderate treatment immediacy and 3) have a predicted cost-effectiveness value averaging less than $\$6/yd^3$. Sites meeting these criteria and having a high or moderate erosion potential are more likely to assume a higher priority. In addition, sites that are grouped in relatively close proximity are more likely to be treated because of the lowered costs of opening equipment access and travelling between work sites.

Sites that have a very high estimated cost-effectiveness value ($>\$7/yd^3$), or are judged to have a lower erosion potential or treatment immediacy, are less likely to be treated as a part of the primary fisheries improvement program. However, these sites would logically be addressed during future road reconstruction (when access is reopened into areas for future timber harvests), or when heavy equipment is performing work on nearby, higher priority sites.

V. Results

A. Air Photo Analysis

1. Road Construction History

Road construction history for the Pine Creek study area was determined from aerial photographic analysis. Roads were categorized as being constructed during periods bracketed by dates of aerial photography of 1944, 1962, 1965, 1972, 1977 and 1990 (Table 1).

Initially, at the beginning of the inventory project, the Tribal Forestry Department estimated the Hoopa road network in the Pine Creek basin to be about "35 to 40 miles" in length. Subsequent field inventories and aerial photo analysis showed there to be a vast network of abandoned roads throughout Tribal lands in Pine Creek. In addition, the road network on private lands west of the reservation, but still within the Pine Creek watershed, appears even more dense. As will become evident, these roads have played an important part in erosion and sedimentation processes in the watershed.

Plate 1 shows the entire road network that has been constructed in the Pine Creek study area. The roads are depicted using symbols to show their date of initial construction. By the time of this survey (1990), much of the road system had been abandoned (Plate

2). A number of older, once abandoned roads in Pine Creek have been reconstructed in the last year as renewed harvesting in the area occurs. Likewise, several miles of new road construction has occurred during 1990.

Table 1. Road construction by time period, Pine Creek in Hoopa Square.

Date of Construction	Length Built (miles)	Cumulative Length (mi)	Rate (mi/yr)
before 1944	19.1	19.1	--
1944 - 1962	30.0	49.1	1.6
1963 - 1965	14.3	63.4	4.8
1966 - 1972	15.6	79.0	2.2
1973 - 1977	8.8	87.8	1.8
1978 - 1990	16.0	103.8	1.2

Many roads in the study area have been abandoned, and then reconstructed, several times, in order to access new timber sale units. However, when all the timber resources along a particular road system have finally been harvested, the roads are usually abandoned for good.

Many roads that had been abandoned for up to two decades still display considerable potential for future erosion and sediment yield. Others that had weathered the large storm of 1964, and those in the 1970's, appeared to have far less potential for future contribution to channel aggradation and habitat degradation. Finally, a number of roads constructed in the last 15 years (since 1975) have not yet experienced a large runoff event and were found to still be highly susceptible to future erosion.

a. Landslides and Debris Torrents

The occurrence of new slope failures and the enlargement of existing landslides visible on 1:12,000 scale photos were noted during aerial photographic analysis. Landslides and debris torrents contributed tremendous volumes of sediment to tributaries and the main channel of Pine Creek, especially in response to the floods of 1964, 1972 and 1975. These periods also corresponded to times of intense timber harvesting and road building in the basin.

Most slope failures in the study area were associated with logged areas and logging roads. The inner gorge area along incised stream channels was by far the most common location for debris sliding. These stream-side debris slides contributed large quantities of material directly to perennial streams. In response to logging and large floods in 1964, 1972 and 1975, stream-side zones locally experienced continuous shallow debris sliding for several thousand linear feet of the channel on one or both channel banks.

Original landslide mapping is shown on the mylar overlays to the 1990 color aerial photographs. Slope failures are color cataloged according to the year movement was first detected on the historic aerial photos. If additional movement at a site was detected in subsequent years, the enlarged area was also shown by that year's color code.

b. Impacts to Stream Channels and the Effects of Floods

Bedload sediment tends to accumulate behind organic debris in small, steep gradient tributaries during low or moderate flow years. During these periods, continued influxes of coarse sediment, from diffuse hillslope sources and from erosion in lower order watersheds and channels, fills irregularities in the rough bed and accumulates behind these organic debris dams.

During the same time, the resultant diminished sediment influx from small, lower order tributaries (where material is being temporarily stored) causes channel bed and bank deposits in the larger tributaries and in low gradient main stem channels to be removed and slowly flushed downstream. This is a period of recovery for channel morphology, riparian vegetation and anadromous habitat.

In contrast, during years of major floods, stored sediment and organic debris in the steep, small tributaries is flushed into the lower gradient reaches of the main tributaries and the main channel where excessive sediment loads are deposited as thick, long lived fill terraces, overbank deposits and channel bed deposits. The process of main stem aggradation brought about during floods is rapid and its removal is correspondingly slow.

Physical impacts to stream channels in Pine Creek fall into two main categories: 1) *scouring and widening* of steep tributary channels by debris torrents during major flood events and 2) *aggradation* in lower gradient, higher order channels during the same floods. Channel recovery from these two processes, in both the tributaries and the main channel of Pine Creek, has been substantial in the period from 1975 to 1990.

Channel scouring processes severely impacted a number of steep tributary channels where debris torrents, which originated in headwater regions, travelled up to 0.5 mile down incised stream channels. Channel banks and beds were typically scoured down to bedrock in these heavily impacted channels. Organic debris and sediment was carried downstream and deposited in lower gradient reaches or at main channel junctions where stream power diminished. Since the last major episodes of basin-wide debris sliding and torrenting in 1964, 1972 and 1975, the steeper segments of impacted (scoured) tributary channels have largely revegetated and recovered. Little additional sediment is originating from these past sources, yet in some locations debris slide and torrent deposits still reside in low gradient reaches downstream.

Stream channel *aggradation* during historical flood events was common throughout most of the larger tributaries and in the main channel of Pine Creek at locations where channels widened and gradients diminished. Large fill terraces were deposited in wide channel reaches, and sediment and organic debris accumulated behind numerous log jams. The remnants of this stored sediment are still visible as isolated, but common, terraces in the lower tributaries where much of the material originally deposited has now been removed and flushed downstream to the main stem and beyond.

Since the last major flood in 1975, the main stem of Pine Creek has been in a period of recovery. Currently, sediment stored in main stem fill terraces, in the aggraded streambed and in local accumulations behind log jams, still plays an important role in Pine Creek channel processes. Re-erosion and transport of this material continues each winter. Until the accumulations of stored material are naturally removed, they represent a readily available, largely uncontrolled source of sediment which will continue to impact the main stem. As material is continually removed, former channel structural elements emerge, bed material particle size coarsens, and channel habitat and spawning conditions improve.

B. Road Survey Data

1. Erosion, Sediment Delivery and Site Identification

A total of 445 sites were identified and inventoried in the Pine Creek study area (Table 2). Sites were dispersed along roads of various age and maintenance status (maintained or abandoned). Sites included 201 culverted and non-culverted stream crossings, 123 ditch relief culverts, 59 existing and 93 potential debris slides (channelized debris torrents, fill failures and landing failures), 10 deep seated landslides, and a number of gullies, sites of rapid surface erosion (rilling and ravelling), and reaches of channel bank erosion.

In addition, all 445 mapped and inventoried sites are shown on a planimetric map of the Pine Creek study area (Plate 4). Depicted on the fold-out map are symbols for landslides, stream crossings, ditch relief culverts, and other features.

For the purposes of this report, the most important sites are those that show the potential for future sediment delivery to stream channels (Table 3). These are the ones that will continue to impact fisheries habitat in the future. Similarly, only where there is potential for future sediment delivery is there also a potential for controlling or preventing the loss of that eroded sediment, and averting the resultant impacts to anadromous fisheries.

Table 2. Listing of Identified Sites According to Past or Future Sediment Delivery to Streams, Pine Creek Study Area.

Site Type	# of Sites	Existing Debris Slide	Potential Debris Slide	Existing Deep-Seated Slide	Stream Crossing	Other
Sheet 1 (With Delivery)	220	54	60	6	138	22
Sheet 2 (No Delivery)	188	--	--	-	63	125
Sheet 3 (No Delivery)	37	5	33	4	--	3
TOTALS[1]	445	59	93	10	201	150

1 Some sites contain more than one erosion type.

However, analysis of sites of past erosion and sediment yield is also important. Observations and measurements of past erosion and sediment yield (Table 3) are useful in that they allow for a more meaningful analysis of the expected location and probability of erosion occurring in similar settings on sites that have not yet failed. In addition, only through the analysis of past landuse practices and their resultant impacts can meaningful changes in future landuse practices be justified and lead to reduced soil loss and lessened impacts to streams.

TABLE 3. Inventoried sites in relation to roading history and sediment delivery to streams, Pine Creek study area.

Year of Construction	# of Sites	Sites with past Sediment Delivery # (%)	Sites with past Sediment Delivery Vol(yds³)	Sites with future Sediment Delivery # (%)	Sites with future Sediment Delivery Vol(yds³)
pre-1944	24	6 (25%)	1,520	12 (50%)	906
1945-1962	142	69 (49%)	67,906	67 (47%)	22,543
-1955 flood-					
1963-1965	71	11 (15%)	2,878	21 (30%)	4,088
-1964 flood-					
1966-1972	95	32 (34%)	13,496	38 (40%)	8,040
-1972 flood-					
1973-1977	40	17 (43%)	16,199	28 (70%)	18,558
-1975 flood-					
1978-1990	73	10 (14%)	352	25 (34%)	11,306
TOTALS	445	145 (33%)	102,351	191 (43%)	65,441

At first glance, sites that have weathered a number of regionally significant storms and floods in the past might be thought to be reasonable stable under the same conditions today. Indeed, the most unstable sites will have already failed. However, field analysis suggests that a number of other factors are also important in determining erosion potential, as some sites may become increasingly unstable or prone to erosion with time. These factors include slope gradient, hillslope hydrologic conditions, decomposition of buried organic material, subsequent landuse around or upslope from the site, and other factors which modify the hillslope and increase the risk of sediment production. During this study, older roads were still found to contain a number of sites with a high potential for future failure.

2. Road Abandonment

In many cases, the year of road abandonment may be nearly as important as the year of road construction in influencing future sediment yield from sites within the basin. This is especially true for fluvial erosion derived from stream crossing failures and stream diversions along the abandoned, unmaintained roads. Over time, culverts plug or fail, Humboldt (log) crossings begin to deteriorate and undrained fills saturate and begin to show signs of failure over time.

Some common factors leading to erosion and sediment yield along abandoned roads include 1) the presence of buried, rotting wood in stream crossing fills, landings and road fills on steep slopes; 2) settling and the development of slip surfaces in unstable, uncompacted fill slopes; 3) diverted or unculverted surface water flows saturate uncompacted fills; and 4) plugging of unmaintained culverts. In some cases, revegetation acts to partially counter some of these destabilizing factors.

Roads that were passable and in use for timber management just prior to the occurrence of major floods were often quickly rebuilt after crossings washed out and fillslopes failed. In the past, these rebuilt road sections were frequently no better constructed than the original road, and they were just as likely to fail in the next major runoff event. Thus, sections of road which failed in a storm, and then were rebuilt or reconstructed, often became the sites for future failure.

Of all inventoried sites in Pine Creek, 45% (199/445) were found along abandoned logging roads, with over half of these located along old (pre-1965), abandoned roads (Table 4). Of the 199 inventoried sites on abandoned roads, 51% (102) show past sediment delivery to stream channels (totalling 82,390 yds^3) and 58% (115) show potential for future delivery (totalling 52,530 yds^3, and averaging 460 yds^3 per site).

A total of 74 potential work sites with high or moderate treatment immediacy were identified and described along abandoned logging roads in Pine Creek. Work at these 74 sites (47 stream crossings, 26 potential debris slides, one eroding stream bank) would prevent up to 27,800 yds³ of sediment from entering the stream channel system.

TABLE 4. Past and Future Sediment Delivery from Sites on Abandoned Roads, Pine Creek Study Area.

Year of Construction	Sites on Abandoned Rds	Volume of past Delivery (yds^3)	Volume of future Delivery (yds^3)
pre-1944	0	---	---
1945-1962	93	65,081	20,898
1963-1965	13	2,598	1,568
-1964 flood-			
1966-1972	16	3,485	1,278
-1972 flood-			
1973-1977	28	10,974	18,380
-1975 flood-			
1978-1990	49	252	10,406
TOTALS	199	82,390	52,530

Four times as much past delivery and 4.1 times as much future sediment yield is expected to come from sites on abandoned roads as compared to sites on maintained roads (Tables 4 and 5). The reasons for excessive erosion and sedimentation from abandoned roads are several:

1. abandoned roads are generally dead-end spurs built with lower construction standards than main-line, permanent roads;

2. abandoned roads were typically built when construction practices were less stringent than at present (as is evident from the widespread past use of unculverted fills and Humboldt log crossings);

3. drainage structures along abandoned roads are not maintained and eventually plug or fail;

4. when erosion begins to occur on an abandoned road, it is not observed or repaired, but is allowed to continue unabated and uncorrected;

5. Once erosion processes have begun, numerous secondary erosional processes are initiated as hillslopes adjust to changing surface or subsurface hydrologic conditions.

6. erosion along maintained logging roads is often harder to detect (and probably under reported), since subsequent maintenance and reconstruction mask signs of past erosion; and,

7. since many abandoned roads are older than maintained roads, they have often been exposed to more storms and flood events than the younger, maintained roads.

Although 246 sites were identified, described and mapped along maintained roads, far fewer sites account for the past and expected future erosion and sediment delivery. Forty-two sites yielded the observed 19,961 yds^3 of past sediment delivery while future sources of sediment (12,911 yds^3) are confined to 75 sites (Table 5). Thus, each identified, potential source of sediment along a maintained road is expected to yield an average of just over 170 yds^3 to the stream system.

Only 40 sites identified along maintained roads were judged to have a high or moderate treatment immediacy. Work at these 40 sites (31 stream crossings and 9 potential debris slides) could prevent approximately 9,650 yds^3 of sediment delivery to Pine Creek and its tributaries.

TABLE 5. Past and Future Sediment Delivery from Sites on Maintained Roads, Pine Creek Study Area.

Year of Construction	Sites on Maintained Rds	Volume of past Delivery (yds^3)	Volume of future Delivery (yds^3)
pre-1944	24	1,520	906
1945-1962	49	2,825	1,645
-1955 flood-			
1963-1965	58	280	2,520
-1964 flood-			
1966-1972	80	10,011	6,762
-1972 flood-			
1973-1977	12	5,225	178
-1975 flood-			
1978-1990	23	100	900
TOTALS	246	19,961	12,911

Some abandoned roads in the basin are still driveable, even though they are beginning to be sealed off by vegetation regrowth. Access to sites along these roads is still good and, together with maintained roads, these abandoned, driveable roads account for 58 high or moderate immediacy sites with a potential future yield of 13,600 yds^3 of sediment. Other roads will require only minor rebuilding and vegetation removal to access potential work sites. Including these sites, where minor rebuilding is required, raises the number of sites with high or moderate treatment immediacy to 93, with a potential sediment yield of 27,200 yds^3. Seventy percent of these sites call for erosion prevention work at stream crossings.

On the other hand, 37 sites, with a potential future sediment yield of 25,300 yds^3, are found on abandoned roads where major road reconstruction would be required to access the site. Of these 37 sites, 21 were judged to have a high or moderate treatment immediacy with a potential yield of 10,300 yds^3. These are sites that need preventive treatment, yet work costs are likely to be somewhat higher because of the amount of road reconstruction needed to access the work sites, and because of logistic difficulties in correcting erosion problems.

Plate 2 depicts the current maintenance status of all roads on Tribal lands in the Pine Creek basin. Roads have been classified as either maintained, abandoned but driveable, or abandoned but not driveable.

3. *Erosion and Sediment Delivery*

a. Classification of Sites based on Sediment Delivery

For the field survey and analysis, data were collected and sites were cataloged in one of three categories, termed Sheet 1, Sheet 2, or Sheet 3 (the details of these categories have been previously described). One of three separate computerized database sheets was filled out for each of the 445 sites identified in the Pine Creek study area (Figure 1, and Appendix B).

Sheet 1 sites are those that have either delivered sediment to stream channels or have potential for sediment delivery in the future. *Sheet 2* sites consist of stream crossings with no significant erosion potential, stream crossings with no diversion potential and ditch relief culverts. Finally, *Sheet 3* sites consist of landslides and other sources of erosion (eg gullies) that have no past history or future potential for sediment delivery to stream channels.

Thus, *Sheet 2* and *Sheet 3* sites have not contributed to channel sedimentation in the past, and they are not expected to add to channel impacts in the future. From a fisheries perspective, there is little direct benefit to be gained by pursuing erosion control or erosion prevention at these sites. On the other hand, *Sheet 1* sites have either contributed to past channel aggradation, or they are expected to delivery sediment to streams in the future. These are the sites where treatment can play a part in reducing sedimentation and improving channel conditions.

Inventoried sites can be further divided into the following general categories, based on sediment delivery:

1. sites exhibiting past erosion with no sediment delivery to stream channels;

2. sites exhibiting past erosion, with some percentage of the eroded sediment having been delivered to streams;

3. sites showing potential for future erosion without delivery of sediment; and
4. sites showing potential for future erosion with expected sediment delivery to streams.

These four categories of sites are not always exclusive. For example, a number of sites that displayed past erosion and sediment yield still have a potential for continued or renewed sediment loss in the future. Sometimes, as with many potential landslides, this erosion will only be triggered by a large storm. In other circumstances, normal winter precipitation may be enough to initiate substantial erosion and sediment delivery.

Stream crossings are a good example of an erosional feature that may deliver sediment over a long period of time, as they slowly fail and wash material downstream. Normal winter storm runoff is enough to cause some continuing erosion while larger storms can trigger rapid soil loss and sediment yield to the stream system.

1. Sites Displaying Past Erosion with No Sediment Delivery
Sites displaying past erosion without sediment yield fall into two categories; 1) those sites where erosional products did not reach a stream channel and 2) those sites where not all the eroded sediment was delivered to the channel system. In general, all sites displaying erosion over 50 yds^3 in volume were inventoried for this analysis, except cutbank failures which deposited their load on a road bench.

In the first category of sites, seven (7) landslides (*Sheet 3* sites), totalling 3,095 yds^3, were identified in the study area which had failed and not delivered any sediment to a stream. Another 767 yds^3 of erosion (*Sheet 2* sites) from other sources (surface erosion, gullies, etc) produced sediment without any delivery to the channel system. In the second category, 11,484 yds^3 of sediment (*Sheet 1* sites) was stored on the hillslope when landslides and other erosional processes delivered the greater part of their loads to local streams in the study area, but left portions of the failed mass as hillslope deposits.

In total, from these sources, 15,346 yds^3 of sediment was identified as having been eroded along roads and not delivered to streams where it could impact aquatic resources. This volume is small compared to the amount of sediment which was eroded and delivered to the stream network.

2. Sites Displaying Past Erosion with Sediment Delivery to Streams

Sites displaying past erosion along roads typically yielded sediment to stream channels at a very efficient rate. When volumetrically large erosional events (usually >50 yds^3) occurred at a site, on average 90% of the sediment was delivered to a nearby stream channel (Table 6).

Thus, of over 113,000 yds^3 of erosion measured at 145 sites throughout the study area, over 102,000 yds^3 was delivered directly to channels and into, or towards, fish bearing streams. This is sediment that is already in the channel system today, and, for all intents and purposes, is no longer amenable to cost-effective treatment.

TABLE 6. Past erosion and sediment delivery from all sites that have yielded sediment to channels (Sheet 1 sites), Pine Creek.

Year of Construction	Total # of Sites with Past Delivery	Past Erosion (yds^3)	Past Yield (yds^3)	Percent Delivered to Streams
pre-1944	6	3,680	1,520	41
1945-1962	69	75,335	67,906	90
-1955 flood[1]-				
1963-1965	11	3,415	2,878	84
-1964 flood-				
1966-1972	32	14,620	13,496	92
-1972 flood-				
1973-1977	17	16,425	16,199	99
-1975 flood-				
1978-1990	10	360	352	98
TOTALS	145	113,835	102,351	90 avg.

[1] *(Note: flood dates shown for reference only; erosion not necessarily associated with first flood following road construction)*

Many sites displaying past sediment delivery are often good candidates for future erosion and sediment yield. Over 50% of the sites in the study area that delivered sediment in the past also have potential to yield eroded sediment to streams in the future (Table 7). However, many of these sites cannot be cost-effectively treated because future sediment delivery do not warrant the extensive site disturbance that would be needed to gain access and retrieve unstable material.

3. Sites Showing Potential for Future Erosion without Delivery

Not all sites that were identified as future sources of erosion are expected to delivery sediment to local streams. For example, 100 sites show no significant potential for sediment delivery to streams; consisting of 37 potential landslide sites and 63 stream crossings (Table 2). Another 125 sites consist of ditch relief culverts, inactive gullies, and other potential sources of fluvial erosion that are not expected to yield significant volumes of sediment to streams or impact fisheries resources.

These 225 sites (50% of the total number of sites for the entire watershed) show little potential for future sediment yield to stream channels, even though the expected future volume of erosion from these sites is estimated to be 32,400 yds^3 (60% of this volume comes from six large midslope landslides). These 225 sites do not merit further analysis for potential erosion prevention or erosion control projects whose aim is the protection or enhancement of fisheries habitat. However, if the roads that these sites are located on are abandoned in the future, the probability for erosion and sediment yield will increase dramatically.

4. Sites Showing Erosion Potential with Expected Sediment Delivery

This is the only class of sites where the opportunity exists for meaningful erosion control and erosion prevention work. Table 3 identifies 191 sites in this category (43% of the 445 total) with the potential for 65,441 yds^3 of sediment to be delivered to the stream system. Some of these sites are more likely than others to fail, or erode, and deliver their sediment load.

Although they may eventually yield sediment to streams, not all of these sites represent potential sources of erosion that are a high priority to treat. That is, some of these sites contain potential sediment sources that are not likely to fail or erode, except in the largest of storms. These are of lower priority to treat than those sites where erosion is more likely to occur during the next normal winter. Other sites might be sources where substantial erosion is likely to occur soon, but only a small amount is expected to be delivered to the stream channel (the rest being stored on the hillslope before reaching the stream system).

In spite of having weathered storms, more sites (n=191) still show a potential for future sediment yield to streams than those that show evidence of past sediment delivery (n=145) (Table 3). In addition, roads that have been constructed or reconstructed since 1975 have not experienced a significant storm or flood. These roads contain features that may be more highly susceptible to significant erosion than on older roads. In addition, some of the sites which have failed and delivered sediment in the past continue to threaten streams with additional, future erosion and sediment yield.

b. Landslides

Landslides represent the single largest source of past and future erosion and sediment delivery in Pine Creek (Table 7). Over twice as much sediment has been delivered from landslides along roads as compared to sediment delivered from documented, washed out stream crossings and gullies cause by stream diversions.

TABLE 7. Landslides Erosion and Sediment Delivery from all Sheet 1 sites, Pine Creek.

Year of Construction	Total # of Slide sites w/Delivery	---- Past Processes ---- Erosion (yds³)	Yield (yds³)	Delivery (%)	---- Future Processes --- Erosion (yds³)	Yield (yds³)	Delivery (%)
pre-1944	2	2,100	940	45	10	0	0
1945-1962	40	61,030	54,226	89	35,115	18,080	51
-1955 flood-							
1963-1965	7	2,785	2,248	81	1,655	1,323	80
-1964 flood-							
1966-1972	9	6,520	5,560	85	1,215	883	73
-1972 flood-							
1973-1977	17	13,925	13,709	98	17,905	16,493	92
-1975 flood-							
1978-1990	8	40	40	100	14,630	8,498	58
TOTALS	83	86,400	76,723	89	70,530	45,277	64

Plate 6 shows all existing and potential road-related landslides in the Pine Creek study area. Each landslide site is further characterized as delivering, or not delivering, sediment to stream channels.

Measurements from existing road-related landslides in the study area show 54 sites yielding over 76,700 yds³ of sediment to stream channels. Another 45,300 yds³ is expected to be delivered from 60 sites in the future. Thirty six (36) sites show evidence of both past sediment yield and future potential for additional delivery.

Landslides were categorized as either existing debris slides, existing deep seated landslides or potential debris slides. Fifty-four (54) existing debris slides accounted for over 71,500 yds³ of past sediment delivery to streams. Thirty of these sites are expected to yield an additional 27,000 yds³ of sediment in the future if they are left untreated and if they fail.

Potential debris slides, including those from sites that have already partially failed (see preceding paragraph) are expected to yield a total of over 39,600 yds³ of sediment from 56 separate sites. The expected yield from each of these sites is summarized according to the potential size (volume) of each debris slide in Table 8.

The data reveals the volumetric importance of the large debris slides in their total contribution to sediment yield, as compared to the smaller slides. For example, 29% of the potential debris slides identified in the field survey are expected to account for 82% of the future sediment yield from this source.

***Table 8.** Future Sediment Delivery from Potential Debris Slide Sites as a Function of Individual Debris Slide Volume, Pine Creek.*

Volume of Potential Debris Slides	Potential Debris Slide Sites (#)	(% total #)	Volume of Sediment Delivery (yds³)	(% total)
>0 yds³	56	100	39,621	100
>100 yds³	44	79	38,980	98
>500 yds³	16	29	32,540	82
>1000 yds³	10	18	28,440	72

If they are judged to be controllable, these larger slides will be prime candidates for cost-effective erosion prevention treatment. Of the 56 identified potential debris slides threatening future sediment delivery, 35 were judged to be of high or moderate immediacy for treatment. The nine largest of these potential debris slides (26% of the total number), all over 500 yds³ each, are expected to contribute 16,650 yds³ (76%) of the predicted future volume. The remaining 26 sites will deliver an estimated 5,279 yds³.

c. Fluvial Erosion: Stream Crossings and Gullies

1. Causes of Erosion

Stream crossings cause sediment to be delivered to stream channels in a number of different ways. The fill in the crossing may be "washed out" when the culvert plugs or the logs in a Humboldt crossing decay and collapse. This type of failure was found to be common along abandoned roads located in tributaries to Pine Creek. Crossings that may have failed during a large flood were often rebuilt to the same inadequate standards. These sites either failed again, or can be expected to fail in the next significant flood event.

A number of first order streams were never fitted with drainage facilities, and fill material was simply pushed into the channel. These "fill crossings" wash out as soon as severe winter storms generate enough flow to scour the fill in the crossing. Many of the fill crossings built since 1975, the last severe flood, are still largely intact. Older fill crossings are generally in some state of failure.

Finally, stream crossings may cause erosion and sediment delivery by diverting flow out of the natural watercourse channel, and onto and down the adjacent road or hillslope. The diversion typically occurs during a large storm, when the culvert plugs with sediment or woody debris, or the culvert's capacity is exceeded by large discharges. A gully system then develops rapidly in the unprotected ditch and/or on the adjacent hillslope.

The largest gullies develop where discharges are large, soils are fine grained and non-cohesive, slopes are steep, and soils have been exposed by road construction or harvesting activities. Steep gradient reaches are often gullied deeply and on gentler pitches the gully's widths and depths may decrease markedly. Rates of sediment delivery for gully systems from diverted streams are typically very high, often exceeding 80 to 90% of the eroded material.

Plate 5 shows all stream crossings in the Pine Creek study area. Site numbers are labelled, as are symbols designating the type of crossing (culvert, Humboldt, fill, bridge or ford). Stream crossings with a high diversion potential or a high failure potential are also mapped.

2. Erosion and Sediment Delivery from Stream Crossings

In each case, because stream crossings are located directly in the stream channel, the rate of sediment delivery to the channel system is extremely high. That is, sediment eroded from the crossing site is virtually assured of eventually entering the stream channel, being transported through the channel system and being delivered to fish-bearing streams. Sediment delivery may range from an average of 80 to 90% for gully systems caused by stream diversions, to nearly 100% for sediment eroded and washed into and down the channel as a crossing is eroded, or "washed-out."

Erosion and sediment delivery from stream crossings and stream diversions is depicted in Table 9. These figures include only very conservative estimates for erosion associated with potential stream diversions, since predicting gully locations and volumes is an overly complex and time-consuming task for this analysis.

TABLE 9. *Stream Crossing Erosion and Sediment Delivery from all Sheet 1 sites, Pine Creek.*

Year of Construction	Total # of Xing sites w/Delivery	---- Past Processes ---- Erosion (yds³)	Yield (yds³)	Delivery (%)	---- Future Processes --- Erosion (yds³)	Yield (yds³)	Delivery (%)
pre-1944	11	1,580	580	38	895	876	98
1945-1962	48	21,055	18,963	90	9,985	7,208	72
-1955 flood-							
1963-1965	18	1,830	1,830	100	3,930	3,653	93
-1964 flood-							
1966-1972	29	7,595	7,455	98	6,955	6,800	98
-1972 flood-							
1973-1977	16	6,850	6,840	100	3,600	3,576	99
-1975 flood-							
1978-1990	16	265	257	97	3,165	2,658	81
TOTALS	138	39,175	35,925	92	28,530	24,771	87

Significantly, of the 138 identified and mapped stream crossing sites, only 73 were culverted. The remaining 65 included Humboldt crossings (33), fills with no visible drainage facilities (26), bridges (including collapsed bridges) (4), fords (1) and excavated crossings (1). All fill crossings, Humboldt (log) crossings and all culverts on abandoned roads are prime candidates for eventual failure.

Of the unculverted stream crossings, 43 (66%) have partially or completely washed out at least once, 7 (11%) have diverted in the past and fifteen (23%) are still intact. Of the 10 unculverted crossings with a high diversion potential, seven have diverted at least once. Currently, 6 of the streams at these crossings are still diverted. Thirty-eight (38) of the 65 unculverted stream crossings are in some stage of deterioration leading to complete wash-out.

Because of their small drainage areas, gullying from the currently diverted streams at unculverted crossings is expected to deliver less than 500 yds^3 to the stream system. However, delivery volumes for the eventual wash-out of unculverted crossings is expected to total over 11,600 yds^3.

Culverted stream crossings have fared somewhat better than those without adequate drainage facilities, but future erosion from the 73 culverted crossings could still be substantial. Currently, 51 (70%) of the 73 culverted crossings have a high diversion potential, yet only two small streams are now diverted. Over 13,500 yds^3 have been delivered from past washouts, partial washouts and past diversions at 34 of these sites. In the most severe case, a past stream diversion from one crossing delivered nearly 4,000 yds^3 of sediment directly to the main stem of Pine Creek. Another 12,000 yds^3 is estimated as the potential for future sediment delivery from washouts and diversions at these crossings.

In Pine Creek, 60 stream crossings were identified as currently having a high potential for stream diversion. That is, if the culvert (or other drainage structure) plugged, water that then flowed onto the road surface would be diverted down the road or ditch and away from the crossing. If a stream crossing has no diversion potential, streamflow which flows onto the road surface merely flows over the fill and back into the channel. The fill may be washed out, but no gully network develops on the adjacent road or hillslope.

Of the 60 crossings with a high diversion potential (DP), 51 are currently culverted and the remainder are either unculverted fills or Humboldt log crossings. Although some streams (8) are so small that no treatment is recommended, suggestions for constructing rolling dips (40) or excavating the fills (7) are included in a later section. It is very conservatively estimated that over 8,200 yds^3 of sediment could be delivered to Pine Creek and its tributaries during a large storm if the preventive treatments are not performed at these sites. Twenty-eight of the sites (47%) have been given a high or moderate priority for such preventive treatment, saving well over 5,600 yds^3 of sediment from being delivered to the streams.

In addition to stream diversions, stream crossing washouts have been a substantial source of sediment delivered to Pine Creek. They continue to represent a real threat for additional sedimentation, if they are not treated before the next major storm. The field survey revealed 60 stream crossings with a high failure potential. In the past, 48 of these crossings delivered 25,000 yds^3 of sediment to the stream system. Estimates of future yield suggest 59 sites will generate and yield over 14,000 yds^3 of additional material. Failure of the eight culverted crossings in this group alone (52 [87%] of the crossings are unculverted) is expected to yield 4,250 yds^3 of sediment to Pine Creek and its tributaries.

Sites judged to have a high or moderate treatment immediacy include seven culverted crossings, 12 fill crossings, 21 Humboldt log crossings and 2 failing bridges. If left untreated, these washouts are expected to generate and deliver 9,900 yds^3 of sediment to the Pine Creek stream system.

VI. Recommendations for Erosion Prevention and Control

A. Treatment Immediacy

Not all sites that display potential for sediment delivery to stream channels have the same need, or urgency, for treatment. This fact led to the development of criteria for prioritizing all the potential work sites in the basin.

For example, many sites may show potential for substantial future erosion and sediment delivery, but the likelihood of the erosion occurring is low. In some cases, such erosion may be dependent on the occurrence of an extremely large storm. In other cases, the erosion may be imminent, but the site may be a long distance away from a stream channel that could be damaged. In contrast, sites which have a high potential for significant erosion and sediment yield in the near future, or are already contributing erosional products to a stream, would be classified as having a relatively higher need for immediate treatment.

These factors suggest the necessity of having a rational system for determining the relative priority for treatment of sites with future delivery potential. Recognition of site differences, and differences in erosion and sediment delivery potential, led to the development of a rating system based on "treatment immediacy."

In the field, sites were designated as having a *high, moderate or low immediacy of needed treatment*. Table 10 outlines the immediacy of needed treatment for sites in the Pine Creek study area that threaten to deliver sediment to stream channels in the future. Of the 445 inventoried sites, 225 exhibit little or no threat to deliver sediment to streams in the Pine Creek planning area. Approximately half (106) of the remaining 220 sites were classified as having a low treatment immediacy. Only 114 sites were designated as having a high (50) or moderate (64) treatment immediacy, for a total delivered yield of 37,428 yds^3.

TABLE 10. Treatment Immediacy and Future Sediment Delivery of Inventoried Sites in the Pine Creek Study Area.

Year of Construction	Treatment Immediacy: High (#)	High (yds^3)	Moderate (#)	Moderate (yds^3)	Low (#)	Low (yds^3)
pre-1944	0	0	7	696	7	210
1945-1962	14	4,475	27	4,147	45	13,921
-1955 flood-						
1963-1965	6	1,895	3	1,310	14	883
-1964 flood-						
1966-1972	9	3,380	12	2,687	20	1,973
-1972 flood-						
1973-1977	12	13,848	8	1,294	11	3,416
-1975 flood-						
1978-1990	9	2,328	7	1,368	9	7,610
TOTALS	50	25,926	64	11,502	106	28,013

The erosion or failure potential of landslides is a difficult and somewhat subjective determination to make in a field reconnaissance evaluation. Many potential debris slides that were mapped and described in the field have scarps and cracks clearly visible on the ground. Scarps may range from 6" to 6', or more, in height. These scarps were often located along the outside edge of a road's fill prism, but in a number of locations extended across the entire road and involved both the uncompacted road fill as well as a large volume of native hillslope.

On abandoned roads, some scarps appear fresh while others probably formed shortly after the road was abandoned and have not enlarged since then. In some locations, potential debris slides are situated on steep slopes and in wet swales. Other potential instabilities are located on planar, dry slopes that are less conducive to landsliding. All these factors influence the possibility of future slope failure and sediment delivery.

Unlike sediment delivery from potential debris slides, fluvial erosion from stream crossings is predictable and almost entirely preventable. Culverted and non-culverted stream crossing fills can be excavated along roads that cannot be maintained or are to be abandoned for a number of years. Along actively maintained roads, culverts can be sized for the 50-year return period runoff event, Humboldt crossings can be rebuilt with properly sized culverts and stream crossing fills can be "dipped" to eliminate the potential for stream diversion. Trash racks can be installed where culvert plugging by organic debris is likely, and downspouts can be added where culvert outfall flows onto unprotected fill slopes.

Failure to provide proper drainage structures (such as culverts) and to regularly maintain stream crossing facilities will almost assuredly result in eventual crossing failure and washout. Where these factors are found (typically on abandoned roads) the need to perform immediate treatment is high. That is, if the erosion prevention work is not completed, erosion and sediment delivery is assured. Similarly, where culverts are likely to plug and the stream crossing displays a high diversion potential, treatment immediacy is typically judged to be high.

Table 11 outlines, by age of road construction, those 114 sites judged to have high or moderate treatment immediacy. Plate 7 depicts these same sites on a large scale planimetric map of the Pine Creek basin study area. These are the sites that are in greatest need of treatment. Further analysis of treatment costs and effectiveness have been used to place these in final priority order for eventual treatment. The prescriptions and details of costs and access for these sites is included in the next section of this report.

Field measurements suggest that over 41,600 yds^3 of material may erode from these 114 sites and deliver over 37,400 yds^3 to streams if they are left untreated. Forty-one (41) of these sites (15,500 yds^3) represent newly developed or developing erosion sources that have never delivered sediment to streams in the past. The remaining 73 sites have already yielded 27,700 yds^3 of sediment to streams during past erosional events, and threaten to deliver another 21,900 yds^3 in the future unless preventive action is undertaken.

Table 11. *Future Sediment Delivery of Sites with a High or Moderate Treatment Immediacy, Pine Creek.*

Year of Construction	Number of Sites	Sites with High/ Mod.Tmt.Immediacy	Volume of future Delivery (yds^3)
pre-1944	24	7	696
1945-1962	142	41	8,622
1963-1965	71	9	3,205
-1964 flood-			
1966-1972	95	21	6,067
-1972 flood-			
1973-1977	40	20	15,142
-1975 flood-			
1978-1990	73	14	3,696
TOTALS	445	114(26%)	37,428 yds^3

The 114 high and moderate treatment immediacy sites consist of 31 potential debris slides, 74 stream crossings, 4 combined stream crossing/potential debris slide sites and 5 miscellaneous sites (gullies, surface erosion and channel erosion) (Table 12).

Table 12. Breakdown of sites with a high or moderate treatment immediacy, Pine Creek inventory area.

1. Potential Debris Slides	31	20,129 yds^3
2. Stream Crossings	74	14,767 yds^3
3. Combined Slides/Crossings	4	1,800 yds^3
4. Other Sites	5	732 yds^3
TOTAL....	114	37,428 yds^3

Most of the potential debris slides are located along abandoned roads and the typical treatment calls for excavation of the unstable fill material that is reachable using excavating equipment operating on the road prism. Typical treatments for the stream crossings include adding rolling dips to crossings with a high diversion potential that are found along maintained logging roads, and excavating unstable, poorly built or poorly drained crossings found along abandoned roads. For example, 42 of the 77 crossings on abandoned roads do not contain culverts and should be excavated if they are not rebuilt with culverts, and properly maintained.

B. Prescribed erosion control and erosion prevention treatments

1. Types of Prescribed Treatments

Appendix "A" gives generic specifications for the general treatments that have been prescribed for roads in the Pine Creek study area. Recommended treatments range from no treatment or simple waterbarring, to full excavation of unstable sidecast or stream crossing material which has direct access to Pine Creek or its tributaries. Each of the treatments prescribed for roads or hillslopes have been fully tested and evaluated in erosion control and erosion prevention projects in nearby north-coastal watersheds.

a. Heavy equipment operations

The general heavy equipment treatments prescribed for this site, from least intensive to most intensive, include the following:

1. *rolling dip installation/construction* (dipping the roadbed at stream crossings on maintained roads where the diversion potential is high,

2. Installing or cleaning culverts (adding new or larger culverts where they are needed, or cleaning the inlets or outlets of partially plugged culverts on maintained roads).

3. waterbar and cross-road drain construction (installed at 25, 50, or 75 foot intervals to disperse road surface runoff),

4. ripping (surface disaggregation of the roadbed to promote infiltration and reduce runoff),

5. deep dish excavations (partial excavation of road fill that was placed in steep swales; used to reduce the potential for mass failure in channels where erosive storm runoff is unlikely),

6. in-place stream crossing excavations (IPRX) (excavation of fill from stream crossings where erosive runoff is likely during a design size storm; spoil is stored in nearby stable locations where it will not erode, sometimes being pushed up to 300 feet from the crossing by crawler tractor(s),

7. exported stream crossing excavations (ERX) (spoil is moved up to 2000 feet up or down-road from the crossing, due to the limited amount of stable storage locations at the excavation site),

8. in-place outsloping (IPOS) (excavation of unstable or potentially unstable sidecast material along the outside edge of the road prism or landing, and replacement of the spoil on the roadbed against the corresponding, adjacent cutbank, or within several hundred feet of the site),

9. exported outsloping (EOS) (outsloping, as above, where spoil material is moved up to 2000 feet down the road bench to a stable location where there is sufficient room to permanently and safely store the excavated material),

10. filter windrow construction (placing and compacting cut brush, limbs and small logs on contour into bare soil slopes to create local sediment storage sites, disperse surface runoff and reduce rill and gully erosion on the newly treated (excavated) areas.

Each of these prescriptive treatments are described in greater detail in Appendix A, pages A-1 through A-15.

b. Labor intensive erosion control and revegetation treatments Labor intensive erosion control treatments are often needed on sites where heavy equipment has been used to perform preventive excavations. Their use is primarily confined to those measures required to stabilize and revegetate soils exposed by heavy equipment operations. Only the most effective and cost-effective techniques have been prescribed (Appendix A).

Mulching with straw at selected locations, (2 tons per acre application rate, on average) will be especially useful for controlling surface erosion on the bare banks of excavated stream crossings, and where outsloping has exposed bare soil areas near channels. However, large quantities of straw mulch will not be used over widespread areas; straw is prescribed only at locations where bare soil could otherwise be expected to erode and be transported into a nearby stream.

Locally derived mulch materials may also be used to provide protection to soils exposed during heavy equipment operations. Laborers will be expected to use brush and limbs scavenged or thinned from native vegetation at each immediate treatment site for application to the surface. Occasional small logs and tree trunks will be secured to the surface to retard erosion and sediment transport. This work will be accomplished in concert with the heavy equipment operations to minimize costs and improve erosion control effectiveness.

Most bare soil areas near stream channels will be seeded with a mixture of native grasses. Seed from shrubs that are native to the area may be included in the mixture, but local, natural seed sources are probably sufficient to ensure rapid invasion of native woody vegetation at most sites.

2. Logistics and Timing of Project Implementation

a. Project Duration

The duration of each erosion prevention and erosion control "project" will be largely determined by the rate of heavy equipment excavations within each treatment area. Heavy equipment used for excavating crossings and for removing unstable spoil material will last from roughly one to 3.5 weeks, depending upon the treatment area.

This "core" work period will be preceded by up to one week of labor work to import and distribute needed straw mulch and other materials to the treatment area, as well as to open and improve the access roads for the duration of the project. The core work period will, in turn, be followed by up to three to five days to move equipment out, install erosion control structures along the access roads and to make final repairs to the road surface.

b. Project Timing

The 220 sites with high, moderate or low treatment immediacy have been broken into nine treatment areas that contain from 13 to 41 individual sites each (these nine treatment areas are described in greater detail in text, in tables and on maps, below). Each treatment area is designed to stand on its own, but more than one treatment area could easily be completed in a single work season. The number of treatment areas that can be completed in a summer work season will largely be determined by funding levels and equipment availability.

Most of the project areas which contain abandoned roads are designed to be undertaken in the Summer and early Fall months. Access to these sites typically involves stream crossing excavations which are best performed in dry conditions. The two sites involving work on maintained roads (No. 2 Road Treatment Area and Snow Camp/Bald Hills Road Treatment Area) could be worked on during extended dry periods during the winter months, as long as water quality is not impaired.

Typically, work undertaken during extended dry periods during the winter should be subject to winter period operating rules. These might include the following:

1. erosion control measures should be kept up to date, and completed for all newly exposed bare soil areas on a daily basis when the chance of rain is 30% or greater for the following day,

2. labor intensive erosion control work should never lag more than two days behind heavy equipment operations,

3. erosion control measures on roads (eg, waterbarring) should be kept up to the equipment prior to each weekend,

4. if it rains, work will not re-commence until the soils have dried sufficiently to prevent damaging erosion.

c. Heavy Equipment Needs

The following pieces of heavy equipment constitute the most efficient and cost-effective combination for erosion prevention work on treatment areas in Pine Creek. In general the largest sized machines that can logistically operate on the various road surfaces will be the most efficient pieces of equipment for performing the erosion prevention excavation work. The following general categories of heavy equipment will be needed to perform work at most sites.

1. hydraulic excavator, track driven, minimum 35 foot surface reach, minimum 2.0 - 2.5 cubic yard bucket, maximum 12-13 foot outside track width,

2. track driven dozer; D-7, D-8, or equivalent, late model, preferable power angle/tilt U-blade with 6-way motion, hydraulic winch or hydraulic ripping attachment,

3. dump trucks, locking differential (all wheel drive), 10 yds^3 capacity.

4. backhoe, wheeled with extendable boom.

d. Material Needs
A wide variety of material will be utilized in the conduct of these projects. Materials and supplies will include:

1. Eighty pound bales of straw for mulching,

2. Native or other suitable annual grass seed,

3. If desired, Simplot 16-20-0 dry, homogenized, pelletized fertilizer,

4. flat bed 1 ton (or greater) long bed 4x4 truck to transport straw, laborers and other materials

5. Commercial belly grinders to spread seed and fertilizer

6. Brush cutting tools and equipment

7. Shovels and other hand tools for erosion control work

8. Miscellaneous tools, equipment and supplies needed to provide final layout of equipment prescriptions and to conduct project supervision (flagging, spray paint, measuring tapes, film (for documentation), mylar film and other drafting supplies, water bottles, packs, safety and emergency first aid supplies, etc.)

e. Personnel Needs
Personnel are needed to operate the heavy equipment, perform the hand labor erosion control work and to coordinate and supervise both the heavy equipment and labor activities. Basic personnel needs for the conduct of this project are as follows:

1. *Excavator and dozer operators*, preferably experienced in similar erosion control projects involving sidecast and stream crossing excavations along narrow, mountainous roads,

2. *Laborers* (2 to 4 per excavator/tractor pair) to transport and spread straw, cut and place brush mulch, spread seed and fertilizer, punch straw and perform manual excavations and clean-up,

3. *Project coordinators/supervisors* to lay out and coordinate specific heavy equipment and labor intensive tasks at each work site; arrange for logistics (seed, fertilizer, mulch, heavy equipment, etc); monitor, track and supervise project and work progress; and issue final completion report.

C. Treatment Areas

Potential work sites in the Pine Creek basin have been divided into nine (9) logical treatment areas, incorporating all 220 work sites displaying either high, moderate or low treatment immediacy (priority)(Table 13). The nine treatment areas contain sites that, when combined, are limited in scope (to accommodate annual funding levels), and are in relatively close, or interconnected, proximity (for logistic purposes and to minimize transportation costs).

Table 13. Treatment Areas in the Pine Creek Study Area.

Treatment Area	Total No. of Sites	No. of Sites to be Treated	Volume of Sediment to be Saved (yds^3)
1. Upper Snow Camp Creek	13	11	2,140
2. Lower Snow Camp Creek	14	4	1,075
3. Little Pine Creek	27	22	8,995
4. Lower Pine Creek	20	10	10,782
5. Bald Hill/Snow Camp Roads	35	24	2,633
6. Pine "G"	17	16	4,521
7. No. 2 Road	41	31	9,000
8. No. 2 Road Spurs	33	26	4,779
9. Misc. Sites	20	6	1,485
Summary	220	150	45,410

Each of the treatment areas contain sites that are of high, moderate and low treatment immediacy. The minimum volume of sediment that will be prevented from entering Pine Creek and its tributaries, as a result of the erosion prevention and erosion control work on all nine treatment areas, will be in excess of 45,000 yds^3 (Table 13).

The detailed locations of treatment sites are outlined on maps of each of the nine treatment areas (Maps 2 - 7 and Maps 8A - 8D). In addition, each treatment area is described by a summary table of information which outlines the following data for each site within the area:

1. Road name (location of, or access to, the site),
2. Maintenance status of road up to that site (abandoned = Yes or No),
3. Site number,
4. Aerial photograph (1990) containing original mapping on mylar overlay,
5. Treatment recommendation (Yes, Yes?, No?, No),
6. The judged potential for future erosion at the site (High, Moderate, Low),
7. The relative urgency of treating the site (Immediacy = High, Mod., Low),
8. Treatment type
    - IPOS - in-place outsloping (excavation)
    - EOS - exported outsloping (excavation and endhauling)
    - IPRX - in-place stream crossing excavation
    - ERX - exported stream crossing excavation (and endhauling)
    - XRD - construct cross-road drain or deep dish drain
    - RD - construct rolling dip on maintained road
    - OTHER- other treatment, as detailed in text of data base
9. Base hydraulic excavator time (hrs) to treat the site,
10. Base crawler tractor time (hrs) to treat the site,
11. Other notes on equipment needs, as outlined in the text,
12. Future volume of erosion (yds^3) expected if site is left untreated,
13. Future volume of sediment delivered (yds^3) to streams, if these sites are left untreated, and
14. Expected volume of sediment prevented from entering streams as a result of completing this work.

Additional descriptive and quantitative information related to site treatments and site characteristics are included on the treatment page of the database form for each of the 220 sites where treatments have been recommended. Much more data was also collected for each site, and this information is included in the computerized database and on the printed database forms for each of the 445 sites inventoried in Pine Creek (see Appendix C).

It should be noted that virtually all abandoned roads within the nine treatment areas access regions of the basin where little or no commercially viable timber exists. Excavation of failing stream crossings on these abandoned roads will help protect these routes from severe damage during major storms and floods. If these roads are needed for future management when second growth timber is ready for commercial thinning or harvest, stream crossings can be temporarily or permanently rebuilt to current standards.

1. Upper Snow Camp Creek Treatment Area

Location

The Upper Snow Camp Creek Treatment Area (Map 2; see end of treatment section for large scale treatment area maps) consists of 13 identified sites in watersheds tributary to Snow Camp Creek (Table 14). Most sites are located along spurs to Snow Camp Road. Two sites, located on a tributary to Snow Camp Creek, are accessed from Bloody Camp Road near the watershed divide. Sites within this treatment area were mapped on 1990 aerial photographs 4-19, 4-21 and 5-21. Four of the sites are found on abandoned roads.

Treatments

Eleven of the 13 sites within this treatment area are recommended for physical erosion prevention or erosion control treatment (Table 14). The two sites that are not recommended for treatment include a small (170 yds^3) potential debris slide that would be difficult and very costly to access and has a moderate-to-low failure potential (Site 845). In addition, a pre-existing debris slide along the same remote, abandoned, spur road (Site 846) has no future potential for sediment delivery and will not be treated.

Table 14 lists the basic treatments prescribed for the remaining eleven sites. Some of the treatments are simple and inexpensive. These include checking on the stability of an existing log bridge (#815), installing rolling dips to prevent stream diversions during future flood events (#823, #835), or repairing or replacing failing culverts (#820, #836, #839). Other treatments involve more substantial work including the excavation of stream crossings on abandoned roads (#842, #864) and the excavation of unstable fill material along maintained (#840, #841) and abandoned (#865) roads.

By effectively treating these eleven sites, a total of 2,140 yds^3 will be prevented from entering the Pine Creek stream system.

Equipment Needs

Equipment needs are expressed in the database as direct excavation times, in hours. These hourly estimates include only the time needed to treat each of the sites, and do not include travel time between work sites, the time needed to reconstruct or clear roads which have been abandoned for years, or the time needed for work conferences at each site. These additional times are accumulated and added to the work times to determine total equipment costs as shown in Table 15.

Completion of eleven work sites in the Upper Pine Creek Treatment Area will require approximately 37 hours of hydraulic excavator time and 30 hours of crawler tractor time. A standard backhoe may be needed for 2 hours to assist in the installation of a culvert downspout at Site #836.

Estimated Costs

At $100/hr and $80/hr for the excavator and cat, respectively, treatment costs would be $6100. In addition, approximately $100 may be required for backhoe work at site #836. Total project treatment costs of $11,100 will yield a cost-effectiveness value of approximately $5.18 per cubic yard of sediment kept from entering the stream system. All peripheral costs including layout, equipment move-in and move-out, supervision, hand labor, road rebuilding, travel times between work sites, conference times, and final reporting are included in the final costs. Only materials for mulching and seeding have been omitted from the calculations. These items are not expected to add significantly to project costs.

Table 14. EROSION PREVENTION AND EROSION CONTROL SITE DATA
UPPER SNOW CAMP CREEK TREATMENT AREA, PINE CREEK

Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
PINE J RD OFF SNOW CAMP 7.29	N	835	04-19	Y	L	M						Y	Y	0.0	2.0		100	100	100
	N	836	04-19	Y	L	L							Y	0.0	0.0	Y	150	150	150
	N	839	04-19	Y	L	M,L						Y	Y	0.0	1.0		200	200	200
	N	840	04-19	Y	H	H,M		Y						2.5	2.5		150	75	75
SNOW CAMP ROAD OFF B.H.E.	N	815	04-21	Y	M	H							Y	0.0	0.0		75	75	75
	N	820	04-21	Y	H	H							Y	4.0	0.0		200	200	200
	N	823	04-21	Y	L	L						Y	Y	0.0	1.5		100	100	100
SPUR 6.03;SNOW CAMP ROAD	N	841	4-21	Y?	M,H	H,M	Y							1.5	1.5		135	135	135
	N	842	4-21	Y	M,H	H,M				Y				13.0	13.0		660	660	660
SPUR OFF BLOODY CAMP ROAD	Y	864	5-21	Y?	L	L			Y					1.0	1.0		25	25	25
	Y	865	5-21	Y	H	H	Y							6.0	0.0		420	420	420
SUBSPUR TO SPUR 4.85;SNOW C.	Y	845	4-21	N	M,L	M,L											340	170	
	Y	846	4-21	N	L	L											0	0	
Count:	5	13					2	1	1	1	0	3	6						
Total:														28.0	22.5		2,555	2,310	2,140

Table 15. Estimated logistic requirements and costs for the Upper Snow Camp Creek Treatment Area.

Cost Category[1]	Cost Rate ($/hr)	---Estimated Project Times--- Treatment[2] + (hours)	Logistics[3] = (hours)	Total (hours)	Total Estimated Cost ($)
1. Move-in; Move-out (Low Boy expenses)	50	--	18	18	900
2. Heavy Equipment					
D-7 Tractor	80	23	7	30	2400
Excavator	100	28	9	37	3700
Dump Trucks	50	--	--	--	----
Backhoe	50	--	--	--	----
3. Laborer(s)	15	40	--	40	600
4. Layout, Coordination Supervision, Reporting[3]	50	70	--	70	3500
TOTAL COST					$11,100

[1] Costs for culvert materials have not been included in these estimates. Costs for mulching and related materials (grass seed, fertilizer and straw) are not included, but are expected to be fairly small components of each project (estimated $500 - $1000).

[2] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[3] Logistic times include all equipment hours expended for opening access to sites on abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies.

[4] Supervision time includes 1 person-days for detailed layout (flagging, etc) prior to equipment arrival, supervision during equipment operations, and 2 person-days for post-project documentation and reporting.

2. Lower Snow Camp Creek Treatment Area

Location

The lower Snow Camp Creek treatment area consists of 14 potential work sites in the lower Snow Camp Creek basin (Map 3). The work sites are located along an abandoned logging road constructed on inner gorge slopes above Snow Camp Creek between 1955 and 1962. Most of the landsliding that occurred along the road was triggered during the 1964 flood. Numerous slopes along the inner gorge failed and a minimum 23,000 yds^3 of sediment was delivered from landsliding at these same sites.

It is estimated that another 12,000 yds^3 will be delivered sometime in the future, probably in response to a large winter storm. Unfortunately, the largest potential contributors to future erosion and sediment yield are several very large, deep seated landslides that cannot be cost-effectively controlled. They appear to have been largely stable since their last movement approximately 20-30 years ago (as evidenced by undisturbed conifer regrowth on their surfaces). However, the existence of large, continuous scarps on both their lateral margins and in the head region still portends potential failure and sediment delivery.

The logging road which was constructed into this inner gorge area was abandoned shortly after logging along the steep slopes was completed. Since then, numerous hillslope failures and streamside landslides have removed many segments of the road. Future access to most of the identified sites would require extensive road reconstruction.

Therefore, because of 1) difficult access, 2) high costs of road reconstruction, 3) low-to-moderate erosion potential (many of the slides have been "stable" since 1964), and 4) the existence of deep seated, difficult-to-control landslides, this treatment area has been designated of lower overall immediacy than many of the other areas. Treatment at this location will be deferred until other, higher priority treatment areas have been addressed.

Treatments

Only four of the 14 identified sites in the Lower Snow Camp Creek Treatment Area have been suggested for tentative treatment (Table 16). These include excavation of two stream crossings (#850, #851) near the beginning or the road, excavation of a 500 foot length of road fill that still threatens to fail into Snow Camp Creek (#856), and outsloping of approximately 200 feet of vertical channel bank near the confluence of Snow Camp Creek with its major tributary at the end of the road (see Map 2).

The first two sites are very small, and the later two sites would require considerable road reconstruction to access and therefore are of lower overall priority. The total volume of sediment to be prevented from entering Snow Camp Creek from these four erosion prevention projects is approximately 1,000 - 1,500 yds^3.

Equipment Needs

Approximately 38 hours hydraulic excavator and 46 hours crawler tractor time would be needed for direct excavation at the four identified work sites (Table 17). The excess tractor time would be needed to open access and reconstruct the road past the existing landslides. If the large, quasi-stable landslides were to be excavated near their headscarps, considerable dump truck time would also be needed for endhauling 800 feet to the nearest stable landing.

Logistics
Treatment of sites #850 and #851 would require only minimal road reconstruction to access. Site #853 is the first of a number of deep seated landslides with scarps up to 7 ft high crossing and disrupting the road bench for up to 100 lineal feet. Access beyond this point would require major road reconstruction.

Estimated Costs
At $100/hr and $80/hr for the excavator and cat, respectively, treatment costs would approach $11,900, for a miserable cost-effectiveness value of $8.00 per cubic yard kept from entering the stream system. Road rebuilding and access costs drive up the unit costs for this site. This site will not be undertaken until other, more cost-effective projects are undertaken.

Table 16. EROSION PREVENTION AND EROSION CONTROL SITE DATA
LOWER SNOW CAMP CREEK TREATMENT AREA, PINE CREEK

Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
SPUR 1.92, SNOW CAMP ROAD	Y	850	3-19	Y?	H	M,L			Y					1.0	1		75	75	75
	Y	851	3-19	Y?	L,M	M,L			Y					0.5	1		40	30	30
	Y	852	3-19	N	L	L											1,100	440	
	Y	853	3-19	N?	L	L											4,400	1,760	
	Y	854	3-19	N?	L,M	L											17,000	8,500	
	Y	855	3-19	N	L	L											0	0	
	Y	856	3-19	Y?	L	L	Y							10.0	10		1,900	570	570
	Y	857	3-19	Y?	H,M	M,L	Y			Y				20.0	20		400	400	400
	Y	858	3-19	N?	H	H,M			Y								100	100	
	Y	859	3-19	N	L	L											0	0	
	Y	860	3-19	N	L	L											100	0	
	Y	861	3-19	N	L	L											0	0	
	Y	862	3-19	N?	H	M,L			Y								125	113	
	Y	863	3-19	N	L	L											0	0	
Count:	1	14					2	0	4	1	0	0	0						
Total:														31.5	32		25,240	11,988	1,075

Table 17. Estimated logistic requirements and costs for the Lower Snow Camp Creek treatment area.

Cost Category[1]	Cost Rate ($/hr)	---Estimated Project Times--- Treatment[2] + (hours)	Logistics[3] = (hours)	Total (hours)	Total Estimated Cost ($)
1. Move-in; Move-out (Low Boy expenses)	50	--	16	16	800
2. Heavy Equipment					
D-7 Tractor	80	32	14	46	3700
Excavator	100	32	6	38	3800
Dump Trucks	50	--	--	--	----
Backhoe	50	--	--	--	----
3. Laborer(s)	15	40	--	40	600
4. Layout, Coordination Supervision, Reporting[3]	50	60	--	60	3000
TOTAL COST					$11,900

[1] Costs for culvert materials have not been included in these estimates. Costs for mulching and related materials (grass seed, fertilizer and straw) are not included, but are expected to be fairly small components of each project (estimated $500 - $1000).

[2] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[3] Logistic times include all equipment hours expended for opening access to sites on abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies.

[4] Supervision time includes 1 person-days for detailed layout (flagging, etc) prior to equipment arrival, supervision during equipment operations, and 1 person-days for post-project documentation and reporting.

3. *Little Pine Creek Treatment Area*

Location

The Little Pine Creek Treatment Area consists of 27 sites located on lower hillslopes along Little Pine Creek near the northwest corner of the Hoopa Square (Map 4). The original mapping for the treatment area is found on mylar overlays of aerial photographs #1-5 and #2-11.

Most of the Little Pine Creek watershed is on private land outside and upstream from the Hoopa Square. Private lands in the watershed have been heavily impacted by past timber harvesting and road construction during the 1960's and early 1970's. Numerous road-related debris slides, washed out stream crossings, stream diversions (and resultant gullies), and large stream-side debris slides can be seen on aerial photographs of the basin. The main channel passing through the square has been heavily impacted by large influxes of sediment from adjacent and upstream lands.

In addition, a number of stream-side landslides occurred along lower portions of Little Pine Creek, in the Hoopa Square, during the 1964 storm and storms in 1972 and 1975. These sources were a consequence of heavy aggradation in the main channel at the base of the slope, together with timber removal from the stream-side zones. Sediment delivered to the stream system from past road-related erosion sources in the lower basin totalled 5,000 yds^3. This was probably only a fraction of the input from stream-side landslides in the same reach. Over half of the inventoried volume of sediment came from two landslides that no longer represent potential sediment sources. By treating 22 of the potential work sites identified for this treatment area, it is estimated that at least 9,000 yds^3 of sediment will be prevented from entering Little Pine Creek in the future (Table 18).

Treatments

The site treatments are evenly split between stream crossing excavations and excavations of unstable fill at potential landslide locations (Table 18). However, over half of the predicted future yield volume (5,400 yds^3) will be addressed by landslide treatments at two locations (site #533 and #630). Both these sites were identified as having a high erosion potential and a high treatment immediacy during field inventory and mapping.

In spite of the large volumes of material to be moved from several of the treatment sites, only one site (#630) will require endhauling a portion of the spoil material. A local terrace 800 feet down the road will provide adequate storage space for this potential landslide debris.

Table 18. EROSION PREVENTION AND EROSION CONTROL SITE DATA
LITTLE PINE CREEK, PINE CREEK

Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
0.01 SPUR OFF BALD HILL WEST	Y	630	02-11	Y	H	H		Y						32.0	32.0	Y	3,000	2,700	2,700
0.59 SPUR ON BALD HILL WEST	Y	612	02-11	Y	M	M			Y					0.0	1.5		60	60	60
	Y	615	02-11	Y?	M	L			Y					1.0	1.0		70	70	70
	Y	616	02-11	N	L	L											200	0	
	Y	617	02-11	N	L	L											1,000	0	
	Y	618	01-05	N	L	L											50	0	
	Y	619	01-05	Y?	L	L			Y					3.0	4.0		200	200	200
	Y	621	01-05	Y?	M	L			Y					1.0	1.0		50	50	50
LITTLE PINE CK (201) RD	N	521	01-05	Y	H	H							Y	1.0	1.0	Y?	75	75	75
	N	522	01-05	Y	M	M						Y		0.0	1.0		100	100	100
	N	524	01-05	Y	H	M	Y							2.0	2.0		150	75	75
	N	525	01-05	N	L	L											0	0	
	N	536	01-05	Y	H	H	Y							4.0	4.0		350	350	350
SPUR @1.72, LITTLE PINE 201 RD	Y	527	01-05	Y	H	H	Y		Y					5.0	2.5		125	125	125
	Y	528	01-05	Y	L	M			Y					3.0	3.0		600	600	600
	Y	529	01-05	Y	H	H	Y							3.0	2.0		160	160	160
	Y	530	01-05	Y	H	M			Y					2.5	2.5		100	100	100
	Y	531	01-05	N	L	L											20	20	
	Y	532	01-05	Y	M,H	H,M	Y							4.0	4.0		300	180	180
	Y	533	01-05	Y	H	H	Y							30.0	34.0		2,700	2,700	2,700
	Y	538	02-11	Y	M	ML			Y					3.0	4.0		300	300	300
	Y	539	02-11	Y?	H	L			Y					1.0	1.0		40	40	40
	Y	540	02-11	Y	M	M	Y							3.0	3.0		300	150	150
	Y	541	02-11	Y	H	M,L			Y					2.0	1.0		100	100	100
	Y	542	02-11	Y	H	M			Y					2.0	2.0		75	75	75
	Y	543	02-11	Y?	L	L	Y							8.0	9.0	Y?	1,100	660	660
	Y	544	02-11	Y	H	M,L			Y					2.0	3.0		125	125	125
Count:	4	27					8	1	12	0	0	1	1						
Total:														112.5	118.5		11,350	9,015	8,995

Twelve stream crossings are recommended for excavation on roads which are currently abandoned and are not expected to be used for timber operations in the near future. Work at these sites will prevent approximately 1,850 yds^3 of sediment from being delivered to Little Pine Creek and its tributaries, through the physical excavation of 1,620 yds^3 of material.

In addition, nine excavations are recommended for unstable fill material that threatens to fail and deliver sediment to Little Pine Creek. Work at these nine sites will require the excavation of approximately 7,800 yds^3 of material to prevent that sediment from entering the stream system.

Equipment Needs

The Little Pine Creek Treatment Area will require approximately 143 hours of excavator time and 155 hours of crawler tractor time to complete work at the 22 recommended treatment sites (Table 19). In addition, approximately 113 hours of dump truck time (Site #630) will be needed to endhaul material to stable storage locations. Site #543 may also need a small amount of dump truck time (10 hours) if local storage becomes limiting.

Logistics

Only five of the sites are located on maintained, drivable roads. However, the remaining 22 sites are found on abandoned roads that will require only brushing or minor reconstruction to provide access the work sites. Site #630, the only work location on a short, abandoned spur road near the mouth of Little Pine Creek, is logistically separated from the rest of the work sites. This will simplify (eliminate) the task of having to coordinate timing of dump truck endhauling with equipment work at other sites in the treatment area.

The old stream crossing of Little Pine creek should not be reopened for this erosion prevention project. Sites to the north of Little Pine Creek (#621 - #612; see map 4) should be treated in that order, progressing from the end of the spur road to its intersection with the Bald Hills Road. Sites to the south of Little Pine Creek (#521 - #544) should be treated from access roads found on that side of the basin. As always, dead end, abandoned, spur roads should be treated from the end to their junction with maintained roads.

Estimated Costs

At $100/hr and $80/hr for the excavator and cat, respectively, treatment costs would be $26,700. In addition, approximately $5,650 will be required for endhauling (dump trucks) on the spur road at site #630. Complete treatment costs of $46,200 yields a cost-effectiveness value of $5.10 per cubic yard kept from entering the stream system. Road rebuilding and access costs are included in this cost estimate. Total cost-effectiveness values should remain at or below $5.00/yds^3 for the Little Pine Creek Treatment Area.

Table 19. Estimated logistic requirements and costs for the Little Pine Creek Treatment Area.

Cost Category[1]	Cost Rate ($/hr)	---Estimated Project Times--- Treatment[2] + (hours)	Logistics[3] (hours)	= Total (hours)	Total Estimated Cost ($)
1. Move-in; Move-out (Low Boy expenses)	50	--	32	32	1600
2. Heavy Equipment					
D-7 Tractor	80	120	35	155	12,400
Excavator	100	113	30	143	14,300
Dump Trucks	50	90	23	113	5,650
Backhoe	50	---	--	---	----
3. Laborer(s)	15	150	--	150	2,250
4. Layout, Coordination Supervision, Reporting[3]	50	200	--	200	10,000
TOTAL COST					$46,200

[1] Costs for culvert materials have not been included in these estimates. Costs for mulching and related materials (grass seed, fertilizer and straw) are not included, but are expected to be fairly small components of each project (estimated $1000 - $1500).

[2] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[3] Logistic times include all equipment hours expended for opening access to sites on abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies.

[4] Supervision time includes 2 person-days for detailed layout (flagging, etc) prior to equipment arrival, supervision during equipment operations, and 2 person-days for post-project documentation and reporting.

4. Lower Pine Creek Treatment Area

Location

The Lower Pine Creek Treatment Area is a large unit that encompasses 20 sites located on three abandoned spur roads off the Bald Hills Road (Map 5). These spur roads approach a steep, deeply incised perennial tributary to Pine Creek that has received huge volumes of sediment in the past. The original mapping for all the units is contained on the mylar overlay of 1990 aerial photograph #2-13.

The lowest of the spur roads (lower spur, Spur @ 0.34), built prior to 1962, crossed the channel and continued parallel on the lower hillslopes along Pine Creek for 0.5 mile. The Upper spur (Spur @ 1.26) was also built to access a tractor clearcut prior to 1962.
The middle spur road (upper spur off Spur @ 0.34) was constructed prior to 1977 (see Map 5) and thus escaped the 1964 flood.

The sites which show the greatest past erosion and sediment delivery, as well as those which still display the greatest potential for future erosion and sediment delivery, are underlain by deeply weathered, sheared black schist. The soil materials are very unstable and are saturated for much of the year. Soil mottling, active springs, hydrophytic vegetation and other signs of abundant moisture, combined with steep slopes, attest to the potential instability of the soil materials.

Treatments

Over 37,000 yds^3 of sediment has been delivered to the stream system, and to Pine Creek, as a result of erosion along the roads in this treatment area. Another 14,650 yds^3 are expected to be delivered if preventive treatments are not employed (Table 20).

Of the 20 sites identified in this treatment area, ten (10) are targeted for future treatment. Addressing these ten will prevent the introduction of up to 10,800 yds^3 of sediment to Pine Creek and its tributaries. Virtually all the identified work sites in this treatment area involve the excavation of unstable fill and hillslope materials that threaten to deliver sediment to the streams. Stream crossings along these abandoned roads are typically a small subset of larger existing or potential hillslope failures which will require excavation to stabilize.

Because of the extremely wet slopes and road materials along the later portion of the middle spur road, all excavated material from four work sites (#651, #652, #653, #655) will have to be endhauled approximately 1000 feet to be deposited along dry sections of the roadbed. Use of two to four dump trucks to transport approximately 5000 yds^3 will increase work site costs for this section of the hillslope. This particular site, because of high soil moisture, will need to be treated near the end of the dry summer months. It should be field checked before equipment is committed to the site.

Equipment Needs

The Lower Pine Creek Treatment Area will require approximately 162 hours of excavator time and 156 hours of crawler tractor time to complete work at the ten treatment sites. In addition, approximately 240 hours of dump truck time will be needed to endhaul material away from wet sites where local disposal is not possible.

Logistics

All three spur roads in this treatment area have been abandoned since at least 1977. All three of the spur roads would require "major road reconstruction" to access the most remote of the treatment sites.

Major reconstruction implies that the road is washed out at one or more stream crossings, or there are large scarps crossing the road alignment which would have to be regraded to provide access to trucks and equipment. The reconstruction work needed to pass each of the sites in this treatment area is fairly straight forward and should not require significant additional time to accomplish.

Endhauling on the middle roads will require close coordination to ensure that trucks are as efficient as possible in their runs to the disposal sits. Reconstruction will entail developing several wide spots along the road for passing and pull-out lanes.

Estimated Costs

At $100/hr and $80/hr for the excavator and cat, respectively, and $50/hr for the dump trucks, direct equipment costs exceed $40,000. Total treatment costs of 54,280 will yield a cost-effectiveness value of $5.00 per cubic yard kept from entering the stream system. Road rebuilding and access costs are included, as are supervision, manual labor and move-in and move-out costs.

Table 20. EROSION PREVENTION AND EROSION CONTROL SITE DATA
LOWER PINE CREEK TREATMENT AREA, PINE CREEK

Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
0.34 SPUR OFF BALD HILL W.	Y	634	02-13	Y	H	H	Y							12.0	24		1,000	800	800
	Y	635	02-13	N	L	L											25	25	
	Y	636	02-13	Y	H	H,M	Y							20.0	25		1,800	1,620	1,620
	Y	637	02-13	Y	MH	M	Y							3.0	2		225	79	79
	Y	638	02-13	Y	M	M	Y							7.0	4		600	210	210
	Y	640	02-13	N	M	L											500	0	
	Y	644	02-13	N	L	L											0	0	
	Y	646	02-13	N	L	L											0	0	
	Y	647	02-13	Y?	M	M	Y							6.0	6		500	500	500
SPUR @ MP1.26, BALD H. W.	Y	658	2-13	N	L	L											100	100	
	Y	659	2-13	N	M,L	L											200	200	
	Y	660	2-13	N	L	L											100	100	
	Y	661	2-13	N	L	L											150	150	
SPUR/SPUR @ MP.34,BALD H. W.	Y	649	2-13	N	H	L											1,500	1,500	
	Y	650	2-13	N	H	L											1,800	1,800	
	Y	651	2-13	Y	H	M		Y		Y				2.5	1	Y	200	200	200
	Y	652	2-13	Y	H	H		Y						10.0	0	Y	450	338	338
	Y	653	2-13	Y	H	H,M		Y						25.0	0	Y	5,000	5,000	5,000
	Y	654	2-13	Y	M	M,L	Y		Y					10.0	10		275	275	275
	Y	655	2-13	Y	H,M	H,M		Y						27.0	27	Y	2,200	1,760	1,760
Count:	3	20					6	4	1	1	0	0	0						
Total:														122.5	99		16,625	14,657	10,782

Table 21. Estimated logistic requirements and costs for the Lower Pine Creek Treatment Area.

Cost Category[1]	Cost Rate ($/hr)	---Estimated Project Times--- Treatment[2] + (hours)	Logistics[3] = (hours)	Total (hours)	Total Estimated Cost ($)
1. Move-in; Move-out (Low Boy expenses)	50	---	16	16	800
2. Heavy Equipment					
D-7 Tractor	80	120	36	156	12,480
Excavator	100	125	37	162	16,200
Dump Trucks	50	200	40	240	11,600
Backhoe	50	--	--	--	----
3. Laborer(s)	15	180	--	180	2,700
4. Layout, Coordination Supervision, Reporting[3]	50	210	--	210	10,500
TOTAL COST					$54,280

[1] Costs for culvert materials have not been included in these estimates. Costs for mulching and related materials (grass seed, fertilizer and straw) are not included, but are expected to be fairly small components of each project (estimated $1000 - $1500).

[2] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[3] Logistic times include all equipment hours expended for opening access to sites on abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies.

[4] Supervision time includes 2 person-days for detailed layout (flagging, etc) prior to equipment arrival, supervision during equipment operations, and 3 person-days for post-project documentation and reporting.

5. *Bald Hill/Snow Camp Roads Treatment Area*

Location

The Bald Hill/Snow Camp Roads Treatment Area contains 35 sites stretching across the lower Pine Creek watershed (Map 6). All sites are located either on the Bald Hills Road or on the Snow Camp Creek Road. Both routes are maintained as permanent through-going logging roads, and the all-weather Bald Hills Road is surfaced with rock. Snow Camp Creek Road is a lower standard surface, often being single lane and displaying numerous sections that are muddy and soft during the winter months.

For the purposes of this report, both these road systems are classified as permanent, maintained roads that will remain a part of the permanent road network. Both roads are active and maintained. For this reason, our erosion control and erosion prevention recommendations call for local upgrading of drainage facilities and other improvements that will help erosion-proof the roads for future storms.

The Bald Hills Road, east of the Pine Creek Bridge, was constructed prior to 1944. Most of the remaining roads in the treatment area were built by 1962. Only a short section of the western portion of the Bald Hills Road was constructed since 1975. Thus, the bulk of the stream crossings and fill-slopes on these roads have endured the largest storms and floods of the last three decades. Those features that were unstable after construction likely failed, and have since been rebuilt. The road-bed and drainage structures along these routes are now largely stable. Future erosion and sediment yield to be expected from these roads might, therefore, be less than from comparable lengths of newer road.

At a minimum, past delivery from road-related erosion sources in the Bald Hill/Snow Camp Roads Treatment Area total 8,800 yds^3. One stream diversion (Site #719; 3,950 yds^3) and one past debris slide (Site #627; 1600 yds^3) account for 63% of the measured yield from this treatment area. Future erosion predicted from this treatment area is expected to be approximately 3,300 yds^3 of sediment.

Treatments

Our recommendations for this treatment area involve upgrading and erosion proofing the permanent road system to prevent future erosion and sediment delivery to Pine Creek. If left unattended and untreated through one or more large floods in the future, an estimated 3,300 yds^3 of sediment would be eroded. Nearly 3,100 yds^3 of sediment could be directly delivered to the channel system of Pine Creek. Treatment of the 24 treatable sites on the Bald Hills Road, Snow Camp Creek Road and four spur roads will prevent the introduction of over 2,600 yds^3 of sediment to Pine Creek (Table 22).

Eight stream crossings on abandoned roads are recommended for excavation, until such time as these dead-end spurs are again needed for access to timber (Table 22; Map 6). All of the stream crossings are small and each will require less than 3 hours of excavator time to complete. Similarly, the resultant volume of sediment prevented from entering the stream system from these crossings barely exceeds 700 yds^3.

Relatively small excavations of unstable road fill will be accomplished at five sites and prevent the discharge of nearly 750 yds^3 of sediment to channels. Two of these sites (#507 and #811) will require endhauling to dispose of the spoil materials.

The remaining work prescriptions involve the construction of cross road drains on abandoned roads, building rolling dips at selected locations on maintained roads, and installing drainage improvement structures at existing culverts. Recommendations which call for installing rolling dips in the road bed are aimed at preventing future stream diversions in the event of culvert plugging. Typically, at these same sites, recommendations are included for culvert installation, cleaning culvert inlets, adding downspouts, or other maintenance/improvement items.

Equipment Needs

The Bald Hills/Snow Camp Creek Treatment Area will require approximately 61 hours of excavator time and 56 hours of crawler tractor time to complete work at the 24 recommended treatment sites (Table 23). Little endhauling (perhaps 5-10 total hours of dump truck time) will be necessary. Hand labor will be required to assist in culvert cleaning, culvert installation and culvert improvement work at sites on maintained roads.

Logistics

This a very large and sprawling treatment area. As a result, travel times between work sites will be higher than in other treatment areas. Sixteen of the 24 treatment sites are located on maintained roads and spur roads, thereby providing easy access to work locations. Installation of rolling dips on the Bald Hills Road will, in many cases, require an extra 15 minutes at each site because of the extra road width. Most treatments on maintained roads can be performed without closing the roads to through-traffic. A few new culverts will have to be installed to prepare the road for large storms.

The other eight sites (#605-#609, #625, #719-#720), located on abandoned spur roads, will require brush clearing or minor reconstruction for equipment to reach and treat the potential erosion problems. In general, stream crossings on those abandoned roads that have no near-term timber reserves are recommended for excavation. If the roads are ever needed again, the crossing sites can be easily rebuilt.

Estimated Costs
At \$100/hr and \$80/hr for the excavator and cat, respectively, treatment costs would be \$11,100 (Table 23). Costs for limited dump truck and backhoe use (total approximately 10 hrs each @ \$50/hr) will add approximately \$500 to project costs. Additional costs will be incurred for hand labor and materials associated with culvert and drainage improvements on maintained roads.

Full project costs of \$17,300 will yield a cost-effectiveness value of \$6.60 per cubic yard kept from entering the Pine Creek stream system. Road rebuilding and travel time between sites increased costs somewhat since the roads are long and the sites are sometimes far between. Total cost-effectiveness values should remain well below \$7.00/yds^3 for the Bald Hill/Snow Camp Creek Treatment Area.

Table 22. EROSION PREVENTION AND EROSION CONTROL SITE DATA
BALD HILLS/SNOW CAMP ROADS TREATMENT AREA, PINE CREEK

Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
1.10 SPUR ON BALD HILL WEST	Y	622	02-11	N	L	L											20	20	
	Y	623	02-11	N?	L	L											160	112	
1.95 SPUR ON BALD HILL WEST	Y	625	01-07	Y	H	M			Y				Y	2.5	0.0		100	100	100
	Y	627	01-07	N	L	L											100	100	
	Y	628	01-07	N?	M	L											30	30	
2.536 SPUR ON BALD HILL WEST	Y	605	01-07	Y	H	H,M			Y				Y	2.5	2.5		150	150	150
	Y	606	01-07	Y	H	H,M			Y					3.0	3.0		150	150	150
	Y	607	01-07	Y	H	H,M	Y							2.0	1.0		180	162	162
	Y	608	01-07	Y	M	M			Y					2.0	1.0		75	75	75
	Y	609	01-07	Y	H	M			Y					2.0	1.0		100	100	100
BALD HILL EAST (E. OF BRIDGE)	N	702	02-11	N	L	L											0	0	
	N	703	02-11	N	L	L											10	10	
	N	704	02-11	N	L	L											10	0	
	N	707	03.17	N	L	L											20	20	
	N	708	03-17	Y	L	M,L						Y		0.0	1.5		150	150	150
	N	709	03.17	Y	L	M						Y		0.0	1.5		75	75	75
	N	712	03.17	Y	L	L	Y							1.0	0.0		30	30	30
	N	713	03.17	Y	H	M	Y							1.0	0.0		30	30	30
	N	714	3-17	Y?	L	L					Y				1.5		75	75	75
	N	715	3-17	Y?	L	L					Y				1.5		75	75	75
	N	717	3-17	Y	L	M					Y		Y	2.0	1.0		75	56	56
	N	718	3-17	Y	L	M,L			Y					1.0	1.0		85	85	50
BALD HILL WEST OF PINE CK.	N	600	01-07	Y	L	M						Y		0.0	1.5		100	100	100
	N	601	01-07	Y	L	M						Y?	Y	3.0	1.0		200	200	200
LITTLE PINE CK (201) RD	N	503	03-17	Y?	L	L							Y	0.0	0.0	Y	150	150	150
	N	507	03-17	Y	M	M		Y						2.5	0.0	Y	220	220	220
	N	508	03-17	Y	L	M						Y	Y	3.0	1.0		100	100	100
SNOW CAMP ROAD OFF B.H.E.	N	800	02-11	Y	L	L						Y		0.0	1.0		0	0	100
	N	803	02-11	Y	H	H						Y	Y	0.0	1.0	Y	100	100	100
	N	806	02-13	N?	M,L	L											300	210	
	N	809	02-13	N?	L	L											0	0	
	N	811	02-13	Y	H	H		Y						6.0	6.0		300	300	300
	N	813	02-13	N	L	L											0	0	
SPUR 1.123; PINE CK/BALD HILL	Y	719	3-19	Y	H	M			Y				Y	2.0	2.0		50	50	50
	Y	720	3-19	Y	H	M,L			Y?			Y	Y	1.5	1.5		35	35	35

Table 22.(cont) EROSION PREVENTION AND EROSION CONTROL SITE DATA
BALD HILLS/SNOW CAMP ROADS TREATMENT AREA, PINE CREEK

Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
Count:	8	35					3	2	8	0	3	8	9						
Total:														37.0	31.5		3,255	3,070	2,633

Table 23. Estimated logistic requirements and costs for the Bald Hills/Snow Camp Roads Treatment Area.

Cost Category[1]	Cost Rate ($/hr)	---Estimated Project Times--- Treatment[2] + (hours)	Logistics[3] (hours)	= Total (hours)	Total Estimated Cost ($)
1. Move-in; Move-out (Low Boy expenses)	50	--	16	16	800
2. Heavy Equipment					
D-7 Tractor	80	32	24	56	4500
Excavator	100	37	24	61	6100
Dump Trucks	50	10	0	10	500
Backhoe	50	--	--	--	----
3. Laborer(s)	15	60	--	60	900
4. Layout, Coordination Supervision, Reporting[3]	50	90	--	90	4500
TOTAL COST					$17,300

[1] Costs for culvert materials have not been included in these estimates. Costs for mulching and related materials (grass seed, fertilizer and straw) are not included, but are expected to be fairly small components of each project (estimated $500 - $1000).

[2] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[3] Logistic times include all equipment hours expended for opening access to sites on abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies.

[4] Supervision time includes 1 person-days for detailed layout (flagging, etc) prior to equipment arrival, supervision during equipment operations, and 2 person-days for post-project documentation and reporting.

6. Pine "G" Treatment Area

Location

The Pine "G" Treatment Area consists of 17 sites located on upper and middle hillslopes directly tributary to the main channel of Pine Creek (Map 7). This treatment area is physically isolated from the other areas in that it is accessed from the 100-Acre Prairie Road along the eastern divide of Pine Creek. The original mapping for the Pine "G" Treatment Area is found on mylar overlays of aerial photographs #3-11, #3-13 and #3-15.

The Pine "G" Road and its spurs were constructed in 1980-1981 for timber harvesting. All four of the roads are now technically abandoned and have not had significant maintenance or clearing since they were constructed. In several locations, brush has now covered the roadway and a few stream crossings are beginning to wash out. Although the Pine "G" Road is still passable to 4-wheel drive vehicles, its three spur roads are typically overgrown and not drivable. The spur at MP 2.55 is abandoned and completely overgrown (Map 7). It displays several potential and existing landslides and should be put to bed (Sites #28, #31, #34).

For the purposes of this report, we have classified the main road system as active and maintained. This is the status it should have, based on the abundant timber resources still to be harvested and accessed over these roads in the near future. Our recommendations call for upgrading, maintaining and erosion proofing this road system.

Past delivery from road-related erosion sources in the Pine "G" Treatment Area total just 202 yds^3. Clearly, since the road system was constructed, there have been no significant winter storms or runoff events which would trigger significant erosion and sediment yield. In contrast, field mapping has identified nearly 10,000 yds^3 of potential sediment yield ready to enter the channel system during future storms (Table 24).

Treatments

Our recommendations for this treatment area involve upgrading and erosion proofing of the road system to prevent future erosion and sediment delivery to Pine Creek. If left unattended and untreated through one or more large floods in the future, 16,500 yds^3 of sediment could be eroded and nearly 10,000 yds^3 of sediment could be directly delivered to the channel system of Pine Creek (Table 24). Treatment of the 16 treatable sites on Pine "G" and its spurs will prevent the introduction of over 4,500 yds^3 of sediment to Pine Creek.

Table 24. EROSION PREVENTION AND EROSION CONTROL SITE DATA
PINE "G" TREATMENT AREA, PINE CREEK

Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
PINE CREEK G ROAD	Y	4	03-11	Y	L	M						Y	Y	1.0	1		500	450	500
	Y	5	03-11	Y	M	M						Y	Y	2.0	1		100	100	100
	Y	6	03-13	Y	H	H	Y					Y	Y	4.0	0		150	113	113
	Y	7	03-13	Y	H	H	Y?	Y				Y	Y	6.0	2	Y?	200	100	100
	Y	8	03-13	Y	H	H							Y	1.5	0		225	225	225
	Y	9	03-13	Y	L	H						Y	Y	0.0	3	Y	450	225	225
	Y	11	03-13	Y	L	L						Y		0.0	1		100	20	20
	Y	16	03-13	Y	L	L						Y	Y	2.0	1		100	100	100
	Y	17	03-13	Y	M	L							Y	2.0	0		1,100	1,100	1,100
	Y	18	03-13	Y	L	L						Y	Y	0.0	1		90	90	100
	Y	19	03-13	Y	M	M	Y							4.0	5	Y?	310	233	233
SPUR @ 0.46 OFF PINE G RD.	Y	42	03-11	Y	L	L						Y		0.0	1		600	600	600
	Y	43	03-11	Y	M	M						Y	Y	1.0	2		150	135	135
SPUR @ 2.55 ON PINE CK G RD.	Y	28	03-13	Y	H	H		Y						5.0	6		400	100	100
	Y	31	03-13	N	H	L											11,000	5,500	
	Y	34	03-13	Y	H	H	Y							11.0	11		900	720	720
SPUR @ 3.70 ON PINE CK G RD.	Y	35	03-13	Y	H	M					Y			0.0	2	Y	150	150	150
Count:	4	17					4	2	0	0	1	10	10						
Total:														39.5	37		16,525	9,961	4,521

At ten of the treatment sites, recommendations call for installing rolling dips in the road bed to prevent future stream diversions in the event of culvert plugging. Typically, at these same sites, recommendations are also included for culvert installation, cleaning culvert inlets, adding downspouts, or other maintenance/improvement items.

Excavation of unstable fill material is called for at five sites, two of which are on the abandoned Spur @ 2.55 (see map) that is scheduled for temporary closure. Work on these five sites will prevent the delivery of up to 1,300 yds^3 of sediment to the channel system. None of the sites is large enough to require endhauling.

Equipment Needs
The Pine "G" Treatment Area is a fairly small unit and will require approximately 52 hours of excavator time and 54 hours of crawler tractor time to complete work at the 16 recommended treatment sites. Little or no endhauling should be necessary. Hand labor will be required to assist in culvert cleaning, culvert installation and culvert improvement work.

Logistics
All 16 work sites are located on abandoned roads. However, only one (#34) will require road rebuilding (in one spot) in order to access the site. To reach the site, the scarp system at Site #31 have to be regraded to permit equipment passage. The remaining 15 sites require minor road brushing to reach the work areas.

Treatment of the one abandoned spur road (Spur @ 2.55) should progress from the end of the road, back to its junction with the Pine "G" Road.

Estimated Costs
At $100/hr and $80/hr for the excavator and cat, respectively, direct equipment costs for the Pine "G" Unit would be $9,500. The only additional costs would be for hand labor and materials associated with culvert improvements, move-in and move-out costs and supervision. Total project costs of $15,000 will yield a cost-effectiveness value of $3.30 per cubic yard kept from entering the Pine Creek stream system. Little more than brushing is required to reach the majority of work sites. Total cost-effectiveness values should remain below $3.50/$yds^3$ for the Little Pine Creek Treatment Area.

Table 25. Estimated logistic requirements and costs for the Pine "G" Treatment Area.

Cost Category[1]	Cost Rate ($/hr)	---Estimated Project Times--- Treatment[2] + (hours)	Logistics[3] = (hours)	Total (hours)	Total Estimated Cost ($)
1. Move-in; Move-out (Low Boy expenses)	50	--	12	12	600
2. Heavy Equipment					
D-7 Tractor	80	37	17	54	4300
Excavator	100	40	12	52	5200
Dump Trucks	50	--	--	--	----
Backhoe	50	--	--	--	----
3. Laborer(s)	15	60	--	60	900
4. Layout, Coordination Supervision, Reporting[3]	50	80	--	80	4000
TOTAL COST					$15,000

[1] Costs for culvert materials have not been included in these estimates. Costs for mulching and related materials (grass seed, fertilizer and straw) are not included, but are expected to be fairly small components of each project (estimated $1000 - $1500).

[2] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[3] Logistic times include all equipment hours expended for opening access to sites on abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies.

[4] Supervision time includes 2 person-days for detailed layout (flagging, etc) prior to equipment arrival, supervision during equipment operations, and 2 person-days for post-project documentation and reporting.

7. No. 2 Road Treatment Area

Location

The No. 2 Road Treatment Area contains 41 sites stretching from near the headwaters of the Pine Creek basin, downstream to its intersection with the No. 201 Road to Ranger Mountain (near the Bald Hills Road)(Maps 8A-8D). All sites are located on the No. 2 Road, which is maintained as permanent logging road.

Much of the No. 2 Road was reconstructed in 1990, having experienced a number of fill failures and stream crossing washouts since it was last used a decade ago. In 1990, failed stream crossings were rebuilt to current standards and new culverts were installed at many locations where drainage was previously inadequate. In addition, several long reaches of the No. 2 Road were surfaced with at least one layer of rock to make portions of the route useable for winter hauling.

The No. 2 Road can be divided into a northern and a southern segment, logically separated at the ford crossing of Pine Creek (see Map 8C). South of the ford crossing, the No. 2 Road is largely unsurfaced and occasionally may be impassable during the wettest conditions. It is not an all-weather haul road. North of the ford crossing, the road is only locally surfaced for winter hauling, but many new culverts have been installed to bring the drainage facilities up to higher standards.

For the purposes of this report, both the northern and the southern segments of the No. 2 Road are classified and treated as a permanent, maintained road that will remain a part of the permanent road network. As with other currently maintained, permanent roads, we have assumed that the No. 2 Road will never again be abandoned. For this reason, our erosion control and erosion prevention recommendations call for local upgrading of drainage facilities and other improvements that will help erosion-proof the road to withstand future storms.

The No. 2 Road was constructed in the 1960's and early 1970's. The road was entirely in-place by 1972. Numerous road failures and stream crossing washouts occurred during the floods of 1964, 1972 and 1975. At a minimum, past delivery from road-related erosion sources in the No. 2 Road Treatment Area totals 15,500 yds^3. Six sites of past erosion and sediment delivery each yielded over 1000 yds^3 of sediment to Pine Creek. Future erosion predicted from this treatment area is expected to be approximately 8,450 yds^3 of sediment (Table 26).

Importantly, any sediment eroded from fillslopes and stream crossings along the No. 2 Road is rapidly carried down the steep inner gorge slopes to the main channel of Pine Creek. Erosion along the road is often quickly translated into sediment delivery to this important fish-bearing stream. Past sediment contributions from this road system have been significant. Future sediment delivery from this treatment area can be largely avoided by straight forward erosion prevention treatments (Table 26).

Table 26. EROSION PREVENTION AND EROSION CONTROL SITE DATA
NO. 2 ROAD TREATMENT AREA, PINE CREEK

Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
No. 2 ROAD	N	100.1	04-04	Y	H	L							Y	0.0	3.0	Y	50	40	40
	N	106.0	03-05	Y	L	L						Y		0.0	1.0		100	60	60
	N	107.0	03-05	Y?	L	L						Y	Y	0.0	1.5		-100	85	85
	N	111.0	03-05	Y?	L	L						Y		0.0	1.5		300	270	270
	N	113.0	03-05	Y	H	H							Y	0.0	0.0	Y	2,100	2,100	2,100
	N	114.0	03-05	Y	L	M,L					Y			0.0	1.0		200	180	180
	N	116.0	03-05	Y	M	M							Y	0.0	0.0	Y	30	27	27
	N	117.0	03-05	Y	H	H							Y	0.0	0.0	Y	50	50	300
	N	118.0	03-05	Y	M	M							Y	20.0	15.0		1,200	1,200	1,200
	N	122.0	03-07	Y?	L	L						Y		0.0	1.5		100	100	100
	N	124.0	03-07	Y	L	L						Y		0.0	1.0		80	80	80
	N	128.0	03-07	Y	H	H							Y	4.0	3.0	Y	330	330	330
	N	129.0	03-07	N	L	L											500	500	
	N	130.0	03-07	N	L	L											50	0	
	N	131.0	03-07	N	L	L											125	125	
	N	140.0	03-09	Y	H	H	Y							2.0	2.0		200	200	200
	N	146.0	03-11	Y?	L	L						Y		0.0	1.5		30	30	300
	N	158.0	02-05	Y	M	H,M		Y				Y	Y	3.0	1.0		100	100	100
	N	159.0	02-05	Y	H	H	Y							3.0	3.0		300	300	300
	N	160.0	02-5	Y	H	H,M	Y							1.5	1.0		130	78	78
	N	161.0	02-5	N	L	L											100	15	
	N	168.0	02-5	Y?	M	M							Y				300	300	300
	N	169.0	02-5	N?	L	L											200	200	
	N	170.0	02-5	Y	H	H	Y						Y	2.0	0.0		50	50	50
	N	172.0	02-5	N	L	L											10	10	
	N	173.0	02-07	N	L	L											50	0	
	N	174.0	02-07	Y	L	M							Y	3.0	0.0		75	75	425
	N	175.0	02-07	N?	L	L											20	20	
	N	178.0	02-07	Y	H	H							Y	2.0	0.0		100	100	100
	N	179.0	02-07	Y	L	L						Y	Y	0.0	1.5		85	85	85
	N	180.0	02-07	Y	L	L						Y		0.0	1.5		85	85	85
	N	183.0	02-07	Y	L	L					Y			1.0	1.0		50	50	500
	N	186.0	2-7	Y	H	H							Y	0.0	0.0	Y	400	400	400
	N	187.0	2-7	Y	L	M					Y			0.0	1.0		400	360	360

Table 26.(cont) EROSION PREVENTION AND EROSION CONTROL SITE DATA
NO. 2 ROAD TREATMENT AREA, PINE CREEK

	Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
	No. 2 ROAD	N	196.0	3-15	Y?	L	L						Y		0.0	1.5		50	45	45
		N	197.0	3-15	Y	H	H,M						Y	Y	0.0	2.0	Y?	300	300	300
		N	199.0	3-15	N?	L	L											100	80	
		N	203.0	3-17	Y	L	L						Y		0.0	1.0		30	30	400
		N	204.0	3-17	Y	H	L						Y		0.0	1.0		20	20	100
		N	209.0	3-17	N	L	L											40	40	
		N	211.0	3-17	Y?	L	L						Y		0.0	1.5		100	100	100
Count:	1		41					4	1	0	0	3	14	15						
Total:															41.5	49.0		8,440	8,220	9,000

Treatments

Recommendations for the No. 2 Road Treatment Area involve upgrading and erosion proofing the permanent road system to prevent future erosion and sediment delivery to Pine Creek. Treatment of the 31 treatable sites on the road will prevent the direct introduction of up to 9,000 yds^3 of sediment to Pine Creek.

No stream crossing excavations have been recommended, because of the permanent status of the road. However, 14 rolling dips need to be constructed to prevent future stream diversions, and a number of the existing stream crossings (15) require improvements (such as the addition of downspouts, trash racks, culvert extensions, etc) to help protect them from failure during large storms.

Recommendations which call for installing rolling dips in the road bed are aimed at preventing future stream diversions in the event of culvert plugging. Typically, at these same sites, additional recommendations are also included for culvert installation, cleaning culvert inlets, adding downspouts, or other maintenance/improvement items designed to prevent future erosion.

At five locations, unstable fill materials are recommended for excavation. Sites are typically located along the outside of the road prism, or in the immediate vicinity of newly installed stream crossings. Treating these five sites will prevent the eventual delivery of approximately 730 yds3 of sediment to the main channel of Pine Creek.

Equipment Needs

The No. 2 Road Treatment Area will require approximately 65 hours of excavator time and 72 hours of crawler tractor time to complete work at the 31 recommended treatment sites. One high priority site (#128) will require approximately 15-20 hours of dump truck time for endhauling unstable spoil material. In addition, dump trucks will be required to import rock surfacing materials to two short stretches of road that are currently soft and potentially unstable.

Finally, a backhoe will be needed for 11-15 hours of work at four sites for culvert installation and culvert improvement work. Hand labor will be required to assist in culvert cleaning, culvert installation and culvert improvement work at a number of sites and for most of the project duration. These costs are all incorporated in Table 27.

Logistics

All of the work sites in this treatment area are on the No. 2 Road, thereby providing easy access to work locations. Endhauling storage sites are all locally available. Installation of rolling dips will, in many cases, require an extra 15 minutes beyond the normally required time because of the extra road width.

Estimated Costs
At $100/hr and $80/hr for the excavator and cat, respectively, equipment costs would total $12,200. Costs for limited dump truck and backhoe use (total approximately 20 hrs and 15 hrs, respectively, (@ $50/hr) will add approximately $1,750 to project costs. Additional costs for hand labor and supervision are shown in Table 27. The cost of materials needed for culvert and drainage improvements are not included.

Total treatment costs of $20,350 will yield a cost-effectiveness value of $2.25 expended for every cubic yard of sediment kept from entering the Pine Creek stream system. Road resurfacing and materials costs could increase costs for the project. Total cost-effectiveness values should remain below $4.00/yds^3 for preventive treatments along the No. 2 Road.

Table 27. Estimated logistic requirements and costs for the No. 2 Road Treatment Area.

Cost Category[1]	Cost Rate ($/hr)	---Estimated Project Times--- Treatment[2] + (hours)	Logistics[3] (hours)	= Total (hours)	Total Estimated Cost ($)
1. Move-in; Move-out (Low Boy expenses)	50	--	24	24	1200
2. Heavy Equipment					
D-7 Tractor	80	49	23	72	5700
Excavator	100	42	23	65	6500
Dump Trucks	50	20	0	20	1000
Backhoe	50	15	0	15	750
3. Laborer(s)	15	80	--	80	1200
4. Layout, Coordination Supervision, Reporting[3]	50	80	--	80	4000
TOTAL COST					$20,350

[1] Costs for culvert materials have not been included in these estimates. Costs for mulching and related materials (grass seed, fertilizer and straw) are not included, but are expected to be fairly small components of each project (estimated $500 - $1000).

[2] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[3] Logistic times include all equipment hours expended for opening access to sites on abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies.

[4] Supervision time includes 1 person-days for detailed layout (flagging, etc) prior to equipment arrival, supervision during equipment operations, and 2 person-days for post-project documentation and reporting.

8. No. 2 Road Spurs Treatment Area

Location

The No. 2 Road Spurs Treatment Area contains 33 sites located on six abandoned spurs to the No. 2 Road (Maps 8A-8D). Relative to the beginning of the No. 2 Road, at the divide entering the Pine Creek basin at its southern end, the spurs roads are found at the following mileposts: 0.37 miles (Map 8D), 3.45 miles (Map 8C), 4.26 miles (Map 8C), 5.86 miles (Map 8B), 10.87 miles (Map 8A), and 12.12 miles (Map 8A). The original mapping for this spur road is found on mylar overlays of aerial photographs #4-6 and #3-5.

The first spur in this treatment area takes off the No. 2 Road at 0.37 miles (Map 8D). It contains 14 sites, 11 of which are recommended for treatment (Table 28). At one point, the spur appears to cross onto private land before it re-enters Tribal lands. For most of its length, this abandoned spur road parallels Pine Creek and is located from 100 to 200 feet up the inner gorge hillslope. Erosion of stream crossings and failure of unstable fill material often has an excellent chance of reaching the channel.

The second spur takes off the No. 2 Road at 3.45 miles from the southern end of the road, several hundred feet north of the ford crossing over Pine Creek (Map 8C). Only two sites on this spur are tentatively scheduled for treatment. Both sites are partially washed out stream crossings. The original mapping is found on a mylar overlay of aerial photograph #3-7.

The third spur takes off the No. 2 Road at 4.26 miles and has only a single site of low to moderate treatment immediacy (Map 8C). The spur takes off the No. 2 Road and extends downslope about 0.25 mile where it ends at a terminal landing. The road was built between 1965 and 1972.

Spur 5.86, the third spur with recommended treatment sites, extends upslope from the No. 2 Road to three potential work sites; one partially washed out stream crossing at the end of the road and two potential slope failures (Map 8B). Together, the three sites threaten to deliver over 600 yds^3 of sediment to a steep tributary of Pine Creek. Built prior to 1977, the road has been abandoned and overgrown for a number of years.

The fourth spur with recommended treatment sites takes off the No. 2 Road at milepost 10.87 (Map 8A). It is a relatively long, abandoned spur road that has five viable work sites identified on it. The road was constructed prior to 1972 and each of the sites is marked by a high potential for future erosion and sediment yield. Original mapping of the site is contained on the mylar overlay of aerial photograph #2-7.

Table 28. EROSION PREVENTION AND EROSION CONTROL SITE DATA
NO. 2 ROAD SPURS (6 SPURS), PINE CREEK

Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
0.37 SPUR OFF NO. 2 ROAD	Y	309	04-06	Y	H	H			Y					5.0	5.0		150	150	150
	Y	311	04-06	Y	H	H	Y							5.0	3.0		400	400	400
	Y	312	04-06	Y	M	M			Y					3.0	3.0		150	150	150
	Y	314	04-06	Y	H	M			Y					5.0	5.0		100	85	85
	Y	315	03-05	N	L	L											5	0	
	Y	316	03-05	N	L	L											5	0	
	Y	317	03-05	Y	H	H			Y					6.0	6.0		250	250	250
	Y	318	03-05	Y	M	M	Y							2.5	1.0		200	120	120
	Y	319	03-05	Y	H	M			Y					1.5	1.5		50	50	50
	Y	320	03-05	N	L	L											20	4	
	Y	321	03-05	Y	H	M			Y					1.5	1.5		40	40	40
	Y	322	03-05	Y	H	H			Y					2.0	2.0		50	50	50
	Y	323	03-05	Y	M	M,L	Y							2.5	1.0		250	150	150
	Y	324	03-05	Y	H	L			Y					1.5	0.0		50	50	50
10.87 SPUR OFF #2 ROAD	Y	381	02-07	Y	H	H,M			Y					2.5	2.0		200	200	200
	Y	383	02-07	Y	H	H,M			Y					0.0	1.0		200	150	150
	Y	386	02-07	Y	H	L	Y							2.0	2.0		100	50	200
	Y	387	02-07	Y	H	M	Y							2.0	0.0		100	100	100
	Y	388	02-07	Y	H	M	Y							2.5	2.5		250	250	250
12.12 SPUR OFF #2 RD.	Y	372	03-15	Y	H	M			Y					3.0	3.0		100	100	100
	Y	373	03-15	Y	L	L	Y	Y						2.5	2.5	Y?	200	200	200
	Y	374	03-15	N	L	L											20	0	
	Y	375	03-15	Y	L	L			Y					2.0	1.0		80	80	80
	Y	376	03-15	N	L	L											0	0	
	Y	377	03-15	N	M	L											200	100	
	Y	378	03-15	Y	H,L	M		Y		Y				7.0	7.0		850	850	850
	Y	379	03-15	N	M	L											250	38	
5.86 SPUR OFF #2 ROAD	Y	336	03-09	Y	M	L	Y							0.5	0.0		70	0	50
	Y	337	03-09	Y	M	M	Y							1.5	1.5		125	94	94
	Y	338	03-09	Y	H	H			Y				Y	10.0	10.0		590	590	590
SPUR 3.45 ON NO. 2 ROAD	Y	329	03-07	Y?	H	M			Y					1.5	1.5		60	60	60
	Y	331	03-07	Y?	H	M			Y					1.5	1.5		60	60	60
SPUR 4.26 ON NO. 2 ROAD	Y	332	03-09	Y	LM	M,L	Y							3.5	3.5		400	300	300
Count:	6	33					10	2	15	1	0	0	1						
Total:														77.5	68.0		5,575	4,721	4,779

The final spur, at milepost 12.12, contains eight recommended work sites. It extends below the No. 2 Road and approaches the inner gorge slope along the channel (Map 8A). In the past, erosion from this abandoned spur road delivered over 2000 yds^3 of sediment directly to Pine Creek. Nearly 1500 yds^3 of future sediment delivery can be prevented by completing the recommended treatments before the next major flood event.

At a minimum, past delivery from road-related erosion sources in the No. 2 Road Spurs Treatment Area totalled nearly 5,800 yds^3. Future sediment delivery predicted from this treatment area is expected to be approximately 4,800 yds^3 of sediment if treatments are not undertaken (Table 28). Because of their close proximity to Pine Creek, erosion and sediment delivery to the main channel system is typically rapid. Slopes and tributary stream channel gradients are steep.

Treatments

Each prescription in this treatment area calls for either the excavation of a stream crossing or the removal of unstable fill material which threatens to deliver sediment to a stream channel. Since the spur roads were mostly built prior to 1975, each has been through at least one major flood event. For this reason, many of the stream crossings recommended for excavation are already partially washed out. Many others have already completely eroded, and require no further work.

Table 28 outlines the general treatments for each of the spur road sites. Sixteen (16) sites call for the excavation of stream crossings and another 12 sites call for the excavation and removal of unstable fill material along roads and landings. In each case, the treatments are straight forward. No endhauling will be needed at any of the work sites.

Recommendations for each of the six spurs acknowledge the fact that these dead-end roads will not be upgraded or maintained in the near future. There is little or no timber to access along any of these routes. Treatments recommended here will erosion proof the most seriously threatening sites that could deliver sediment to the Pine Creek channel, if a large storm and flood were to hit the basin. However, the roads will be addressed and put-to-bed so that they could be reopened and reused in the future if they were needed.

Equipment Needs

The No. 2 Road Spur Treatment Area will require an estimated 95 hours of excavator time and 100 hours of crawler tractor time to complete work at the 26 recommended treatment sites. No sites are expected to require the use of dump trucks for endhauling spoil material. Sufficient local storage sites appear to be available. Some hand labor will be needed on sites involving bridge removal to assist the tractor operator in setting chokers.

Logistics
All the spur roads have been abandoned for a number of years. Four of the spur roads will require little more than brushing and minor blade work to reopen the routes for equipment access to the work sites. Two of the spurs will require major rebuilding to access work sites.

The Spur @ 0.37 milepost crosses Pine Creek near its beginning and the log stringer bridge at that location has already partially failed (site #309). This major crossing will have to be fully removed and a ford (or flat car) crossing rebuilt before access to the remaining sites can be gained. There are also a large number of partially washed out stream crossings along this route that will have to be "bladed through" in order to provide access to sites further out the road.

Most of the sites along the 12.12 Spur can also be reached only by "major" road reconstruction. One road/slope failure near the road's beginning (see site #374) would need to be heavily graded in order for equipment to pass. Instead, it appears that a major skid trail extending directly from the No. 2 Road down to site #375 could be opened to provide equipment access to the remainder of the work sites. This optional route will be further investigated in the field before equipment is committed to treating sites along this spur road.

Estimated Costs
At $100/hr and $80/hr for the excavator and cat, respectively, equipment treatment costs would total $17,500. Overall treatment costs of $26,000 will yield a cost-effectiveness value of $5.44 per cubic yard of sediment kept from entering the Pine Creek stream system. Total cost-effectiveness values should remain below $6.00/yds^3 for preventive treatments along the No. 2 Road Spurs.

Table 29. Estimated logistic requirements and costs for the No. 2 Road Spurs Treatment Area.

Cost Category[1]	Cost Rate ($/hr)	---Estimated Project Times--- Treatment[2] + (hours)	Logistics[3] = (hours)	Total (hours)	Total Estimated Cost ($)
1. Move-in; Move-out (Low Boy expenses)	50	--	--	--	---[5]
2. Heavy Equipment					
D-7 Tractor	80	68	32	100	8000
Excavator	100	78	17	95	9500
Dump Trucks	50	--	--	---	----
Backhoe	50	--	--	---	----
3. Laborer(s)	15	100	--	100	1500
4. Layout, Coordination Supervision, Reporting[3]	50	140	--	140	7000
TOTAL COST					$26,000

[1] Costs for culvert materials have not been included in these estimates. Costs for mulching and related materials (grass seed, fertilizer and straw) are not included, but are expected to be fairly small components of each project (estimated $1000 - $1500).

[2] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[3] Logistic times include all equipment hours expended for opening access to sites on abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies.

[4] Supervision time includes 2 person-days for detailed layout (flagging, etc) prior to equipment arrival, supervision during equipment operations, and 2 person-days for post-project documentation and reporting.

[5] Treatment of the seven (7) abandoned roads in this treatment area will be done in conjunction with work on sites in the No. 2 Road. For this reason, move-in and move-out costs are itemized on the treatment cost table for the No. 2 Road Treatment Area.

9. Low Priority Miscellaneous Sites and No. 2 Road Spurs

Location

The 20 miscellaneous sites included in this treatment area are generally of lower priority than most of the sites included in the other treatment areas. These sites include small or relatively low priority work areas that may be isolated or located among other sites where no treatment has been recommended (Maps 8A-8D).

Eight of the roads (containing 19 of the identified sites) are spurs to the No. 2 Road. The mileposts, and number of sites on each spur, are as follows: 0.00 (1), 0.01 (5), 0.26 (3), 1.39 (1), 3.29 (2), 5.36 (3), 7.11 (3) and 8.2 (1). Aside from Spur 8.2 (which is a newly constructed road) and Spur 7.11, the other six spur roads are abandoned. Spur 7.11 was reopened and rebuilt in 1990. The location of the sites are depicted on Map 8B.

The remaining treatment site is located on one of the southern-most spurs to the 100 Acre Prairie Road (at milepost 8.52). This is a drivable spur road.

At a minimum, past delivery from road-related erosion sources in these miscellaneous sites totalled nearly just over 5,400 yds^3. Future erosion predicted from this treatment area is expected to be significantly less, approaching 1,500 yds^3 of sediment if treatments are not undertaken (Table 30).

Treatments

Because of their low potential yield, or their low probability of failure, only six of the 20 sites are recommended for treatment in this area. Most of the sediment to be "controlled" will come from treatment of two sites on the 0.01 spur to the No. 2 Road. Site #308 simply calls for preventive road reconstruction measures to be undertaken if this abandoned spur road is ever reconstructed (as recent flagging and abundant local timber suggests). The other important site (#304) is a Humboldt crossing of a small, steep stream that could torrent to Pine Creek if it is not excavated.

The other four sites targeted for eventual treatment cumulatively account for only 190 yds^3 of sediment. They will be scheduled for treatment only if equipment is in close proximity, in order to keep total equipment costs to a minimum.

Equipment Needs

The Miscellaneous Sites Treatment Area will require an estimated 4 hours of excavator time and 9 hours of crawler tractor time to complete work at the 6 recommended treatment sites. No sites are expected to require the use of dump trucks for endhauling spoil material. Sufficient local storage sites appear to be available. However, transportation times between sites could be large, since many of the sites a isolated and far removed from each other.

Logistics

Most of the spur roads have been abandoned for a number of years. Spur 0.01, where the two largest sites are located, will require "major" rebuilding of the ford crossing of Pine Creek in order to access the work areas. The remaining sites will require minor rebuilding, or just brushing, to open access.

Estimated Costs

At $100/hr and $80/hr for the excavator and cat, respectively, direct treatment costs would be $1,120, not including transportation, conferencing or other normal costs. Because of the low priority of hits work site, no additional cost breakdown has been made for this site. It is unlikely sites would be treated unless equipment was passing the site for another job. For this reason, treatment area costs would not be particularly meaningful.

Table 30. EROSION PREVENTION AND EROSION CONTROL SITE DATA
LOWER PRIORITY MISCELLANEOUS SITES, PINE CREEK

Road	Abnd?	Site	Photo	TREAT?	EP	Immed.	IPOS	EOS	IPRX	ERX	XRD	RD	OTHER	EXC	CAT	OTHER?	Fut Eros	Fut. del	VOL SAVED
.26 SPUR OFF 7.11 SPUR #2 RD	Y	349	02-05	N	L	L											15	11	
	Y	350	02-05	N	L	L											25	5	
	Y	351	02-05	N	M	L											10	0	
0.01 SPUR OFF NO. 2 ROAD	Y	301	04-04	N	M	L											20	20	
	Y	302	04-04	N?	L	L											0	0	
	Y	304	04-04	Y	M	M			Y					3	3		500	400	400
	Y	306	04-04	N	L	L											50	40	
	Y	308	04-04	Y	H	H							Y	0	0		450	270	900
1.39 SPUR OFF NO. 2 ROAD	Y	326	03-05	N	L	L											110	28	
7.11 SPUR OFF #2 ROAD	N	342	02-03	N?	H	L											10	10	
	N	344	02-03	N	H	L											35	35	
	N	348	02-03	Y?	H	H			Y					0	2		40	40	40
FORD SPUR AT 3.29 ON NO 2 RD.	Y	327	03-07	N	H	L											20	20	
	Y	328	03-07	N?	H	L											225	225	
S. SPUR @ 0.0 #2 ROAD	Y	100	04-04	Y	H	M					Y				2	Y?	50	35	35
SPUR 5.36 ON NO. 2 ROAD .	Y	333	03-09	N	M	L											20	0	
	Y	334	03-09	Y	M	M							Y	1	1		35	35	35
	Y	335	03-09	N	L	L											0	0	
SPUR 8.2 OFF #2 RD	NEW	352	02-05	Y	H	L			Y					0	1		25	25	75
SPUR 8.52;100 ACRE PRAIRIE RD	N	51	4-6	N	M	L											300	300	
Count:	9	20					0	0	3	0	1	0	2						
Total:														4	9		1,940	1,499	1,485

VII. Evaluation of Past and Present Landuse Practices

A. Introduction

Throughout field mapping of active and abandoned roads in the Pine Creek study area, observations were kept on the effect of certain past and current landuse practices on erosion and sediment delivery to stream channels. Some of the practices are no longer widely carried out, others are still in widespread use. Still other practices appear to be the result of careless operations by individual equipment operators and do not represent the concerted practice of local forestry. Regardless, a number of these past and present operations continue to result in erosion and sedimentation impacts to Pine Creek and its tributaries.

Perhaps the most cost-effective tool for reducing future sediment contributions to fish-bearing streams in these highly erodible, steepland drainage basins is the utilization of preventive landuse practices. The greatest majority of documented erosion and sediment yield from managed lands in the study area could have been avoided by more prudent land management. Over time, as practices continue to improve, impacts to fisheries resources will continue to diminish.

Some of the practices described in this section are no longer commonly used in forestry or road building operations, but an analysis of their impacts can continue to assist in lessening the impacts of related, future operations. In other cases, some practices that may seem inconsequential or unintentional continue to affect aquatic resources in the main channel and its tributaries. Drawing attention to these practices will help keep planners, supervisors and operators alert to potentially damaging practices in the field.

Four main categories of landuse practices, and their potential impacts, are briefly described below. These include 1) road location, 2) road construction practices, 3) road maintenance activities, and 4) road abandonment practices.

B. Road Location

Three common locations where landuse activities are especially prone to causing landsliding and the direct delivery of large volumes of sediment to Pine Creek and its tributaries include: 1) steep inner gorge slopes, 2) steep headwater swales and 3) lower hillslope positions along deeply incised tributary streams. Harvesting, tractor yarding and, especially, road construction in these areas dramatically increase the likelihood of large scale slope failure and sediment delivery during large storms.

Perhaps the largest single source of sediment delivered to the main channel of Pine Creek over the last four decades has been ubiquitous stream-side landslides and debris slides. Air photo analysis suggests these landslides were *triggered* by major flood events of 1964, 1972 and 1975. They were commonly located in clearcut areas and in areas where roads had been built and tractor logging had occurred on steep, inner gorge slopes above the stream channel. In the 1960's and the 1970's, a number of logging roads had been built on these steep, stream-side slopes. Most, except the No. 2 Road, have since failed and been abandoned.

Another common source of large quantities of sediment to Pine Creek, especially during flood periods, has been debris torrents that originate in small headwater channels on steep slopes. As typical forest roads cross a hillslope, the fill/cut ratio is usually the greatest in swales (topographic depressions). These relatively deep, wide fill wedges appear to impede subsurface groundwater flows. This results in elevated pore pressures and leads to hillslope failure in areas of steep slopes.

According to the aerial photo analysis, headwater torrents almost always originate where landings or roads have been built across these steep, wet swale areas. Subsequent failure of these "crossings" often leads to scouring of the downslope channel and the delivery of up to 3000 yds^3 of sediment to the stream channel thousands of feet below. Improved road and skid-trail location and design could have prevented most of the headwater debris torrents that were associated with road construction.

Although more geographically confined, the inner gorge slopes along deeply incised tributaries to Pine Creek represent another likely site for fillslope failures, native hillslope failures and stream crossing failures, with resultant sediment delivery to the channel system. These channel sideslopes often display widespread zones of emerging groundwater, as well as either mottled, deeply weathered, highly unstable soils, or deep colluvium. Roads built across these lower hillslopes typically fail shortly after construction and are abandoned or remain as extremely high maintenance areas. Failures of stream crossings and fillslopes built on the approaching hillslopes deliver large quantities of sediment to the tributaries.

Once roads have been built on these hillslopes, there is little that can be done to retroactively stabilize the hillside. Individual sites of potential debris slides (such as those in steep, headwater swales) and stream crossings can be treated through excavation, but larger scale features cannot effectively or economically be treated once instabilities have begun.

It is, therefore, a far more cost-effective procedure to avoid sites of potential instability when the units are logged or roads are constructed. When possible, the following sites or practices should be generally avoided in order to minimize the potential for landuse-caused hillslope failure and sediment delivery to Pine Creek and its tributaries.

1. Avoid constructing roads on steep inner gorge slopes along Pine Creek and its major tributaries. Instead, build roads above the slope-break and cable yard logs

up to gentler, more stable ground. For slopes steeper than 60%, there should be detailed geotechnical planning and design of any proposed road.

2. Encourage cable yarding, rather than tractor yarding, on inner gorge slope areas that are to be logged.

3. Consider leaving old-growth buffer strips along the main fish-bearing stream channels, both to enhance slope stability and for organic recruitment to the channel.

4. Known unstable areas, areas of abundant emergent groundwater and zones of unstable or sheared, mottled soil materials (especially in inner gorge areas) should be considered for exclusion from logging plans.

5. Where it is necessary for roads to cross steep ephemeral drainages, two road design practices could lessen the incidence or magnitude of failures: 1) minimizing the amount of fill placed in swale areas by reducing the width of the road and following the hillslope contours more closely, and 2) providing adequate drainage through and/or under road prisms, using french drains, gravel blankets, or synthetic drainage blankets.
Ideally, such potentially unstable sites should be identified during the planning process and avoided during the construction phase.

6. Where roads must be constructed across inner gorge slopes or other high risk areas, the alignments should be considered temporary. Stream crossings should be excavated, landings should be kept to the minimum size possible, and uncompacted fills should be physically removed before the first winter following operations.

C. Road Construction Practices

Road construction practices have an important impact on erosion and sedimentation processes on managed lands. Operations on steep, stream-side slopes are the most likely type of practices to have direct impacts on stream resources. Field observations in Pine Creek confirm this general conclusion.

Two important practices in the Pine Creek study area include 1) the construction of stream crossings and 2) road construction on steep, streamside or inner gorge slopes. Practices in these sensitive areas have an important bearing on the potential for future sedimentation in Pine Creek and its tributaries.

From field surveys, erosion at stream crossings has come from two main practices. First, crossings of deeply incised stream channels have been characterized by excessive sidecasting on the approaches to the channel. In addition to direct sidecasting into the channel, oversteepened fillslopes soon fail at many of these crossings. Uncompacted sliver-fills on the approaches to the crossing collapse into the channels once the loose material becomes saturated or undercut by stream bank erosion at the toe of the slope. Sidecasting, rather than endhauling, is still a common practice and a ubiquitous source of sediment.

Secondly, many stream crossings have been, and continue to be, built with a high potential for stream diversion (diversion potential (DP)). If the culvert on a high DP stream crossing were to plug with debris during a flood event, water dammed behind the fill would eventually spill out on the road surface and flow down the road (rather than over the fill and back into the stream). At a number of sites, these diverted flows have caused extensive gully networks and individual gullies have delivered thousands of cubic yards of sediment to Pine Creek. There are many existing and newly constructed stream crossings with a high diversion potential in the Pine Creek planning area.

In steep inner gorge areas, excessive sidecasting, building large log landings, and filling of incised stream channels leads to slope failures, debris slides and debris torrenting. Often, these steep slopes are near their stability threshold and additional loading can initiate deep seated instabilities. Shallow debris sliding from unconsolidated landing and road fills was a common source of existing and potential sediment to local stream channels.

Several road construction practices can be used to ensure that erosion from stream crossings during floods is kept to a minimum.

1. All newly constructed stream crossings should be built with no diversion potential. That is, the road should dip into and out of each crossing. If a culvert plugs, the crossing should be designed to direct water over the top of the fill and back into the stream channel as soon as is possible.

2. All roads that are reconstructed, and all crossings on existing roads that have a high diversion potential, should have rolling dips installed. Constructing (excavating) rolling dips on or immediately down-road from the crossing will eliminate the potential for stream diversion.

3. When constructing roads across incised stream channels, the approaches should be excavated and the spoil material should be pushed or endhauled to a stable site. Sidecasting should be avoided, or strictly minimized.

4. When reconstructing and reopening abandoned roads, all Humboldt log crossings and unculverted fills should be excavated and fitted with properly sized culverts.

5. Benching, endhauling and fill construction (placement and compaction, as opposed to uncontrolled sidecasting) are all techniques that may be used on a

regular basis where roads have to be built across steep inner gorge slopes. Sidecasting on slopes over 50% should be strictly minimized or avoided.

D. Road Maintenance, Repair and Upgrading Practices

Road maintenance, by definition, is designed to improve the condition of a road system and to prepare it for winter storm periods. At the same time, many road maintenance practices can directly impact stream resources if they are not carefully undertaken.

Road maintenance practices include tasks which improve road drainage and tasks which improve road stability. Work may include culvert cleaning, repairing culverts and drainage structures, improving road surface drainage, and repairing road instabilities.

Observations in Pine Creek suggest that some techniques could employed to increase the effectiveness of road maintenance practices and improve the protection of stream resources. These observations, not listed in order of importance, include the following general suggestions:

1. Avoid sidecasting at crossings which are being rebuilt, replaced or widened. Endhaul spoil, instead of sidecasting.

2. Avoid widening roads at or near stream crossings by sidecasting on the approaches, unless the main channel culvert is extended to carry streamflow beyond the base of the newly sidecast fill material.

3. Many older and newly installed culverts are about 3 feet too short, so subsequent road grading and sidecasting often plugs or covers the inlet or outlet. This material is then easily eroded during storms and discharges sediment directly to streams. Culverts should be installed or extended so that sidecasting from normal road grading operations is not carried into the flow-course.

4. Downspouts could be more effectively used on a number of existing and newly installed culverts to carry flow across erodible fill material.

5. On several newly installed culverts, a bed for the pipe was built by bulldozing and flattening the bottom of the channel. In one case, this "bed" of exposed soil extended over 40 feet downstream from the eventual end of the culvert outlet, exposing some 40 yds^3 of loose fill to subsequent channel erosion. Soil disturbance in stream channels should not extend below the outlet of the culvert.

6. Several newly installed culverts are oriented at angles that are slightly oblique to their channels, thereby forcing flows to impinge on and undercut adjacent

channel banks. Culverts should be installed on the bed and at the same orientation as the stream.

7. When rebuilding roads and failed stream crossings, sidecasting should be avoided on approaches to incised streams, especially in rocky slope areas or where soils are composed of highly erodible unstable, sheared schist or decomposed ultramafics.

8. Restrict winter traffic on wet fills composed of unstable material. If these areas are to be rock surfaced, geotechnical materials and cloths should be used to keep fine material from pumping through the newly placed rock surfacing.

9. Increase the use of trash barriers on large or active streams which transport debris. They should be placed somewhat upstream from culvert inlets, to protect the inlet against plugging with organic debris.

10. Continue the practice of using 18-inch culverts as the minimum sized pipe utilized in new road construction and culvert replacement projects.

11. Classify and field-code existing culverts to indicate relative need for winter storm maintenance, based on channel characteristics and past history of plugging. Place a marker at each culvert in the field to indicate the pipe's location (milepost), its size (diameter), and its maintenance needs (high, moderate, low). Locating all culverts with road markers will also help grader operators make sure they do not sidecast over culvert outlets.

E. Road Abandonment Procedures

In steepland areas of northwestern California, many harvested watersheds contain extensive road networks that have been progressively constructed over a number of decades. Pine Creek is no exception. Many sections of these roads are abandoned and unmaintained, and exhibit serious and persistent erosion problems. Other roads remain largely intact but display the potential for substantial erosion during future winter storms.

The degree of erosion and off-site sedimentation caused by abandoning roads is dependent upon a number of factors, including:

1) the date of road abandonment (in relation to the occurrence of past and future winter storms and flood events),

2) terrain characteristics (slope steepness, the number and size of stream channels crossed, natural slope and soil stability, and soil erodibility),

3) road characteristics (adequate culvert size, proper culvert location and installation, adequate debris "filters" to prevent culvert plugging, and the grade of the roadbed over the stream crossing) and

4) the extent of sidecasting conducted during road construction and maintenance activities.

On mountainous slopes managed for timber production, such as in Pine Creek, road construction and abandonment practices must address and anticipate the occurrence of extreme storms which frequently trigger widespread fluvial erosion and landsliding. This can be effectively accomplished by employing preventive land management techniques and preventive, proactive road abandonment techniques.

Stream diversions at logging road and skid trail stream crossings have been found to be the overwhelming, leading cause of sediment production from abandoned, unmaintained roads in the neighboring 280 mi^2 Redwood Creek basin. Diverted waters often create large, complex gully systems which are responsible for documented increases in hillslope drainage density, sediment production and yield, and enlarged stream channels. Sediment derived from these gullying processes is quickly and efficiently delivered to fish-bearing streams.

Similarly, mass soil movement of unstable sidecast materials may not occur for years following their placement, as organic debris decomposes and subsurface hydrology interacts with newly loaded slopes. However, because the roads are not maintained, these unstable sites are not recognized or treated as they develop. Existing failures, as well as signs of pending or potential road-related landslides, are common on many abandoned roads in the Pine Creek basin.

Once roads are constructed, the ability to define specific, existing road fills and sidecast sites as areas with high failure potential is essential to optimize cost-effective erosion prevention and road stabilization or removal practices. Field identification of important conditions enables the prediction of potential failure locations. Once identified, treatment can prevent most debris flows that originate directly from the failure of logging road fills. The limited number of road segments that are identified as potentially unstable can be assigned a high priority for treatment. Preventive, proactive treatment of susceptible sites will not only lessen eventual sedimentation and impacts to downstream resources, but will reduce reconstruction costs when access to the area is again needed.

Steps in successful, proactive, cost-effective road closure and abandonment include:

1) determine specific road treatment objectives (controlling current erosion for short term closure, preventing future erosion for longer term closure, or complete road removal (erosion proofing alignment with no intention of reopening))

2) map the road alignment to identify existing and potential erosion problem areas which could affect the roadbed or could damage downstream resources if left untreated (unstable cut banks or fill material, seeps or spring areas, and stream crossings),

3) develop road treatment prescriptions (including excavation locations and specifications, cut and fill requirements, and fill storage sites),

4) contract and/or supervise heavy equipment operations,

5) prescribe and apply the most cost-effective erosion control and revegetation treatments to "critical" sections of the disturbed corridor, and

6) fully document and evaluate the work effort (costs and hours) and results (effectiveness).

The first three planning and mapping steps have been accomplished for all abandoned Pine Creek roads as a part of this watershed assessment. During mapping, the location of all existing and potential erosion problems along the road alignment were clearly identified, described and quantified. The erosion problems were differentiated according to whether or not they: 1) threaten the future integrity of the roadbed, 2) threaten to damage downstream resources through increased sedimentation, or 3) both.

The volume of potential, future erosion and subsequent sediment yield from each potential work site was then quantified to finally determine the cost-effectiveness of treating each areas along the road alignment. Those possible treatments that are not cost-effective, or otherwise required, become lower priority elements of the road closure plan. Erosion problem areas and work sites that would, if left untreated, severely damage the road or cause downstream sedimentation in important streams become higher priority treatment sites.

The third step in developing a cost-effective road closure plan is to develop specific heavy equipment prescriptions and then (fourth) to implement the erosion control and erosion prevention work at the selected work sites. Typically, most abandoned road segments require intensive treatment at only a few locations. The remainder of the alignment may require very little work to prevent future erosion and maintain the integrity of the roadbed for future access.

There are seven basic heavy equipment techniques commonly used for road closure or road removal. Typical road surface treatments include (from least intensive to most intensive) surface decompaction (ripping), ripping and cross road drain construction, partial outsloping and complete outsloping. As a part of each surface treatment, stream crossings are treated (excavated) to reduce the potential for future erosion and sediment delivery. Successfully erosion-proofing most roads will cost a fraction of complete road removal and will leave most of the roadbed intact for later reconstruction.

Table 14. Techniques for successful erosion proofing in planned road abandonment.

Treatment	Typical Use or Application Site	General Costs*
Ripping or decompaction	improve infiltration; decrease runoff; assist revegetation	\$500-1600/mi
Construction of cross-road drains	drain springs; drain insloped roads; drain landings	\$1/ft (\$20 ea)
Partial outsloping (local spoil site)	remove minor unstable fills; disperse cutbank seeps and runoff	\$1.50/yd^3(\$2500 to \$9500/mi
Complete outsloping (local spoil site)	used for unstable fills where cutbank is dry and stable	\$1-\$3/yd^3 or \$5000-10000+/mi
Exported outsloping	used for unstable fills where cutbanks have seeps and springs	\$2-\$6/yd^3, haul-dependent cost
Landing excavation	used for unstable landing fills; spoil deposited locally	\$1-\$2.50/yd^3 wood controls
Stream crossing excavations	complete removal of fill where roads cross streams	\$2-\$2.50/yd^3; (2x if endhaul)

* Heavy equipment treatments performed using D-8 size tractors and hydraulic excavators. Redwood National Park data.

The fourth, and next-to-last, step in road closure is to control erosion on the areas disturbed during heavy equipment excavations, and then to revegetate the alignment. In most areas of Pine Creek, natural revegetation will be sufficiently rapid to stabilize the roadbed. However, even on the most favorable sites, immediate (short-term) erosion control may be needed at sensitive locations. These include 1) in the streambed of excavated stream crossings (to protect against downcutting or channel widening), 2) on the sideslopes of excavated stream crossings (to control surface rilling and gullying where sediment could enter a live stream) and 3) on large expanses of steep, bare soil which have access to a watercourse (to control surface rilling and gullying).

Most of these erosion control practices are performed using hand labor, perhaps with some equipment assistance. The costs and general effectiveness of these techniques have been documented for steeplands in the nearby Redwood Creek basin and elsewhere (Weaver and Sonnevil, 1984). A limited number of specifications have been described and specified in Appendix ___. These include straw mulching, grass seeding, the use of erosion control blankets and jute netting, planting stem cuttings and transplants, rock armoring for excavated stream crossings, and filter windrow construction.

Although included for reference, not all these labor-intensive erosion control techniques will be needed when erosion control and erosion prevention work is actually undertaken. Aside from some notes on the treatment sheets regarding the suggested use of straw mulch and grass seeding (see page four of the data sheets), most post-equipment surface treatments will be developed as detailed planning work is accomplished for each proposed site.

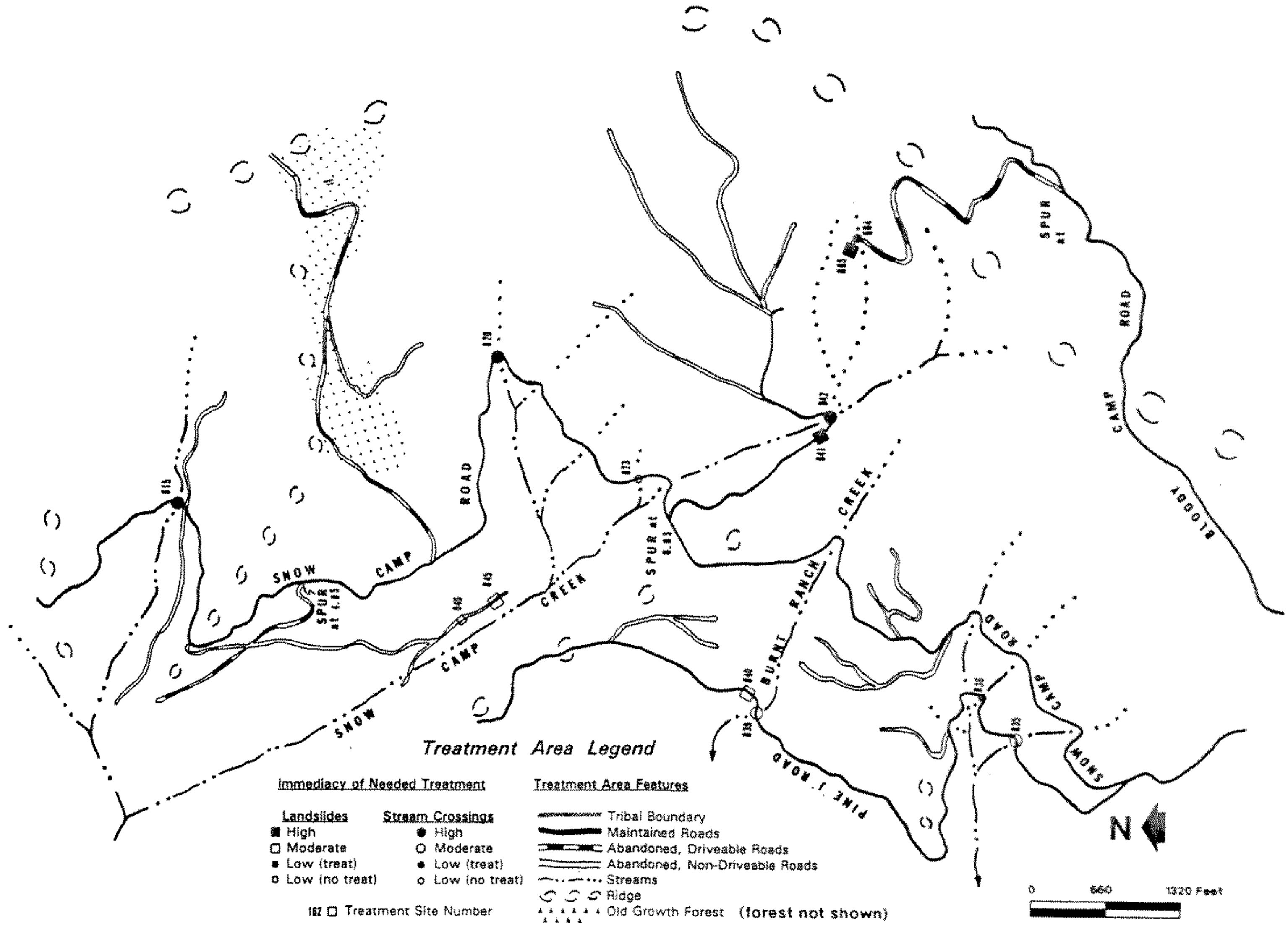
The fifth and final step in the road closure process consists of post-project documentation of work (rates and volumes) and costs (labor and equipment hours for each job element). Quantitative documentation is critical to derive cost estimates for future work, to improve the cost-effectiveness of work prescriptions and to justify future projects based on a comparison with typical costs of road reconstruction where road closure has not been performed.

It is no longer enough to close roads by simply closing the gate or constructing a barrier. Specific techniques listed and recommended in this report will successfully prevent many road- and landing-related debris flows, prevent or correct all stream diversions (the leading cause of serious gullying in many areas), prevent stream crossing washouts, prevent most fill failures and dewater gullies and landslides fed by road runoff.

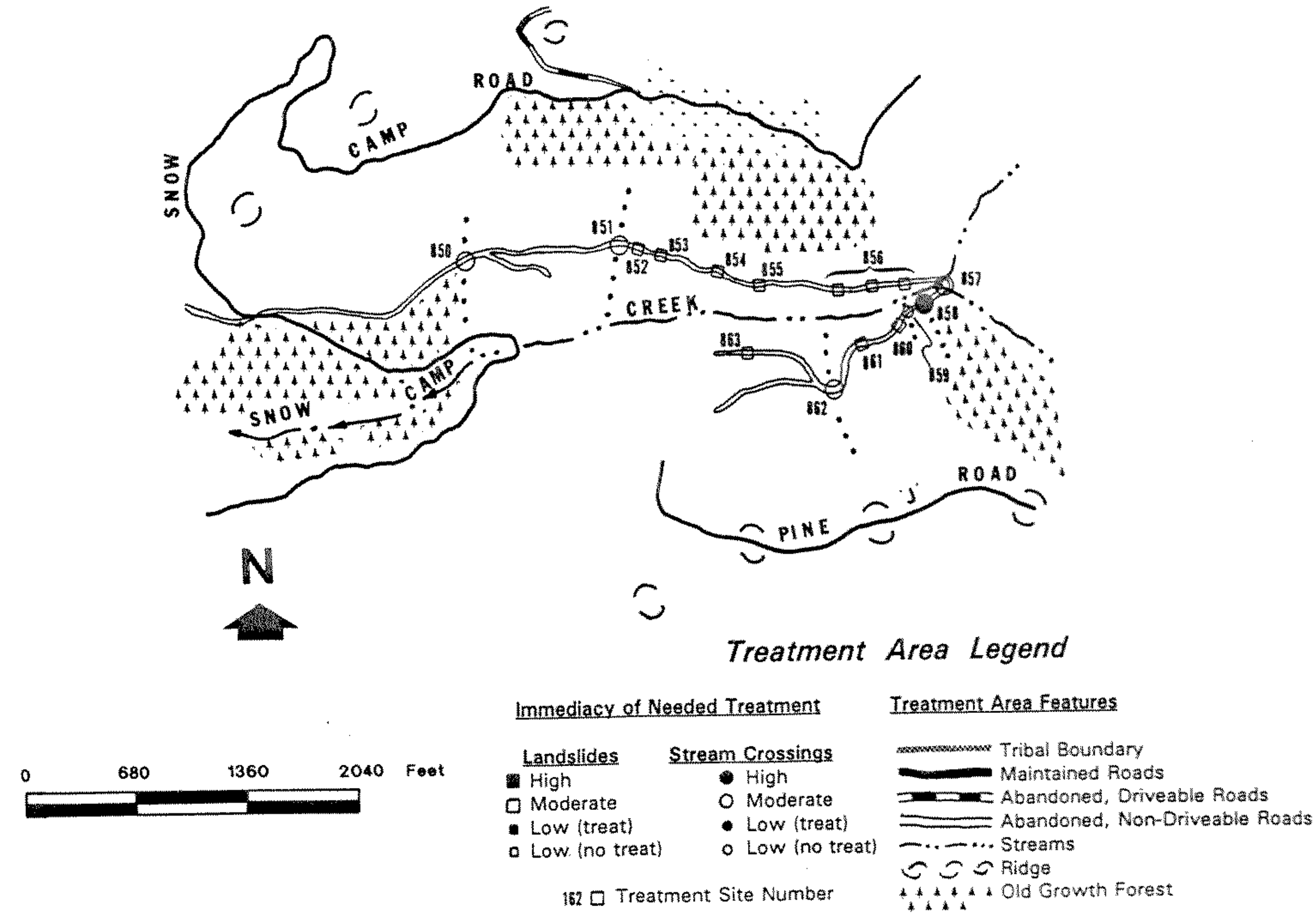
Planned, systematic road closure can be an inexpensive and successful technique for minimizing long term resource damage caused by roads built in steepland areas. This strategy provides the Tribe with the opportunity and plan to permanently prevent or control the majority of post-construction road-related erosion, and its associated on-site and downstream impacts. Implementing technically sound road closure practices also minimizes structural damage to widespread, expensive forest road networks that cannot (and need-not) be economically maintained for the long time period between harvest rotations.

In addition to retroactively treating roads which are now abandoned (as outlined in this plan), we strongly suggest the Tribe undertake a proactive road abandonment program for active forest roads that no longer access timber resources and will not be needed for a number of years. When the need for roads in an area has diminished, they should be actively abandoned. Alternately, if roads are not actively abandoned according to the procedures listed here, we recommend they be aggressively upgraded and maintained to currently accepted standards.

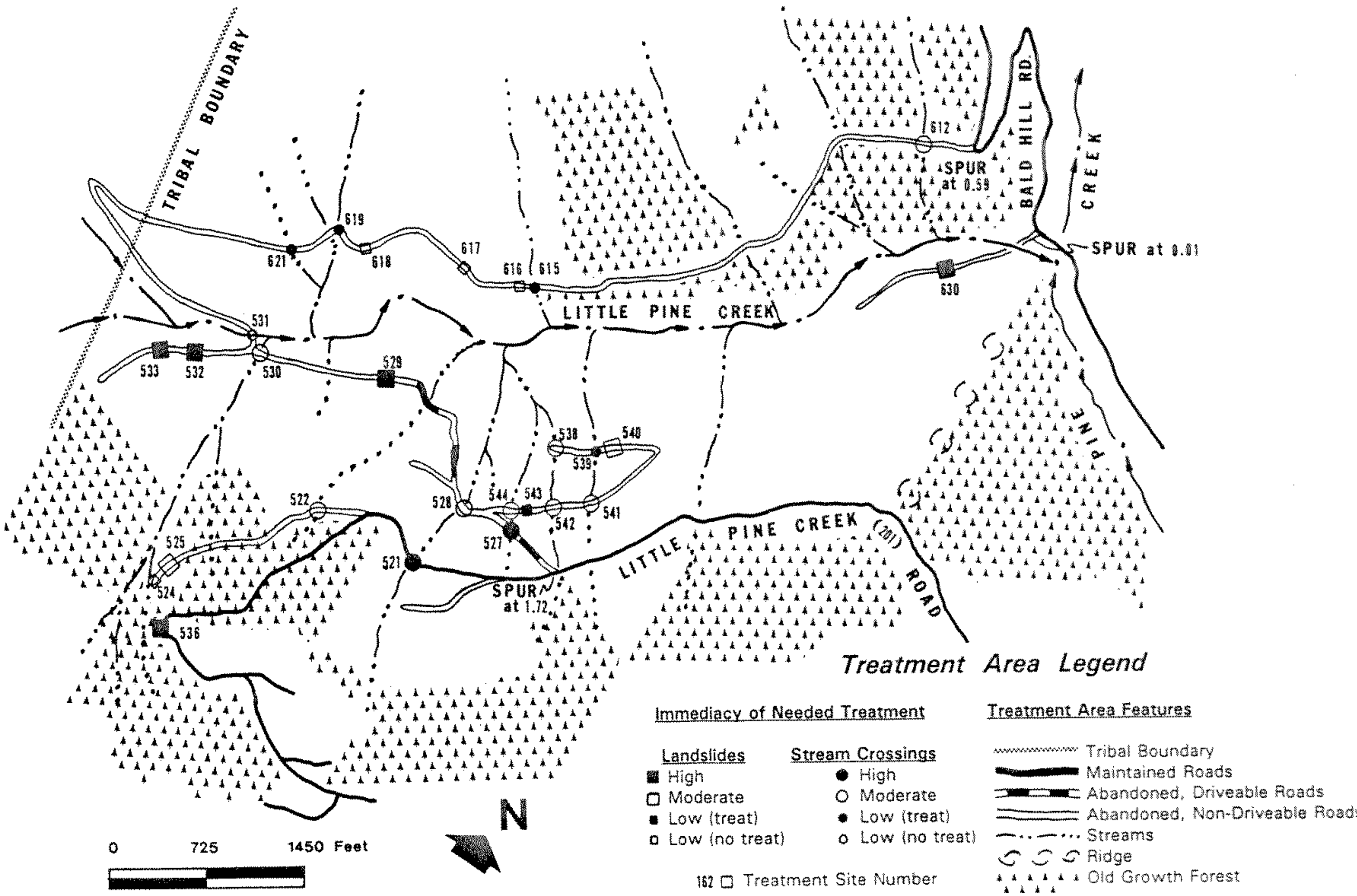
MAP 2. UPPER SNOW CAMP CREEK TREATMENT AREA.



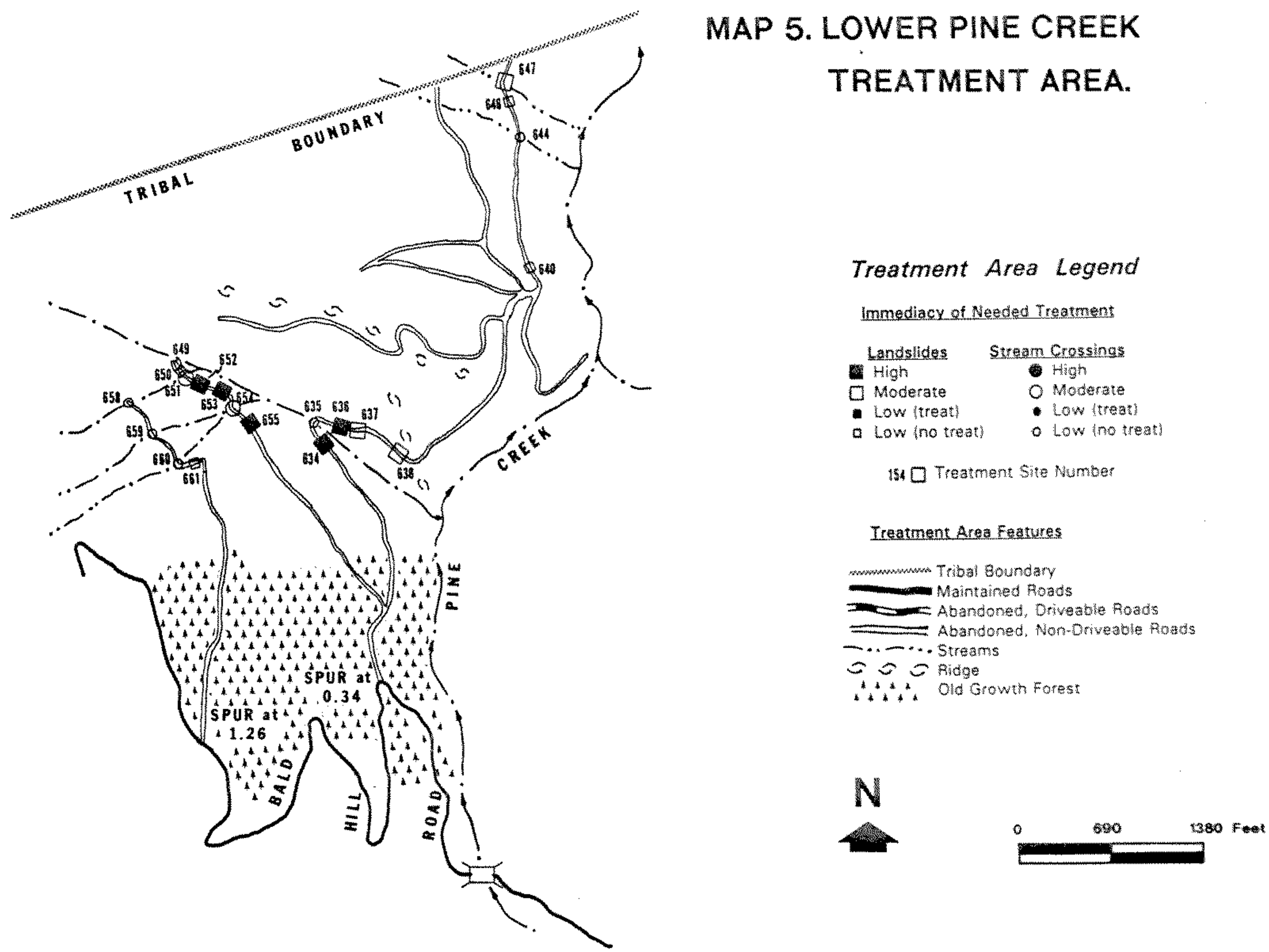
MAP 3. LOWER SNOW CAMP CREEK TREATMENT AREA.



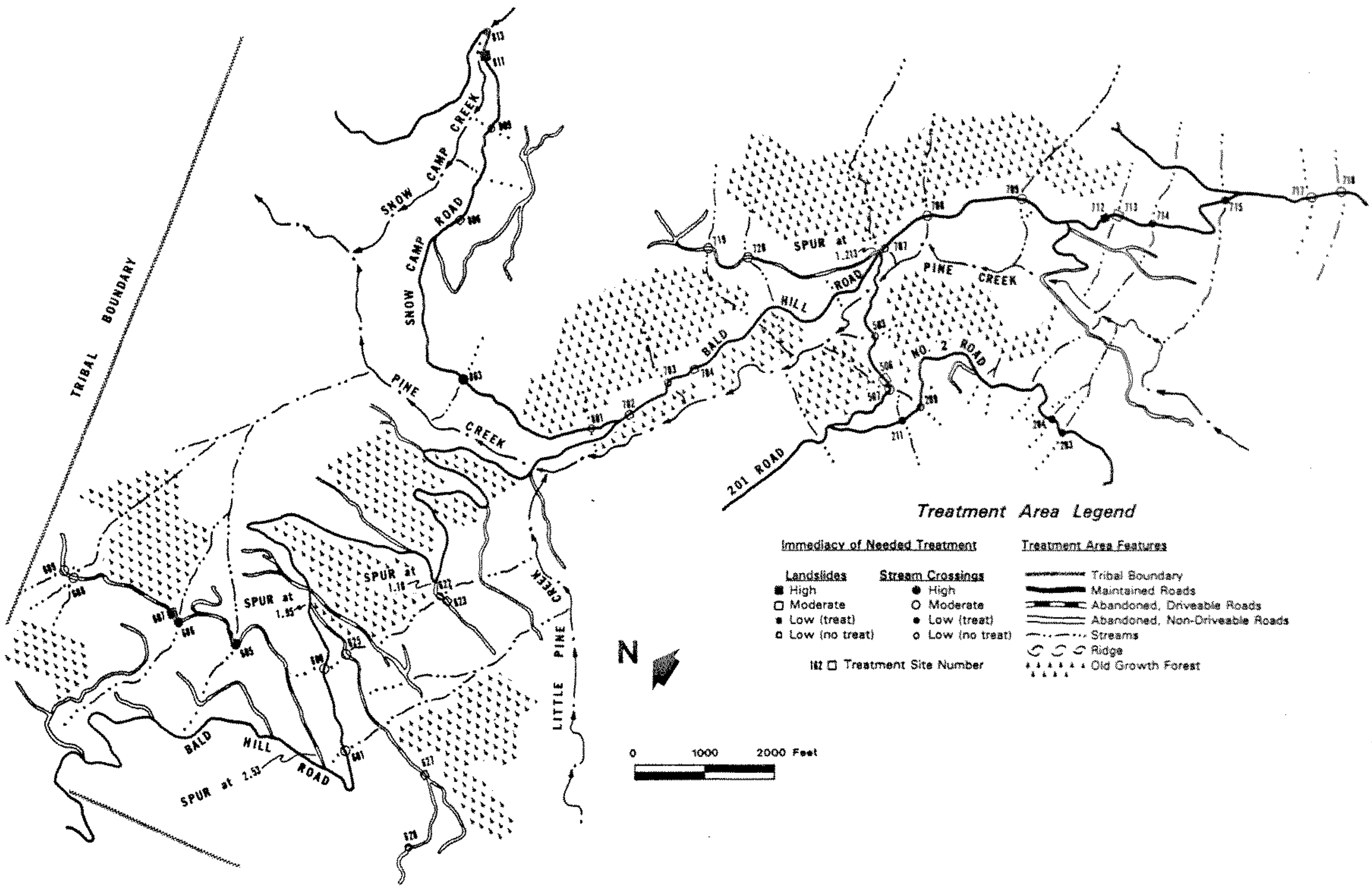
MAP 4. LITTLE PINE CREEK TREATMENT AREA.



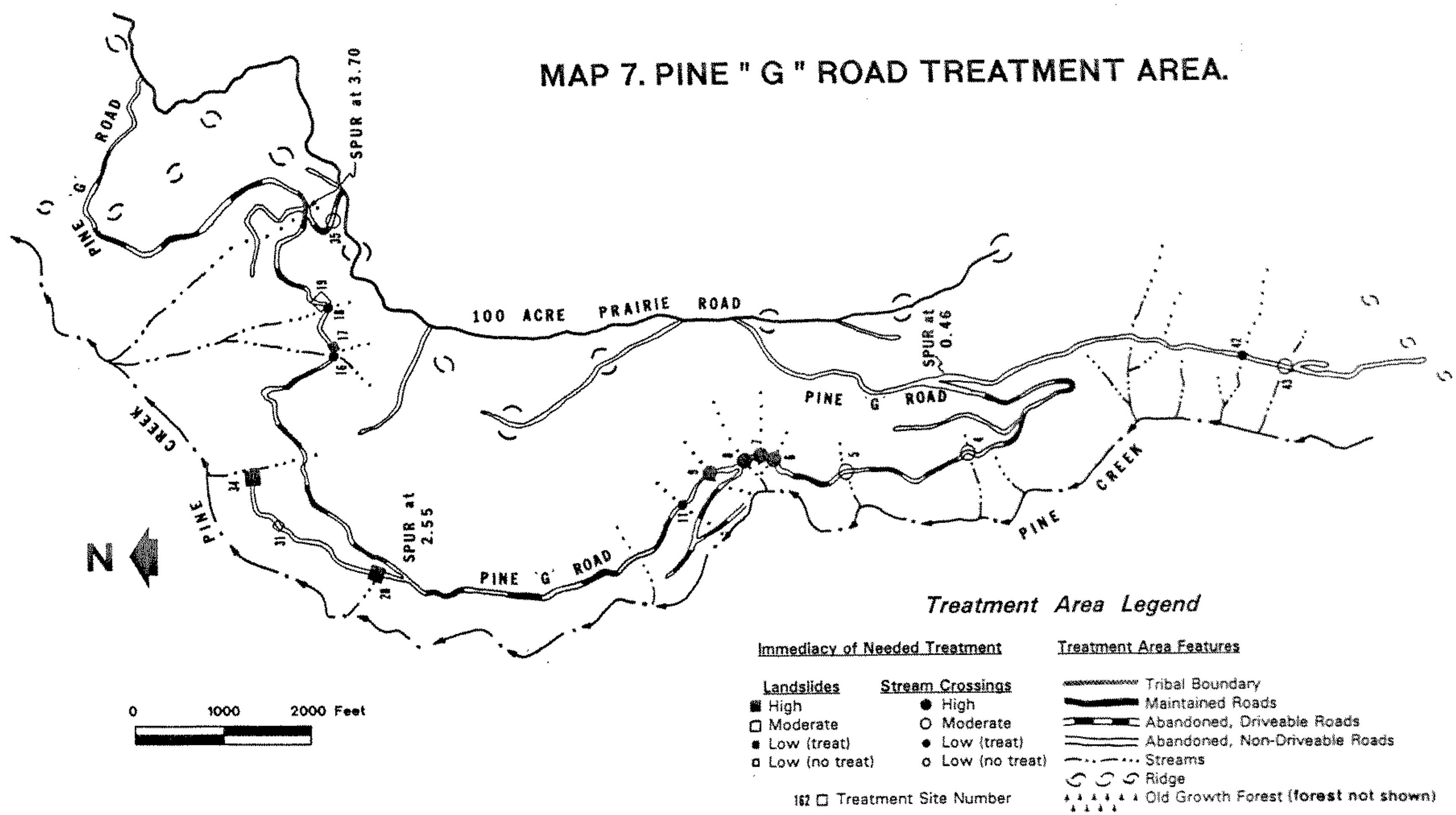
MAP 5. LOWER PINE CREEK TREATMENT AREA.



MAP 6. BALD HILL / SNOW CAMP ROADS TREATMENT AREA.

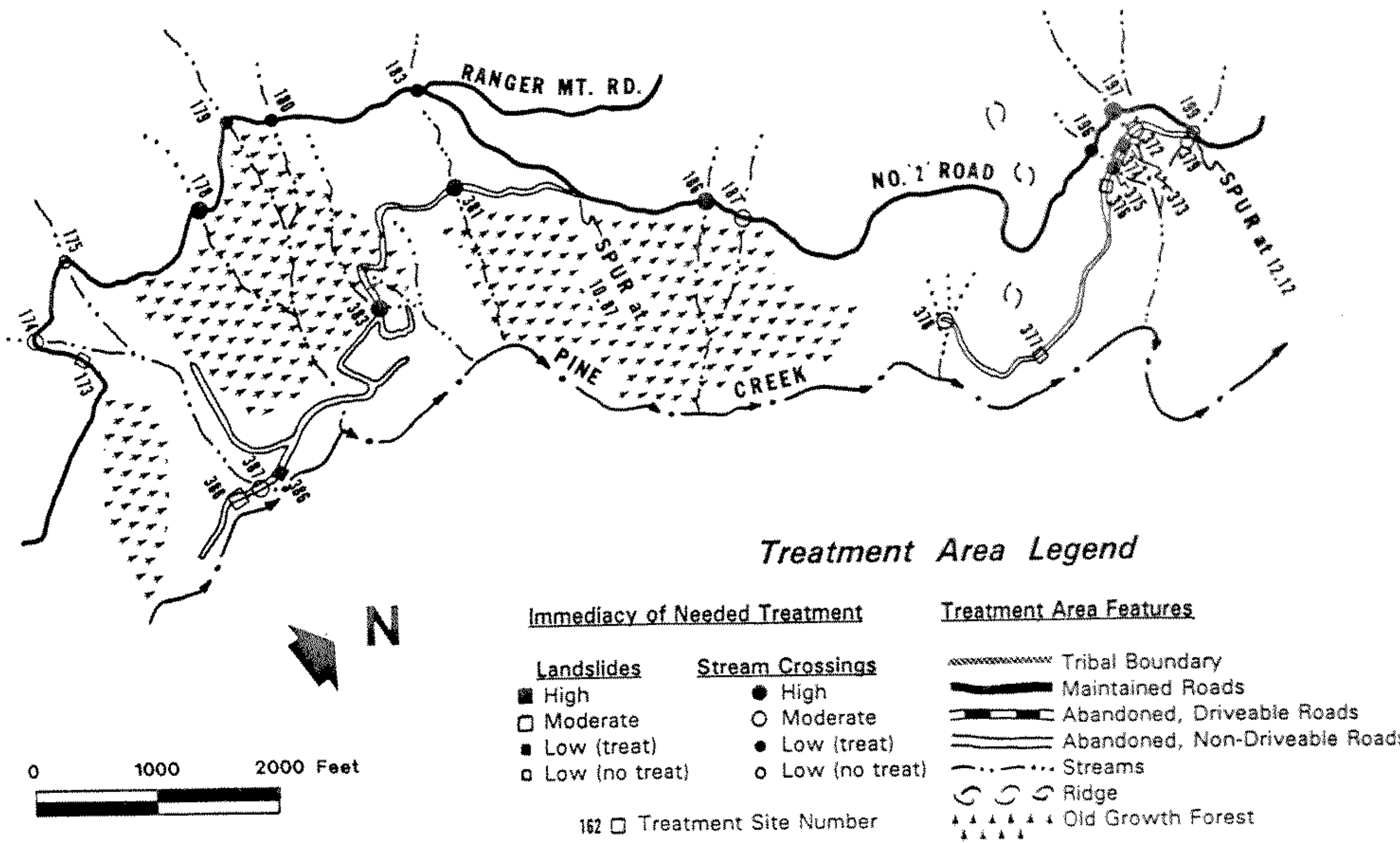


MAP 7. PINE " G " ROAD TREATMENT AREA.



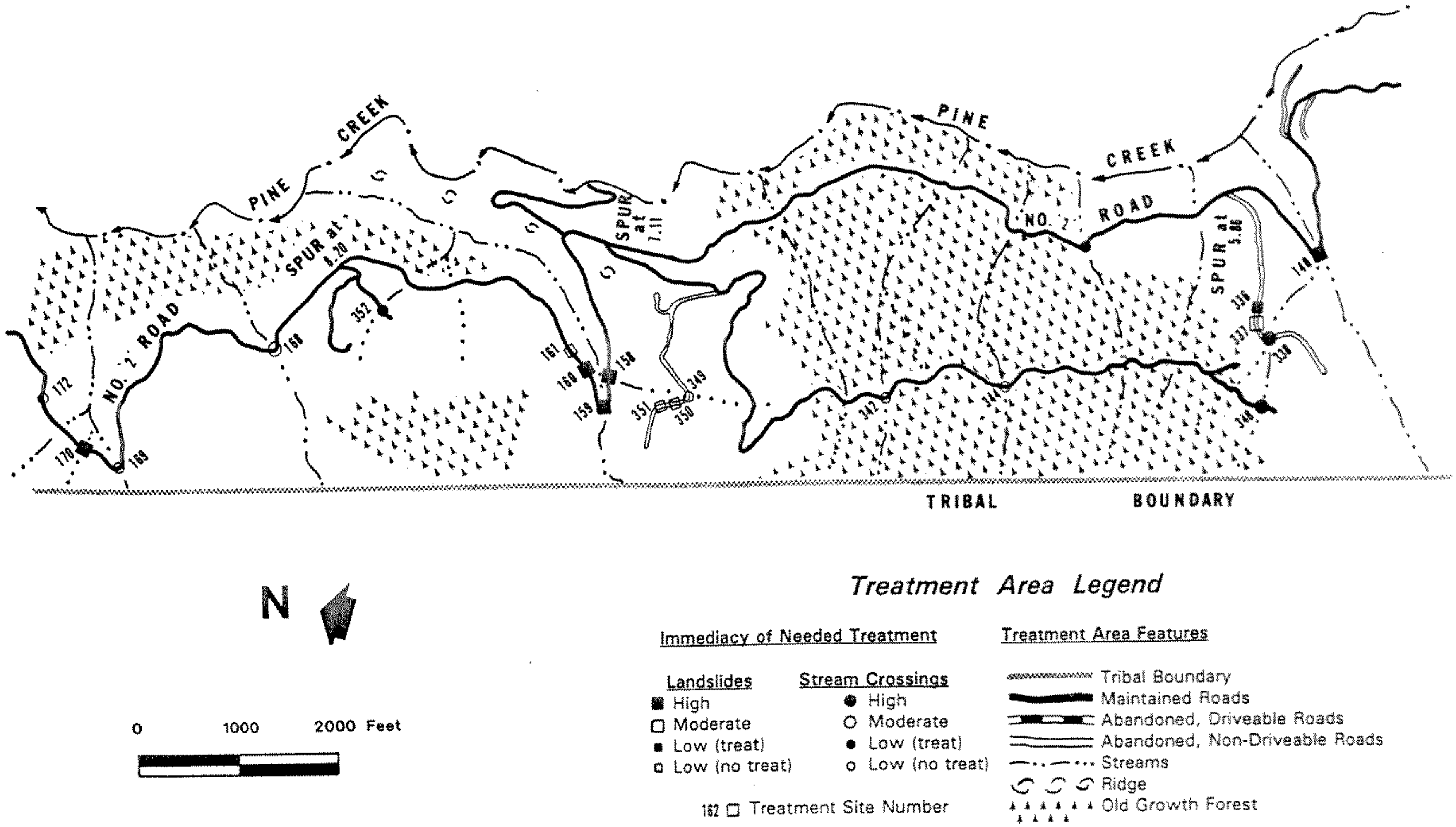
MAP 8A. NO. 2 ROAD & SPURS TREATMENT AREA, SHEET 1 OF 4.

(sheets north to south)



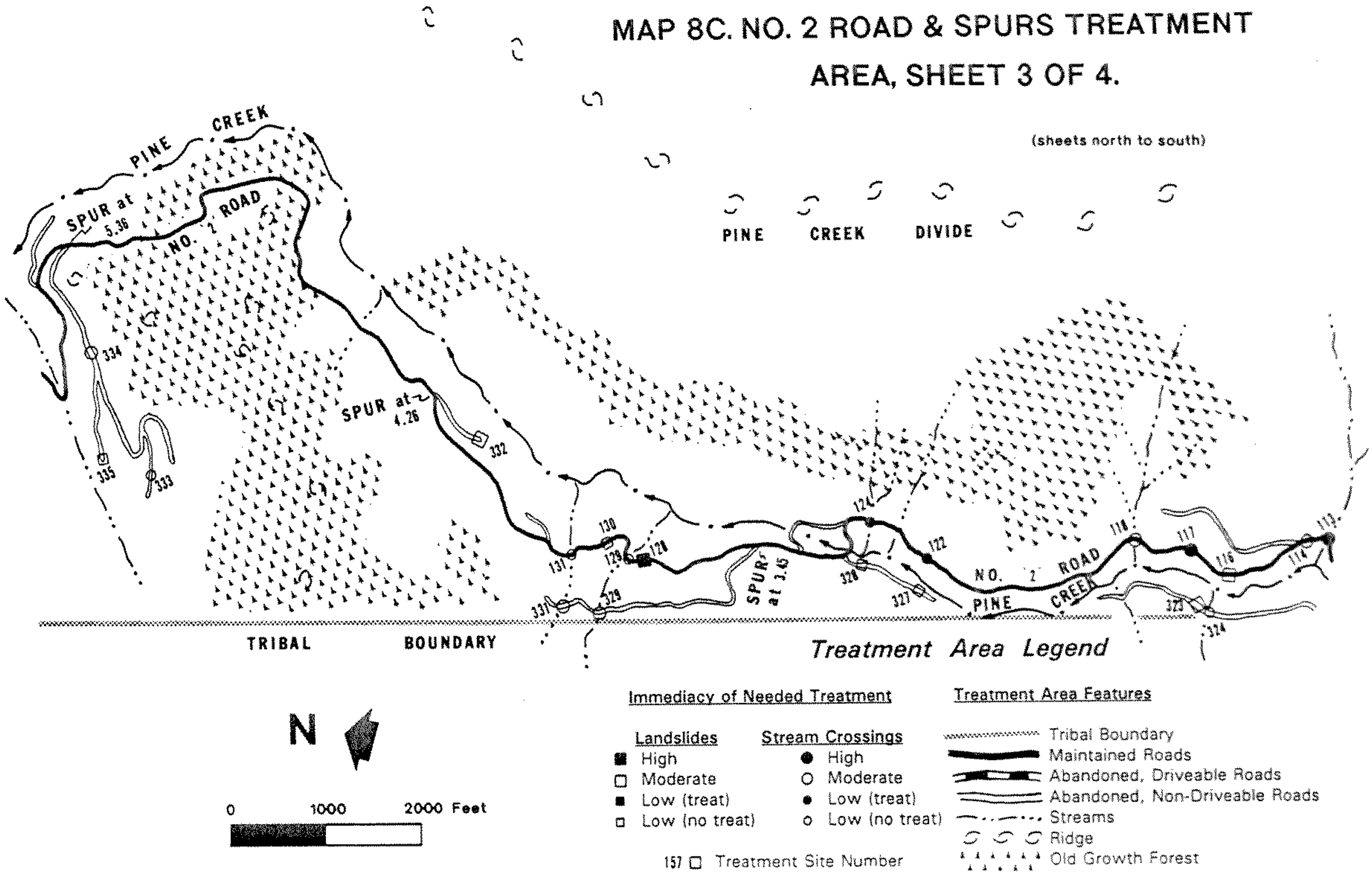
MAP 8B. NO. 2 ROAD & SPURS TREATMENT AREA, SHEET 2 OF 4.

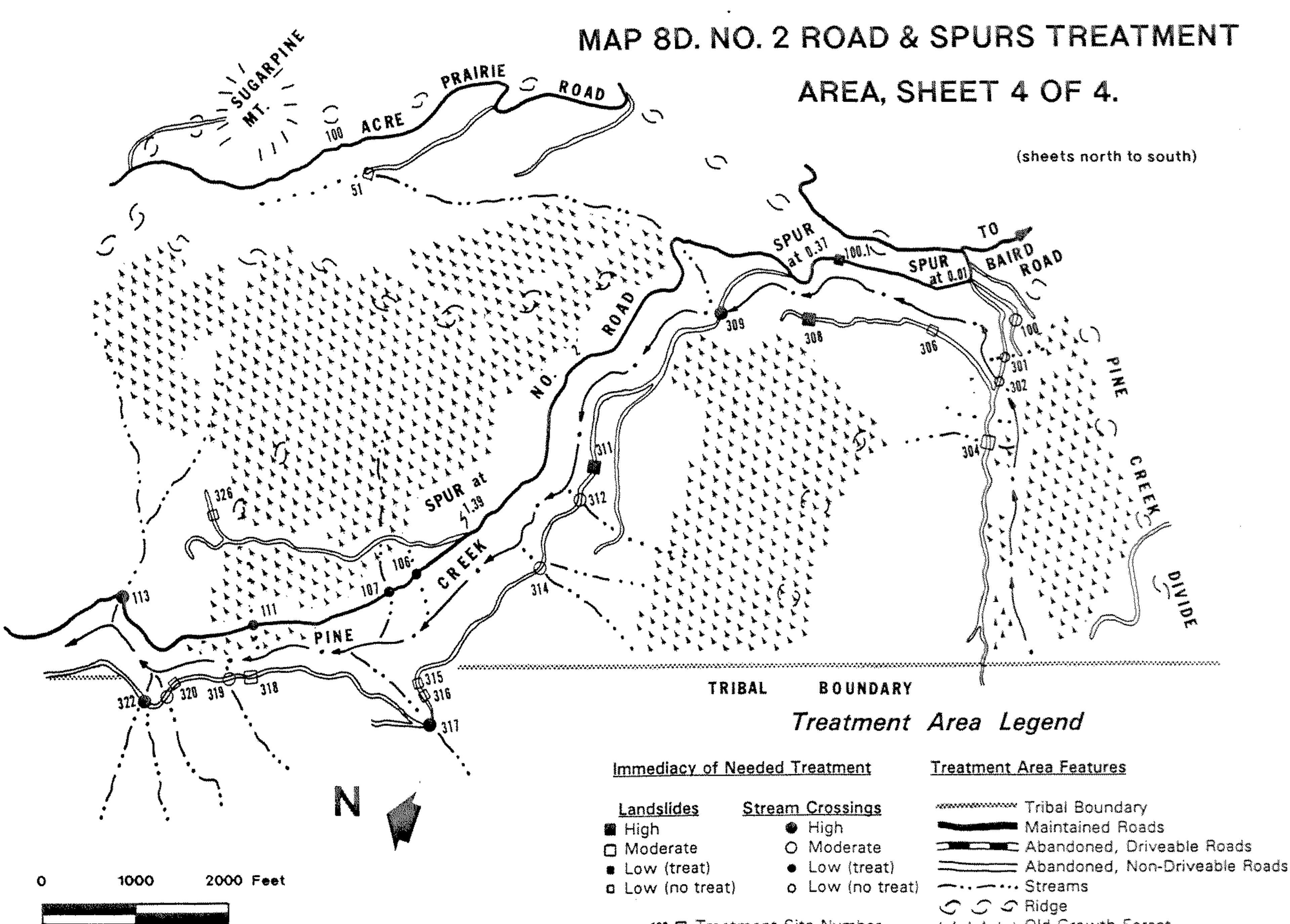
(sheets north to south)



MAP 8C. NO. 2 ROAD & SPURS TREATMENT AREA, SHEET 3 OF 4.

(sheets north to south)




MAP 8D. NO. 2 ROAD & SPURS TREATMENT
AREA, SHEET 4 OF 4.
(sheets north to south)
SUGARPINE MT.
ACRE PRAIRIE ROAD
100
51
NO. 2 ROAD
SPUR at 0.37
100.1
SPUR at 0.01
TO BAIRD ROAD
100
301
302
304
306
308
309
311
312
314
315
316
317
318
319
320
322
326
SPUR at 1.39
106
107
111
113
PINE CREEK
PINE CREEK DIVIDE
TRIBAL BOUNDARY
N
0
1000
2000 Feet
Treatment Area Legend
Immediacy of Needed Treatment
Landslides
High
Moderate
Low (treat)
Low (no treat)
Stream Crossings
High
Moderate
Low (treat)
Low (no treat)
162 Treatment Site Number
Treatment Area Features
Tribal Boundary
Maintained Roads
Abandoned, Driveable Roads
Abandoned, Non-Driveable Roads
Streams
Ridge
Old Growth Forest

Cook, M.J. and J.G. King, 1983, Construction cost and erosion control effectiveness of filter windrows on fill slopes, U.S.D.A. Forest Service, Intermountain Forest and Range Experiment Station Research Note INT-335, 5 pages.

Harden, D.R., R.J. Janda and K.M. Nolan. 1978. Mass movement and storms in the drainage basin of Redwood Creek, Humboldt County, California -- A progress report. US Geological Survey Open File Report 78-486. Menlo Park, California. 161 pages.

Harrigan, J and R. Scott, 1980, Main Stem Trinity River Watershed Investigation. California Department of Water Resources, Northern District. Red Bluff, Calif. 35p.

Haskins, D.M., J.D. Borum and P.J. Seidelman. 1980. A preliminary report on the mass wasting processes, geomorphic zonation, and landslide hazard analysis, South Fork Mountain Schist, Shasta-Trinity National Forest. USDA Forest Service, San Francisco, California. 43 pages.

Kveton, K.J., K.A. Considine, E.M. Babcock, R.G. LaHusen, M.S. Seltenrich, R.A. Sonnevil, and W.E. Weaver. 1984. Comparison of Slope Treatments for Reducing Surface Erosion on Disturbed Sites at Redwood National Park. In: Proceedings of the First Biennial Conference of Research in California's National Parks September 9-10, 1982. University of California at Davis, Davis, California.

Madej, M.A., 1988, Residence Times of Channel-Stored Sediment in Redwood Creek, Northwestern California. in: Erosion and Sedimentation in the Pacific Rim, Proceedings of an International Sympos. held in Corvallis, Oregon, August 3-7, 1987. pp.429-438.

Mathews, S., M.J. Furniss and T. Leskiw, 1990, A study of plant materials suitable for use in watershed and wildlife habitat improvement in the Trinity River watershed, U.S.D.A. Forest Service, Six Rivers National Forest, 165 pages.

Pitlick, J. 1982, Sediment Routing in Tributaries of the Redwood Creek Basin: Northwestern California. Redwood National Park Technical Report #8. Arcata, California. 67 pages.

Sonnevil, R.A., and W.E. Weaver. 1981. The Evolution of Approaches and Techniques to Control Erosion on Logged Lands, Redwood National Park, 1977-1981. In: Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, Calif. pp. 258-272.

Waananen, A.O. and J.R. Crippen. 1977. Magnitude and frequency of floods in California. US Geological Survey, Water Resources Investigations 77-21. Menlo Park, California. 96 pages.

Weaver, W.E. and D.K. Hagans, 1990, Techniques and costs for effective road closure. PWA Technical Report, 7 pages, in press.

Weaver, W.E., 1990, Watershed analysis: identifying, diagnosing and quantifying the relative importance of hillslope erosion processes. In: Proceedings, Eighth Annual Salmon, Steelhead and Trout Restoration Conference, Feb 23-25, 1990, 3 pages.

Weaver, W.E., D.K. Hagans and M.A. Madej. 1987. Managing forest roads to control cumulative erosion and sedimentation effects. In: Proc. of the California watershed management conference, Report 11 (18-20 Nov. 1986, West Sacramento, Calif.), Wildland Resources Center, Univ. of California, Berkeley, California, 6 p.

Weaver, W.E., M.M. Hektner, D.K. Hagans, L.J. Reed, R.A. Sonnevil, G.J. Bundros. 1987. An Evaluation of Experimental Rehabilitation Work, Redwood National Park. Redwood National Park Technical Report 19. National Park Service, Redwood National Park. Arcata, California. 163 pp.

Weaver, W.E. and R.A. Sonnevil. 1984. Relative cost- effectiveness of erosion control for forest land rehabilitation, Redwood National Park. In: Erosion Control...Man and Nature. Proceedings of Conference XV, International Erosion Control Association. February 23 and 24, 1984. Denver, Colorado. pp. 83-115.

Weaver, W.E., A.V. Choquette, D.K. Hagans and J. Schlosser. 1981. The Effects of Intensive Forest Land Use and Subsequent Landscape Rehabilitation on Erosion Rates and Sediment Yield in the Copper Creek Drainage Basin, Redwood National Park. In: Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 298-312.

Weaver, W.E., M.S. Seltenrich, R.A. Sonnevil, and E.M. Babcock. 1981. The Use of Cost-Effectiveness as a Technique to Evaluate and Improve Watershed Rehabilitation for Erosion Control, Redwood National Park. In: Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 341-360.

Wright, R.H., 1980, Lower Klamath River Basin Investigation. Earth Science Associates, Palo Alto, California: prepared for USDI Bureau of Indian Affairs. 98 pages, plus appendices.

PINE CREEK WATERSHED ASSESSMENT REPORT:

A PLAN FOR EROSION PREVENTION AND EROSION CONTROL

APPENDICES

APPENDIX A

Selected Technical Specifications A1 - A15

Appendix A

SELECTED TECHNICAL SPECIFICATIONS for EROSION PREVENTION AND EROSION CONTROL PRACTICES[1]

---

[1]SPECIFICATIONS FOR EROSION PREVENTION AND EROSION CONTROL: The following erosion control and erosion prevention specifications provide basic guidelines for rehabilitating roads and stabilizing bare soil areas exposed during road abandonment or during the heavy equipment phase of erosion control activities. These specifications are subject to revision and modification to fit individual site conditions. Descriptive specifications prepared by Bill Weaver, Pacific Watershed Associates, and Greg Bundros, Redwood National Park.

SECTION A: HEAVY EQUIPMENT OPERATIONS

SPECIFICATIONS FOR MECHANICAL EROSION CONTROL

1. Road and Landing Ripping

Ripping is employed to thoroughly decompact and disaggregate a road or landing surface in order to improve infiltration and speed revegetation. On a road, it is employed from the outboard edge to and including the inboard ditch. Typical equipment used for ripping compacted road and landing surfaces includes D-7 and D-8 size tractors with two or three hydraulically operated ripping or chisel shanks mounted on the rear. On roads which are less well compacted and not heavily surfaced with rock, graders or smaller tractors with chisel teeth mounted on their scraping blades can also be used for decompacting.

Ripping is performed at all fillsites (including where outsloping occurs) prior to the application of fill, and to all road and landing surfaces whether they are to be cross road drained or outsloped. Road and landing surfaces should be ripped before any other treatment is applied (eg., outsloping or storage of spoil materials). The ripping depth and the maximum spacing between adjacent ripper shank passes shall average 1.5 feet and spacing shall not exceed 2.0 feet.

Inboard ditches are not ripped where cross road drains are prescribed, nor are the remaining benches ripped along reaches where Exported Outsloping (EOS) is to be performed. In addition, the surface of stream crossing fills and other road fills which are to be completely excavated (eg., in EOS prescribed areas) need not be ripped if the fill is to be removed as a part of the rehabilitation treatment. In some cases, decompaction of these surfaces may make later excavations easier to accomplish.

2. Cross-Road Drains (XRD)

A cross-road drain is a deeply cut ditch, excavated across a road surface, which drains the road bed and inboard ditch. Cross-road drains are more substantial and deeper than conventional waterbars used to drain forest and ranch roads. Well constructed cross-road drains will often be deep enough to prevent vehicular access to an area. Cross-road drains are typically constructed (excavated) using a tractor, an hydraulic excavator, or a backhoe.

Spacing of cross-road drains is highly dependent on the permeability and erodibility of the soil which is exposed on the road surface. Drains in stable, forested areas may be spaced approximately 200 feet apart when road grades are less than 6%, and roughly 100 feet apart when road grades exceed 6%. In areas of erodible, decomposed granitic soils, road surfaces shall be drained at intervals not exceeding 50 feet, and more frequently if local soil conditions and road gradients dictate. Spacing and placement of cross road drains is usually established on a site specific basis that is determined by road gradient and road width, soil conditions and the location of seeps and springs that may contribute flow to the drain.

Each cross-road drain shall be free draining for its entire length, and have a uniform grade approximately equivalent to the gradient of the ditch or adjacent road surface which flows into the cross-road drain. The depth of the drain at its inlet side should equal the existing inboard ditch level, but shall never be less than 18 inches. In all cases, cross-road drains on ditched roads shall be deep enough to intercept all ditch flow.

Spoil is placed, compacted and smoothed on the downhill side of the excavated drain as a berm. Compacted fill and spoil is also used to completely fill the ditch at the drain inlet (where the drain intercepts the inboard ditch) to prevent ditch flow from bypassing the structure's inlet. Side-bank steepness along the drain should not exceed 50%. Existing inboard ditches are left undisturbed and free flowing to each drain.

No more than 15% of the total excavated volume of each cross-road drain may be sidecast at the drain outlet (there is a tendency to sidecast more material when the drain is built by a tractor). In areas underlain by decomposed granitic soils or other highly erodible soil, or where the drain is to discharge in close proximity to a stream channel, sidecasting shall be entirely avoided. This largely dictates the use of excavators and backhoes.

Cross-road drains shall not discharge onto the sideslopes of freshly excavated stream crossings, or onto long reaches of bare, unprotected slopes. On a site specific basis, energy dissipation (rock armor, secured slash or other suitable materials) will be required to control erosion at the outlet of the cross-road drain.

3. Rolling Dip (RD) Rolling dips are broad swales excavated into the bed of maintained roads in order to eliminate the potential for stream diversion of the culvert plugs during a storm and flood. At stream crossings with a high diversion potential, floodwaters back up behind a plugged culvert, flow onto the road surface (or into the ditch), and flow down the road. In a crossing with NO diversion potential, floodwaters that emerged onto the road surface travel across the road prism and back into the channel on the lower side of the crossing. In the worst case, the fill washes out.

The rolling dip should be broad and shallow enough to permit low-boys, log trucks and other equipment to pass without slowing traffic excessively or causing them to scrape bottom. The depth of the rolling dip will depend on the slope of the road as it crosses the stream crossing site. On a gently sloping road (<5%), the rolling dip may not be deeper than 0.5 feet over a 30 to 50 ft reach of road.

Rolling dips may be excavated over the top of the crossing, provided the culvert is deeper than the proposed excavation. If the culvert is located shallow in the crossing fill, the excavation for the rolling dip may be made immediately down-road from the crossing site. The excavation work can typically be performed exclusively with a crawler tractor in 1 to 1.5 hours time. If the road is surface with rock, addition rock may be needed at the site to resurface the rolling dip after the dip is installed.

4. Deep Drain (DD)

This is simply a miniature version of a stream crossing excavation (see item #5, below) that is constructed along roads or adjacent to streams. It is often constructed (excavated) to drain copious springs and small ephemeral streams that are expected to carry little or infrequent flow, even during design-size discharge events. Like a stream crossing excavation, the upper and lower limits to the excavation are marked in the field by the placement of "TOP" and "BOTTOM" flags. The drain's finished grade is typically a straight line profile.

The bottom of the Deep Drain shall be constructed at least four feet wide to minimize erosive power of the flow during design-size (25-year or 50-year) discharges . Side-bank steepness should be less than 50%, or the maximum stable slope for soils found at the site. Sidecasting at the end of the drain is not permitted. Depending on site specific conditions, the bed of the newly excavated channel may have to be protected with energy absorbing materials (high velocity erosion mats or rock armor).

4. Road Stream-Crossing Excavations (IPRX and ERX)

Specified at points where roads cross stream channels this treatment specifies the removal of road fill, culverts, and organic debris from a stream channel and its valley. In most cases, the finished excavation will closely mimic the original (pre-road) stream channel and valley morphology, as identified in undisturbed reached both above and below the crossing site.

Design considerations for an RX treatment include: 1) base levels, 2) channel grades, 3) channel widths, and 4) side-bank steepness. Stream channel excavations must begin at their lower ends at stable base levels. Stable base levels include gentle stream gradients, large, closely spaced and stable organics and/or exposed bedrock. Stable base levels can be "built" using imported rock armor.

Along the RX centerline (the centerline of the newly excavated stream channel), the upper and lower limits of a channel excavation are marked by the location of the "TOP" and "BOTTOM" flags, respectively. Between these two points, the finished channel grade is commonly a concave upward curve or, less commonly, a straight line. Concave profiles are much more stable and less prone to subsequent channel erosion.

Initially (at the downslope end), the channel excavation assumes a very low grade (essentially flat) to intercept the original stream channel. The grade then gradually sweeps upward, following the original stream gradient and tying into the undisturbed channel at the top of the crossing.

The completed channel width is based upon the anticipated runoff generated by a 25-year (or 50-year) recurrence interval storm. The influence that upstream drainage systems, urban development or landuse will have on the natural hydrologic response of these streams must also be considered when estimating future storm discharges and designing for channel capacity. Side-bank steepness - measured in cross section - is generally less than 50%, but should be tailored to the stability and erodibility of local soil materials found in the excavation.

During an RX treatment, the excavation must be closely monitored to identify and preserve the latent boundary conditions which control channel forming processes and promote stability. Boundary conditions which shall be preserved include original channel armor (organics and/or rock), bedrock outcrops and naturally introduced, large organics that are uncovered during excavation and which mark the original, pre-road location of the bed and banks of the channel.

Stream crossing excavations are performed most efficiently using a combination of tractors and excavators. Backhoes are generally too small to be effective. On most crossings, tractors can perform the bulk of the excavation, moving back and forth across the surface of the fill, lowering the surface and pushing material to stable sections of the road prism on either side of the crossing. This material can eventually be used to outslope these portions of the road. An appropriately-sized hydraulic excavator can then be used to finish the excavation work and lower the excavation down to the final channel grade. It is also used to form the channel bed and place any needed armor in the channel to prevent subsequent channel erosion.

On selected crossings, where the adjacent reaches of road cannot be used to store the excavated spoil material, dump trucks may have to be employed to remove the fill to a stable, permanent storage location. This type of treatment is called an "Exported Stream Crossing Excavation" (ERX). If there is sufficient local storage space for all the excavated material, the treatment is termed an "In-Place Stream Crossing Excavation" (IPRX).

5. Skid-Trail Stream-Crossing Excavations (SX)

This treatment is specified at points where bulldozer constructed trails cross stream channels. The intent of this treatment is identical to full stream crossing excavation, but the scale of the fill crossing is typically much smaller since the road was never used for vehicle traffic.

Depending on the terrain and remoteness of the work sites, either tractors or hydraulic excavators are the most efficient machines for excavating skid trail stream crossings. Because of their limited size it is often too costly to use both machines for excavating each crossing. On gentle and moderate terrain, tractors may be all that is needed to complete the excavation.

6. Outsloping (IPOS)

This treatment calls for the removal of unstable or excess sidecast material from the outer edge of a road prism and replacing this spoil locally on the adjacent, remaining road bench, or at another stable storage site (In-Place Outslope, IPOS). Where deposited against the adjacent cutbank, the fill is shaped into the cut to blend with the surrounding topography. A variety of different outslopes may be developed. These include complete recontouring, partial outsloping, bench outsloping, trail outsloping and exported outsloping (see below). Finished grades on the cut slopes rarely exceed 50%, but may be as low as eight to 10 percent. Individual points or reaches of cutbank which exhibit emerging groundwater (seeps or springs) are not covered with spoil material to avoid saturating the loose fill and initiating mass soil movement.

Outsloping is most frequently performed using a combination of crawler tractors and excavating machinery. Roads crossing moderate or gentle terrain can be outsloped with tractors alone. On steeper sites or where there are numerous trees along the alignment, hydraulic excavators are often the best tool for performing the outsloping work.

7. Exported Outsloping (EOS)

Through this treatment, either all or some portion of the outboard road bench and fill is removed, leaving an inboard bench. The excavated fill is exported (endhauled by dump truck or loader, or pushed by crawler tractor) some distance away to a stable fill-site. Exported outsloping is typically employed only in areas where fillslopes are composed of highly erodible or unstable material, or where the entire cutbank shows signs of springs and is judged an unsuitable site for storing spoil generated during outsloping operations.

Exported outsloping requires the use of dump trucks and excavating/loading equipment such as an hydraulic excavator, drag-line crane and/or front-end loader.

8. Treatment of Fillsites

In most cases, stable fillsites with adequate capacity are within a bulldozer's push distance from a worksite. Where local fillsites are not available for any particular worksite (reach of outsloped road or stream crossing excavation site), that worksite should be identified in the planning and prescription stage of the project and on the applicable prescription map. The fill from those worksites must be endhauled to a stable fill-site that is capable of holding the volume of exported fill. Rock pits, wide, stable sections of road, ridges and landings are typical locations where fill can be stored.

All fillsites shall be thoroughly ripped prior to importing and placing spoil material (see descriptive specifications for ripping above). The fill shall be placed first along the inside of the area (against the cutbank) and then extended outward from the cutbanks to approximately eight feet from the outboard edge of the road or landing. Fill thickness should grade down to not more than three feet along the outboard edge of the road to minimize the potential for mass movement (specific site conditions and circumstances may warrant modifications to these general specifications). The fill shall be shaped conformably into the existing cutbanks, not to exceed the height of the cutbank. The steepness of any finished fill-site shall not exceed 50%. The finished surface shall not trap or pond surface water and must encourage surface flow in the same direction as adjacent lands.

As the fill material is deposited by dump trucks, a crawler tractor can be used to intermittently shape and work the spoil material into place. On large fillsites, tractor work may be needed only intermittently.

SECTION B: SURFACE EROSION

SPECIFICATIONS FOR MULCHING AND SEEDING

1. STRAW MULCH

A. Definition of job. Straw from bales is spread evenly over a predesignated area at an application rate of 4,000 to 8,000 lbs/acre, as specified in the field. The straw will protect the soil surface from rainfall impact and help to retain soil moisture on biologically harsh sites.

B. Specifications.

1. Straw shall be spread evenly at the designated rate and within the designated bare and/or disturbed areas.

2. Baling wire shall be removed from the site and disposed of properly.

3. Straw shall be as free as possible from exotic seeds. Hay shall not be used.

4. Mulching shall be the last task performed on the work area, following any heavy equipment operations, contour terracing, silt fence construction, wattling, wooded terraces, transplants or grass seed and fertilizer application.

2. JUTE-SECURED STRAW

A. Definition of job. The bare soil is first covered with straw mulch (approximately 6000 lbs/acre) and then jute netting is secured on top. This procedure combines the effective surface protection afforded by straw mulch with the stability of the secured jute netting. Installation instruction provided by the manufacturer may also be used.

B. Specifications.

1. Smooth ground surface where the treatment is to be applied, removing lumps, clods and surface irregularities.

2. Apply uniform cover of straw mulch at 6,000 lbs/acre.

3. For ease of installation, roll jute down the fall-line of the hillslope.

4. Staple or secure jute on top of the straw with staples or stakes, on 2 to 3 foot centers, or as recommended by the manufacturer.

5. Staple all low points so jute is in continuous contact with ground.

6. Roll down second strip of jute netting, overlapping adjacent strip by approximately six inches. Staple overlapping areas.

7. Staple second roll to ground.

8. Repeat until ground is covered.

3. EROSION CONTROL BLANKETS

A. Definition of job. Erosion control blankets, typically purchased in four- to five-foot wide rolls, is spread and "stapled" over bare soil areas to hold soil in place and prevent surface erosion and rilling. "High velocity" erosion control blankets can also be used as a lining to control erosion in small channels. Erosion control blankets are available from a number of manufacturers. Most are composed of an organic mulch bound by a photo-degradable netting. Different thicknesses and fibers types are available to control erosion on slopes and in channels subject to different amounts of runoff. Most are very resistant to overland flow and act to disperses surface runoff and improve micro-site conditions needed for seed germination and seedling growth.

B. Specifications.

1. Smooth ground surface where the blanket is to be used.

2. For ease of installation, roll blanket down the fall-line of the hillslope or down the flow-line of the channel.

3. Staple or secure blanket with stakes, on 2 to 3 foot centers, or as recommended by the manufacturer.

4. Staple all low points so the erosion control blanket is in continuous contact with the ground.

5. Roll down second strip of blanket, overlapping adjacent strip by approximately six inches. Staple overlapping areas.

6. Staple second roll to ground.

7. Repeat until ground or the channel is covered.

4. GRASS SEED AND FERTILIZER APPLICATION

A. Definition of job. Grass seed and fertilizer are hand spread with "belly grinders" within flagged areas. Application rates are predesignated and seed and fertilizer may be provided. Grass will serve as an immediate, temporary ground cover to decrease surface erosion. Grass seeding can be an effective erosion control technique provided a thick, consistently uniform cover of grass is obtained prior to the advent of erosive rains. Its erosion control effectiveness is directly related to cover density.

B. Specifications.

1. When stored on-site, fertilizer shall be completely protected from dew and rain by plastic tarps. Grass seed must be stored under dry, cool conditions and protected from animals.

2. Application rates are listed as pounds of seed and pounds of fertilizer to be used in a specified area or, alternately, as pounds-per-acre of each.

3. Occasionally, no fertilizer is to be applied. This will be noted in the site-specific instructions.

4. Scales for weighing, buckets, "belly grinders," rakes and all other application equipment is to be provided by the contractor.

5. When a mixture of seeds with very different sizes and weights is to be applied care must be taken to ensure that seeds are evenly distributed in the mix, to obtain an even distribution on the ground. Since smaller seeds will settle to the bottom it may be necessary to periodically shake the belly grinder to redistribute the seeds or to mix the seeds with a dispersing medium.

6. Seed and fertilizer are to be applied as soon as possible after slope work (heavy equipment operations, contour terraces, wattling, wooded terraces, etc.) is completed in order to take advantage of warm temperatures accompanying the first fall rains. Seed and fertilizer are to be applied before mulching.

7. Seed and fertilizer (applied separately) must be spread uniformly over entire area.

8. Unless otherwise specified, seed and fertilizer are to be raked into the soil immediately after application, covering them with 1/8 to 1/4 inch of soil.

SECTION C: SURFACE EROSION

SPECIFICATIONS FOR WATERBARS AND CONTOUR STRUCTURES

1. WATERBARS

A. Definition of job. Waterbars serve to divert surface runoff from bare soil areas (typically trails, skid trails and roads) onto vegetated areas or other areas where the flowing water is less apt to cause soil erosion. To satisfactorily accomplish this purpose, waterbars shall:

1. Be of sufficient dimensions to accommodate the surface runoff they divert without being overtopped or otherwise failing.

2. Be located properly to successfully divert all the water they are intended to intercept (i.e., when used on a skid trail, they shall extend from the inside edge of the trail to slightly beyond the outside edge of the bare soil area).

3. Be angled down the slope sufficiently to allow water to drain through the trough of the waterbar and freely discharge at the correct end of the structure. Thus, the slope of the waterbar shall be sufficient to drain the intercepted surface runoff without allowing ponding, yet not so steep as to cause erosion or gullying of the bottom of the trough.

4. Be constructed so the lower or discharging end of the waterbar is clear and free from debris and allows for the free discharge of runoff.

5. Be constructed so the point of discharge is onto slash (organic debris), rock, or some other form of energy dissipation. Runoff through the downslope end of the waterbar trough shall not be allowed to erode the soil in that location or within at least three feet immediately downslope. Sufficient energy dissipation shall be provided to prevent future erosion resulting from diversion of flow by the waterbar. Waterbars which discharge on steep bare slopes may cause erosional problems if not installed with energy dissipation at their discharge ends.

B. Specifications for Constructing New Waterbars

1. Waterbar trough shall be excavated at least 8 inches into firm substrate (D=8").

2. Trough shall be at least 12 inches wide (W=12"), with a gentle uphill approach to the trough.

3. Trough shall be free and clear of debris or other obstructions so as to drain freely without ponding water.

4. Trough shall have a gentle slope toward the discharging end (there shall be a total drop of 6 inches to 18 inches along the run of a typical 10-foot long trough).

5. Trough shall abut inside bank of road or trail or otherwise be constructed to assure total diversion of runoff.

6. Berm shall be at least 8 inches high (H=8") and 12 inches wide (W=12").

7. Berm shall be composed of on-site inorganic sediment (rock and subsoil; preferably that material excavated from the trough) and shall

be tamped with shovel, feet or otherwise hand-compacted. No organic debris shall be incorporated in the berm.

8. Point of discharge shall be free and clear of debris so as to allow all water to drain freely from the trough.

9. Berm shall be constructed so as not to allow surface runoff to flow over or around it.

10. From point of discharge for a distance of 3 feet (slope distance) downslope, energy dissipation shall be placed in the path of the diverted surface runoff. This shall primarily consist of rocks 5 to 12 inches in diameter and secondarily (if sufficient numbers of rocks cannot be found within 100 feet of site) of slash or other woody debris no larger than 12 inches in diameter and 24 inches in length.

C. Specifications for repairing waterbars (winter maintenance; see figure).

1. Opening or unblocking point of discharge (Open end of waterbar): The discharging end of the waterbar shall be cleared of organic debris, soil and rock which is preventing or hindering the free flow of water from the trough. Energy dissipator shall be placed below the point of discharge if there exists a gully over 8 inches deep and wide at that point which extends at least 3 feet downslope.

2. Clean out trough of waterbar: The trough shall be cleaned of organic debris, soil and rocks so as to allow free drainage through the trough and across the point of discharge. If the bare slope below the point of discharge displays a gully greater than 8 inches in width and depth and 36 inches in length, energy dissipation shall be installed.

3. Extend end(s) of waterbar: Additions to an existing waterbar shall be built at one or both ends of the waterbar so as to prevent water from flowing around the waterbar structure rather than being diverted by it. Typically, the lower end is not extended far enough downslope, so the surface runoff entering the trough flows around the downslope end of the waterbar rather than through the point of discharge (Figure B-4b). If not present, an energy dissipator shall be provided at the outlet.

SECTION D: REVEGETATION

1. STEM CUTTINGS

A. Definition of job. A stem cutting is a shoot, or cane, cut from a live tree or shrub. Cuttings from sprouting plant species will grow if planted in the ground under certain conditions.

B. Specifications.

1. Prepared cuttings shall have the following characteristics:

   a. From healthy wood of a sprouting plant species native to the planting site.
   b. Reasonable straightness.
   c. Clean cuts with unsplit ends.
   d. Length: 12-inch minimum length.
   e. Diameter: 1/4 - inch minimum diameter; the thicker the cutting, the greater the reserves. Therefore, cuttings greater than 1 inch are desirable, though their numbers may be limited by the supply.
   f. Stem cuttings shall not be from the tips of branches, but rather farther back on the stems. The top of each cutting shall be just above a leaf bud, the bottom cut just below one (see sketch below).
   g. Trim branches from cuttings as close as possible.
   h. At least 2 lateral buds shall be above the ground after planting.

2. Preparing non-dormant cuttings:Leaves shall be stripped from cuttings which are to be used before normal leaf fall occurs. It is preferable to cut dormant stems.

3. Handling of cuttings between cutting and planting: Cuttings must not be allowed to dry out. Cuttings may be planted the same day, and at all times must be kept covered and moist during transport and storage before planting. Under certain dry conditions of either the cutting site or the planting site, the County Agent or his/her representative may require that cuttings be soaked at least 1 day prior to planting, though mandatory soaking will be uncommon. At no time shall a cutting be left exposed to the air to dry out prior to planting.

4. Planting of cuttings: Cuttings must be planted right-side-up. At least 50% of the cuttings length should be planted in the ground. It is preferable if 75% of the cutting length is in the ground, but at least two budding nodes shall be left exposed above ground. Deep planting minimizes loss of water due to transpiration and evaporation. Soil shall be firmly pressed around cutting to reduce moisture loss and improve soil contact.

5. Time of planting: Basically, planting time is between September and April. The earliest possible planting time for wet sites is after first major storm in fall (greater than 1 inch rain). For dry sites, the earliest planting time is after the second major storm. The latest possible date is dependent on the particular year, but will be approximately March 1st. Additional soaking prior to planting may be required for late plantings. Optimum planting time is October through February, when ground is wet and plant material is dormant.

6. Cutting willow and other brushy species for planting: Cutting of plant material for use as wattles or cuttings will be done to minimize disturbance of vegetation and soil adjacent to the willow stands.

Conifers must not be damaged. Ground cover must be preserved as much as possible. Willows should be used as efficiently as possible (i.e., when stakes) for wattles are cut, excess branches should be used as cuttings or wattle bundle material). Willow shoots must be cut by either pruning shears, hand saw or chain saw. Branches from willow must be cut diagonally to expose more surface area to water and to provide a pointed end for stake driving and planting the cuttings. The basal ends of the shoots must be marked clearly in some manner so workers can determine which end to plant. Correct species identification is essential, particularly in the willows and alders which often look similar but have different habitat requirements which in turn may result in different survival success. Species identification should be confirmed by qualified personnel before collection.

7. <u>Placement of stem cuttings and transplants:</u> The required planting distance between transplants and/or stem cuttings will be determined by the COR as "2-foot spacing" or "3-foot spacing" etc. The rows must be staggered rather than be in columns, as depicted in the sketch below:

```
          2'
      o   o   o   o   o            o   o   o   o   o
   2'                                  2'
      o   o   o   o   o              o   o 2'o   o   o

      o   o   o   o   o            o   o   o   o   o

      o   o   o   o   o              o   o   o   o   o

    2-foot spacing                   2-foot spacing
      Wrong Way                         Correct Way
```

Where the plan specifies planting in a zigzag pattern, <u>x</u> foot spacing, <u>y</u> foot offset, a double row is desired with x number of feet between each cutting or transplant in that row and the second row y number of feet to the side. For example, a zigzag pattern with 3-foot spacing and 2-foot offset would be planted as follows:

```
o    3'   o    3'   o         o         o
        2'
     o         o         o         o         o
```

2. TRANSPLANTS

A. <u>Definition of job.</u> Transplanting is the intact removal of an individual plant from one place and replanting it in another.

B. <u>Specifications.</u>

1. Although determining the size of an adequate root ball is necessarily a judgmental decision best made on a plant-by-plant basis in the field, all plants must be dug with a ball of soil containing at least 60% of their roots. If the soil is dry, the soil around the plant shall be soaked prior to digging so that the root ball will hold together. Plants must be transported to the site in such a way that the root ball does not shatter, exposing the roots (size of transplant and root ball varies with species; see species specific specification below).

2. All species shall be replanted within a maximum of 24 hours of being dug up. The root ball must be kept moist at all times to keep the roots from drying out.

3. The planting hole shall be large enough to accommodate the root ball easily, without cramping, bending or cutting roots. Adjust planting depth so that the old soil line (usually visible near the base of trunk or stem) is at the surface level of soil surrounding the planting hole.

4. The hole shall then be refilled about 3/4 full with soil, firmed around the roots and thoroughly watered. If settling occurs, the plant shall be readjusted and the remaining soil added, again firming the soil to eliminate any air pockets.

5. Transplants shall be obtained in such a way that at least one half of the original plants of the species remain scattered within the collection area. The source area must not be denuded of plants.

6. Holes created by removal of plants shall be filled with soil to the original soil surface.

7. Placement of transplants: See "Placement of stem cuttings and transplants" above.

SECTION E: CHANNEL EROSION

1. ROCK ARMOR

A. Definition of job. Rock armor is placed in small stream channels, gullies or other expected flow courses to increase turbulence and energy expenditures, slow velocities and eliminate scour of channel banks and beds. Rock armor to be used in stabilizing excavated stream crossings must meet approval of the County Agent.

B. Specifications.

1. Peak design period discharges (25-year recurrence interval) for the channel reach shall be calculated using an acceptable method or formula (Rational method, SCS, etc.). Estimates must be available for review and must be substantiated by field evidence.

2. For newly constructed channels, the channel bottom shall be made wide enough to handle peak flows. Wide, shallow channels are preferable to deep, narrow cross sections.

3. When channel excavation and rocking channel bed is called for, the channel shall be excavated in such a way that the bed is slightly concave. Rock armor will be placed far enough up the channel banks to contain anticipated heavy flow from the design discharge event. This will prevent failures due to flat-bottomed, rocked channels, where bank cutting can occur during high water.

4. In plan view, the upstream entrance to the rocked channel shall be U-shaped so that flow cannot be diverted along-side or around the rock armor.

5. Sufficient quantities of rock shall be used to adequately protect and armor the bed of the channel.

6. Rock sizes and/or securing techniques shall be employed to assure that peak flows do not remove the protective material. A heterogeneous mixture of rock sizes shall be used which contains enough large rocks (rocks which cannot be moved during peak flows) to keep smaller rocks in place. Where only small rocks are available, securing techniques such as staking or wire reinforcing must be approved in advance.

7. Rocks shall not be so large as to deflect streamflow into the banks.

APPENDIX B

Explanation for Watershed Inventory Datat Sheet B1 - B17

Appendix B

EXPLANATION FOR PINE CREEK WATERSHED INVENTORY DATA SHEET

Purpose: This work-sheet was developed for use in the field inventory of existing and potential erosion problems in the Pine Creek basin. It was used to identify and classify erosion problems, to prioritize potential work sites and to prescribe specific watershed treatments aimed at protecting and restoring fisheries resources.

Use of this work sheet was intended to provide a standardized and comparable analysis of observed features throughout the basin. Using the form, field personnel could measure, describe and interpret landforms and erosional problems in a consistent and uniform manner. In addition, data was collected in a computerized database format that should allow for inventory information to be reanalyzed in the future, or be included in other resource inventories.

Based on field observations and interpretive remarks provided on this form, land managers have been provided with a prioritized listing of the most critical, on-going and potential sediment sources within the basin. The database can be expanded or modified at any time, to accomplish other purposes. In addition, sites can be revisited in the future, if needed, to collect more specific data concerning related site characteristics, the level of current erosional activity or other data needed for planned land use operations.

The following text is provided to help explain the meaning of each question, and associated answer, contained on the database form. The form contains over 200 questions. Not all questions were applicable to each site identified in the field. Therefore, portions of each database form have been left blank. The instructions and comments below are directly keyed to the categories and questions listed on the data sheet.

SHEET #1 - Sites with past or future sediment delivery

1. Site Number: The identification name or number given this specific site. Each of the 445 sites has a unique ID or number for future reference which is shown on a base map or aerial photo, and which is used in database searches.

2. Mileage: For each site that could be reached by vehicle. a mileage is given from the starting point of that road or spur road. If the road was not driveable, the word "WALK" has been used instead of a mileage. The length of walking-roads has then been determined from digitizing maps or aerial photographs.

3. Major? (Y or N). The answer is Yes or No. A major site is one that has been subjectively characterized as having potential for significant sediment delivery to streams. The answer implies only that a subjective evaluation suggests that the site could yield a large volume of sediment. It says nothing about the likelihood that erosion would actually occur.

4. Minor? (Y or N). The answer is Yes or No. Minor sites have little potential for significant sediment yield. Good examples of Minor Sites include ditch relief culverts, inactive gullies, small stream crossings with no diversion potential, and landslides that would not deliver sediment to stream channels.

5. Date Mapped: The date the field mapping for this site was carried out.

6. Mapped By: The names or initials of those who did the field mapping for this particular site.

7. Photos Taken: A listing of any 35 mm ground photographs taken of this site. This will include a brief description of the subject whether or not they were taken in stereo.

8. Watershed: Always answered Pine Creek, for this assessment project.

9. Ownership: For the Pine Creek project, only lands under Hoopa Tribal ownership were inventoried. Private lands outside the Square were not evaluated as a part of this project.

10. Map Sheet: The USGS topographic quadrangle that contains this specific site.

11. Air Photo: The 1990 (scale = 1:12,000) color aerial photograph that was used in the field mapping of this site. Original field mapping information is contained on a frosted mylar overlay for each of the aerial photos covering the Pine Creek assessment area. The photographs used for this project are shown and listed on a large map (plate) of the study area.

12. Air Photo Date: The date the aerial photograph was taken, in 1990.

13. Air Photo Scale: For this project, air photo scale was always 1:12,000 (1 inch = 1000 feet).

14. Road Name: The name of the road which the site is located on, or nearest to. Since many of the spur roads do not have names, we often assigned names based on the mileage of the intersection with the main road it branches from. Main roads are given their common name (eg, No.2 Road).

15. Abandoned (Y,N): Answered "Yes," if the road is abandoned (unmaintained). The road may still be driveable, but it is classified if

there is no obvious maintenance to the culverts, the ditches are not cleaned, and vegetation is overgrowing the roadbed. If the road is not "abandoned," then it is considered "maintained."

16. Driveable (Y,N): If the road is still driveable, this is answered "Yes," even though the roadbed may be largely overgrown and the road is not maintained. If the road is impassable due to vegetation growth, erosion or slope movement, then the road is not driveable.

17. Minor Rebuild (Y,N): This question, and the next, indicate how much work it will be to open the road for equipment and vehicles to access identified sites for erosion control work. "Minor rebuild" includes work such as rebuilding small stream crossings that have partially washed out or regrading small failure scarps that cross the roadbed. Clearing extremely dense vegetation off the roadbed of old, abandoned roads is typically not considered a "rebuild."

18. Major Rebuild (Y,N): If a large stream crossing is washed out, or the entire roadbed has failed and must be reconstructed at a point, that location will require a "Major Rebuild" before equipment can pass to other sites farther out the road. All sites past that point will be classified as requiring a "Major Rebuild" in order to reach it. The site where the first major rebuild is required is not classified as needing major rebuilding, since access to that point is unrestricted.

19. Built by (yr): The first year the road showed up on aerial photographs. This may not be the year of construction. For example, many roads which first showed up on the 1990 aerial photos, but were not visible on the 1977 photos, were actually built in 1980.

20. Sheet (1,2,3): For the field survey and analysis, data were collected and sites were cataloged in one of three categories, termed Sheet 1, Sheet 2, or Sheet 3. Sheet 1 sites are those that have either delivered sediment to stream channels or have potential for sediment delivery in the future. Sheet 2 sites consist of stream crossings with no significant erosion potential, stream crossings with no diversion potential and ditch relief culverts. Sheet 3 sites consist of landslides and other sources of erosion (eg gullies) that have no past history or future potential for sediment delivery to stream channels.

20.5 Treat (Y,N): The answer to this question represents our final recommendation as to whether on not this site should be treated. "Y": Site should be treated. "Y?": Site should be treated if equipment is at or near the site doing other work. "N?": Consider treating this site only if equipment passes over the site and adequate funding is available. "N": This site is not recommended for treatment.

21. Sketch Present (Y,N): Was a separate sketch of the site made during the field mapping work? If a drawing was made, it can be found with the field notes.

22. Summary Comments: The summary comments for each site generally describe the nature of the erosion problem, important site characteristics and suggestions for possible treatments. The summary comments section is here to help the reader quickly gain a feel for the site without having to read all the detailed questions that follow.

23. Existing Debris Slide (Y,N): If the site contains an existing debris slide, one that has already failed (ie, more than just scarps are present; the failure has already occurred) then this should be classified as an existing slide. Existing debris slides can still have potential for additional

landsliding. Most existing debris slides are fairly shallow, and leave tear-drop shaped scars.

24. Potential Debris Slide (Y,N): This is a newly developing debris slide that has not yet failed and moved off the site. By far most treatable or preventable of the potential debris slides are associated with roads or landings located on steep slopes. Debris slides typically fail as rapid, catastrophic slides during heavy rainfall periods. Ground indications and site characteristics of potential debris slides may include unstable, oversteepened fills and debris on landings and roads built on steep slopes, locations in inner gorge areas or steep headwater swales, visible scarps or cracks in the road or on original ground, leaning trees, and/or emergent groundwater on steep slopes.

25. Deep Seated Slide (Y,N): These features usually cover fairly large areas with multiple scarp systems running through natural slopes and/or across roads and skid trails. Arcuate crown scarp regions display deep seated rotating slump features at the head and more translational movement in the middle sections. Along steep streamside areas, the lower section is often a site of shallow debris sliding. Characterized by emerging groundwater, leaning trees, active and inactive scarp systems, and episodic, seasonal movement from several feet to several hundred feet annually. Some may not move annually. Most deep seated landslides are difficult and expensive to control.

25A. Landslide Site? (Y,N): If any one of the landslide features (existing debris slide, potential debris slide, or deep seated slide) exists on this site, this question is answered "Yes." If this question is answered "Yes," this site contains some type of landslide.

26-37. Landslide indicators: Check those that apply with a "Y" for Yes.

26. Landing: Is the site located on a log landing?
27. Swale: Is the site located in a topographic swale?
28. Road Fill: Is the site located on a road fillslope?
29. Cracks: Are there cracks in the ground, suggesting slope movement?
30. Scarps: Are there scarps in the ground with distinct displacement?
31. Range: What is the range of scarp heights? (ft)
32. Average (ft): What is the average scarp height? (ft)
33. Evacuated: Is the slide area completely evacuated? (all gone?)
34. Wet Vegetation: Is there wet veg & shallow ground water at site?
35. Standing Water: Is there standing or ponded water at the site?
36. Leaning Trees: Does the unstable area have leaning conifer trees?
37. Other: Are there other indicators of slope instability?

38. Gully (Y,N): Answered "Yes" if this site contains a large gully as one of the major erosional features. Gullies are new channels that have a cross sectional area over 1 ft^2 (1'x1'). Gullies are caused by concentrated surface runoff (often below culvert outfalls, on skid trails or on large bare areas such as landslide scars) or by stream diversions. Anything smaller is considered a rill and lumped with surface erosion processes.

39. Rilling/Surface (Y,N): Answered "Yes" if this site is characterized by serious past or present surface erosion problems. Rilling and surface erosion occurs on bare soil areas that are not revegetating and typically show evidence of ravelling, sheet erosion and rilling. Most of the soil loss occurs by dry ravel during the summer and by raindrop erosion and rilling during high rainfall periods.

40. Stream/Channel (Y,N): Answered "Yes" if this site is characterized by erosion of stream channel banks or gullied stream channels. Gullied stream channels are those natural channels that have had additional water or increased sediment added to them and they have responded by widening and/or

deepening. Streambank erosion occurs where streams impinge on their confining banks during periods of high flow and cause scouring of the banks. Streambank erosion is often natural and unavoidable but can be accelerated by the build-up of bed deposits in the channel or by increases in discharge. Where necessary to reduce sediment delivery to the channel, banks can be physically protected, or excavated.

- When the stream flows through native ground the hillslope is often undercut and landsliding is initiated. In these areas both stream bank erosion and landsliding should be indicated on the check sheet since both processes have been active. The presence of bare, unvegetated, near-vertical stream banks often signals active channel erosion.

- When the stream flows through alluvial deposits (eg on a flood plain) it cuts away at the deposits as it migrates across the valley.

41. Stream Crossing (Y,N): Stream crossings are locations where ephemeral, intermittent or perennial streams cross a road. The crossing may be a culverted crossing, a Humboldt log crossing, or a fill crossing that has no drainage structure installed. This question is answered "Yes" if this site contains a stream crossing.

42-57: Stream Crossing data: Those that apply are answered.

42. Is there a Culvert? Bridge? Humboldt Log crossing or is it just Fill?

43. What is the culvert diameter, in inches?

44. Does the crossing have a high diversion potential? (Y or N) That is, if the culvert plugged, would flood waters spill over the road and back into the stream channel (No D.P.) or would the water flow down the road or ditch (High D.P.). All stream crossings (where roads cross over stream channels) have either no DP or a high DP. There are no other choices. If the crossing has No D.P., overflow might cause the fill to be washed out, but the streamflow would not be diverted out of its channel. If the crossing has a High D.P., the fill crossing at the point of diversion would not wash out but a gully would form down the road, in the ditch and/or where the water left the road and crossed the slope.

45. For High D.P. crossings, would the diversion go <50' or more than 50' down the road?

46. For High D.P. crossings, give the slope of the road as it falls away from the stream crossing, in the direction the diversion would occur? This is determined by standing over the culvert and shooting the gradient in the downslope or down-road direction.
Even "flat-looking" roads often have a gradient. Only a minimal gradient is necessary to create the diversion once the water is on the roadbed.

47. Does the crossing have a high failure potential? That is, is the culvert or other drainage structure (if there is one) have enough capacity to pass the 50 year storm flow? It has a high failure potential if the capacity is too small, or if the culvert could be easily plugged. This is where you estimate how likely the culvert is to plug in the next big storm. Consider the amount of mobile organic debris and sediment being transported in the channel and whether or not an adequate trash rack is in place (some crossings work fine without a trash rack because little debris moves in the channel during storms), and consider the condition and size of the culvert in relation to the expected flow from a 50-year runoff event.

48. Check CMP Size (Y,N): Should the flood discharge for this crossing be calculated to see if the culvert is large enough? This is typically done where it is not obvious whether or not the culvert is large enough.

49. Xing History (D,W,N,U): What has been the history of this crossing? Has it ever Washed out (W), has the stream ever Diverted (D), has it been functioning OK since it was installed (N=no problems), or is it Unknown if there has ever been a problem (U).

50. Plug Potential (H,M,L): What is the potential for this culvert (or Humboldt log crossing) to plug with sediment or woody debris? (High, Moderate or Low)

51. % Plugged: At the time of the inspection, how much of the inlet was plugged (%)?

52. Sed Transport (H,M,L): What is the relative capability of the stream to transport sediment (and thereby move sediment and debris down to the culvert inlet) (High, Moderate or Low)?

53. Ch Gradient (%): What is the gradient (%) of the channel above the crossing? (This gives another indication of the ability of the channel to move debris into the crossing, and perhaps plug the drainage structure inlet.

54. CMP Plug Cause (W,S,V): If the structure (usually a culvert) is plugged or could plug, what would plug it (Woody debris or Sediment)?

55. Now Diverted (Y,N): Is the stream now diverted at this crossing site? (Yes or No)

56. Pct Washed Out (%): If the crossing fill is partly or completely washed out, give the estimated volume which has been eroded, as a percent of the total fill that could erode (eg, the crossing is 50% washed out).

57. Comment: List any comment, especially as it relates to the stream crossing questions that were answered in the section.

58-83: Landslide Data: if this site is an existing or potential landslide, the following questions that apply are answered.

58. Natural (Y,N): Is the landslide on a "natural" slope (one not affected by timber harvest or road building). "Natural" implies that the erosion has no obvious landuse associations and/or it is occurring in undisturbed or old growth areas.

59. Cutblock (Y,N): Is the landslide feature in a cut unit? "Cutblock" implies that the erosion is occurring within a harvested areas or is associated with a past timber harvesting activity.

60. Road Related (Y,N): Is the landslide associated with a road? "Road related" erosion is that which appears to be caused or directly linked with road construction, landing construction or maintenance activities. Road related erosion could, for example, be a gully on a cutblock that was caused by runoff from a road culvert or stream diversion on a logging road. In this case the original cause was road related (not cutblock related).

61. Other: List any other location or association of the landslide.

62. Active (Y,N): Is the landslide active (moving within the last several years)? "Active" means the erosion is still occurring, even if it is not

at the same level as it once was. Gullies will have vertical, raw banks and/or active headcuts. Landslides will show recent, mostly bare scarps, recently tilted trees and perched blocks which have just started to move.

63. Waiting (Y,N): Features which are assigned the "waiting" classification are thought to be currently inactive (no signs of movement in the last several years), but the scarps and other indicators suggest that during an especially large storm the instability could become active and fail or move downslope.

64. Inactive (Y,N): Inactive features have partially or largely revegetated and show no significant signs of pending erosion or sediment delivery. Gullies will often have armor lag deposits in the channel bed. Landslides may be inactive even though vegetation is still sparse and it still looks bad.

65. % Vegetated: This is a subjective evaluation of the amount of vegetation on the surface of the instability.

66. Describe the Slide Surface: A general description of the surface of the slide, including vegetation, scarp systems, signs of moisture, etc.

67. Slope above (%): List the average slope gradient immediately upslope from the site.

68. Slope below (%): List the average slope gradient immediately downslope from the site.

69. Springs (Y,N): Answered "Yes" if the site displays obvious signs of emergent groundwater (springs).

70. Bedrock: Describe the general bedrock type underlying the site, as identified in the field (not necessarily on maps).

71-82: Eleven important soil and hillslope characteristics have been listed to indicate their presence at the site. These characteristics suggest a potentially high susceptibility for either gullying or landsliding, given the right combination of factors.

71. Soil (ft): List the soil, or colluvium, depth, in feet.

72. FewRx: Few course rock fragments in the soil suggest that concentrated runoff could result in big gullies (with no lag deposits to limit their size),

73. Coh: Very cohesive (clayey) soils would limit the amount of expected gullying but might suggest a susceptibility to mass movement,

74. Dg: Low cohesion soils, such as those developed on decomposed granitic bedrock, are very susceptible to both gully erosion and debris sliding on steep slopes,

75. Mot: Mottled or gleyed soils indicate high water contents for much of the year and are likely sites for slope failure,

76. DpColl: Deep colluvial or landslide deposits also suggest a possible susceptibility to both slope failure and gullying.

77. IG: Inner Gorge hillslope position, located within the steep side slopes of the inner gorge of a stream channel.

78. BIS: Break-in-Slope, located at or immediately below a distinct

- change in hillslope gradient (BIS) which leads from moderate slopes above the feature to steeper slopes below

79. HwS: Headwater Swale, located in a steep topographic swale.

80. U,M,L,S: Hillslope positions located in upper hillslope areas, middle hillslope areas, lower hillslope areas, or located in stream-side hillslope areas.

81. Conv, Pl, Diverg: Sites located on slopes which converge (are bowl-shaped), Diverge, or are Planar

82. Other: A listing of other important hillslope or soil characteristics which affect processes at the site.

83. Comments: This section is used to elaborate or clarify any other important elements related to information collected in the "site information" section.

84-113: Questions about past erosion and future erosion potential of the site. In this important section estimates are given of how much erosion occurred at the site in the past, how much of that was delivered to a stream channel where it might eventually impact fisheries resources, how much future erosion is to be expected from this site and whether or not it appears that the on-going or potential problem can be corrected. The details of actual treatments and prescriptions are then addressed on Sheet #4.

84. Past Erosion (yds): The volume of past erosion (yds^3) at the site is recorded. The volume is typically derived form field measurements.

85. Delivery (%): This is an estimate of the percent of the past eroded material that was actually delivered to the stream channels system.

86. (WxLxD): Measurements of the existing erosion feature, expressed as average Width X Length x Depth. If the feature is complex, several different measurements may be given to account for the entire feature.

87. Erosion Potential (H,M,L): The estimated potential for additional erosion is a judgement call, based on observations already taken, as to the potential for additional, significant erosion at this site. This is a probability estimate, not an estimate of how much erosion is likely to occur. The answer is either High, Moderate or Low.

88. Erode is a Normal Winter (Y,M,N): The answer is "Yes" if it appears that the feature is "ready to go"; that is, will erosion, landsliding or stream diversion likely take place very soon, or within a few moderate storms during a normal winter. The answer is "Maybe" if it is less certain, but it could erode or move in a normal winter. The answer is "No" is the feature appears stable to normal rainfall.

89. Move in a Big Storm (Y,M,N): This is answered "Yes" if it appears that it would move or erode in a relatively large return interval runoff event (10-year). Answer "No" if even a big storm would have trouble triggering erosion, sliding or diversion at this site.

90. St. Diversion yds^3 (<100,<500,>500): This is answered with the approximate expected volume of future erosion (yds^3) that would occur if this High D.P. stream were to divert down the road. Estimating how much erosion would occur from a possible stream diversion can also be fairly complicated. If an estimate can be made as to the possible final location of a newly formed diversion gully, it is possible to make an estimate of its eventual length and

cross sectional dimensions and to calculate a final volume. It often helps to see the size of gullies formed by similar stream diversions in the area to get a ball-park idea of a reasonable estimate. If there are rocky soils and shallow depths to bedrock, large gullies are unlikely to form. Conversely, streamflow diverted across areas of incompetent bedrock and deep, friable soils containing few rock fragments could cause the formation of extremely large gullies and a very high estimate for future erosion.

91. Future Erosion (yds^3): This is the estimated volume of future erosion, determined using the same techniques described in #84 and #86, above. It is determined by taking quantitative planimetric measurements in the field and calculating the size and volume of potential erosion that would be generated. This question calls for an estimate, but the estimate is based on field observations and measurements. For existing gullies, potential and existing landslides and potential stream crossing washouts it is possible to estimate the volume of erosion that is likely to occur in the future.

- Volumes are easiest to estimate for potential stream crossing washouts, because the fills placed in the channels when roads are built are fairly regular in shape and you can assume most of the fill would eventually be lost if the culvert plugged and the crossing washed out by fluvial erosion. - Next, oversteepened landings generate limited volumes of sediment when they fail by debris sliding, and these quantities can be estimated fairly easily.

- Existing, enlarging gullies lengthen, widen and deepen until they become stable and the final dimensions (hence volumes of future erosion) may be estimated. Indeed, many existing gullies that were formed during major storm events and still look raw may already be largely stable. Most sediment to be eroded from these features may well be limited to gradual bank retreat and collapse.

- Debris slides generated from steep headwater swale areas (usually where they are crossed by roads) are limited in size at the point of origination. However, debris slides generated at these sites often grow much larger as they move down the steep channels and scour debris from the channel bed. This makes their final volumes sometimes much larger than that estimated at the initiation site itself. Use your best judgement and base your volume predictions for such features on occurrences that have been documented or observed in your area. If your estimate includes additions of material scoured from channels and downslope areas, via these debris torrent mechanisms, make sure you differentiate the two sources on the check sheet.

- The future of volumetric yield of large translational landslides can be difficult to estimate largely because they move episodically, they move at unpredictable rates and they occasionally become self-stabilized after moving for a period of time. Such slides are typically bounded by scarps or other natural features that place an upper bound on the amount of material that is likely to move downslope and into a stream channel, but you must estimate what portion of that mass is likely to move downslope before the feature eventually stabilizes. Potential volumetric contributions from debris slides and other "fast" mass movements can be predicted much more easily than yields from episodically active translational landslides.

92. (WxLxD): Measurements of the potential erosion feature, expressed as average Width X Length x Depth. If the feature is complex, several different measurements may be given to account for the entire feature. These measurements describe the planimetric assumption used by field personnel to determine future erosion volumes.

93. Comment: Included here are any comments by field personnel regarding past or future erosion at the site.

94. Future Delivery (Y,N): Will future eroded sediment enter a stream channel? If any of the future eroded sediment will enter a stream channel and could eventually be washed to downstream areas, this question is answered "Yes." This is answered "No" only if all the eroded sediment will be stored on the slope and never move into the stream system.

95. Delivery Percent (%): This is an estimate of how much sediment (expresses as a % of the volume of expected erosion) that is likely to be delivered to the stream channel.

96. Can control erosion? (Y,N): Answered Yes if the erosion could be reasonably controlled or prevented.

97. How (E,H,B): This is a brief notation of how the erosion could be controlled or prevented. E, by the use of heavy earth moving equipment; H, by hand labor methods; and B, using both hand labor and equipment.

98. Correct diversion potential? (Y,N): If there is a diversion potential (DP) at the stream crossing site, could it be corrected (note: almost all of them can be!). Answered Yes or No.

99. How (E,H,B): This is a brief notation of how the diversion could be prevented. E, by the use of heavy earth moving equipment; H, by hand labor methods; and B, using both hand labor and equipment. Most work will be done by heavy equipment, unless the sites are very inaccessible.

100. Treatment Immediacy (H,M,L): The subjective answer to this question lets you decide if the work needs to get done right now! or later. Is the feature falling apart and going to change dramatically this coming winter? Does erosion at this site seriously threaten important downslope or downstream resources (eg spawning or rearing areas)? Answer "High", "Moderate" or "Low" (no big rush, but erosional problems or potential erosion source should be corrected in the future). This is question that field personnel summarized how critical it is to perform erosion control work at this site. This answer is based on the severity of the potential erosion, its volume, its predicted activity level and the sensitivity of the resources at risk.

101-110: Possible Treatments, "Y" is placed next to recommended treatments.

101. No treatment suggested at this site.

102. Replace the culvert.

103. Install a larger culvert.

104. Add a culvert to this stream crossing,

105. Clean the ditch or the culvert inlet or the culvert outlet.

106. Excavate a rolling dip over the crossing fill or immediately down-road from the crossing (if the culvert is too shallow to dig the dip over the top). This crossing has a high diversion potential.

107. Add a trash rack at the culvert inlet, or slightly upstream, or add a downspout to the culvert outlet.

108. Pull (excavate) this stream crossing fill. The road is abandoned and

if the fill is not removed it will wash out in the future.

109. Pull (excavate) this road fill and remove the material to a stable location. The fill on the outside of this road or landing is unstable and if it is not removed it will likely fail and move into a stream channel.

110. Other: List any other treatment not mentioned above.

111. Pot Extreme Eros (Y,N): Does this site display the potential for a great amount of erosion and sediment delivery during an extremely severe storm? For example, some small landslides can develop into very large slope failures if the conditions are just right. Does that situation exist here? The subjective answer is listed as Yes or No.

112. Vol (yds^3): This is the largest possible volume to erode or fail from this site, as estimated in the field.

113. Comment: Included are comments regarding the possibility of extreme erosion at this site, as well as any other information related to sediment delivery or erosion prevention treatments.

SHEET #2 - Stream crossings and ditch relief culverts with NO significant potential for sediment delivery

114. Steep Swale, Potential Debris Slide Location (Y,N): If this site is located where a road crosses a steep, wet, colluvial swale, it may be the site for a future debris slide. The is answered Yes only if this condition exists. It is typically left blank if the answer is No.

115. Ditch (Y,N): Answered Yes for ditch relief culverts.

115b. Stream (Y,N): Answered Yes for stream crossings.

115c. Spring (Y,N): Answered Yes for culverts draining springs and seeps.

116. CMP, Humboldt or Fill (C,H,F): Answered to denote the presence (or absence) and type of drainage facilities at the crossing.

117. CMP Dia (in): The culvert diameter, in inches.

118. TR (Y,N): Is a trash rack present to keep organic debris from plugging the culvert inlet? Answered Yes or No.

119. FP? (Y,N): Does this crossing have a high failure potential? See the discussion for Item #47 for the definition of failure potential.

120. Check CMP size (Y,N): Dos the size of the culvert need to be checked relative to the expected flood discharge of the channel (ie, might the culvert be too small?). See the discussion for Item #48, described earlier.

121. Fill Vol. (yds^3): This is an estimate of the volume of the fill material in the stream crossing.

122. Plug Potential (H,M,L): This is a subjective evaluation of the potential for the culvert (or Humboldt log crossing) to plug with sediment or organic debris. See also the discussion for Item #50, above.

123. How? (S,W,V): How would the culvert plug, with sediment (S), or with woody debris (W). See also the discussion under Item #54.

124. Past Erosion (Y,N): Has there been past erosion at this site (answered either Yes or No)?

125. Vol (yds^3): What was the volume of past erosion at this site.

126. Type: This is a brief description of the nature of the past erosion (gullying, rilling, ravelling, streambank erosion, etc).

127. Future Erosion (Y,N): Will there be future erosion at this site (answered either Yes or No)?

128. Vol (yds^3): What is the expected volume of future erosion.

129. Type: This is a brief description of the nature of the expected future erosion (gullying, rilling, ravelling, streambank erosion, etc).

130-138: Possible treatments to be applied to this Sheet #2 site, answered Yes if needed or suggested.

130. Repair or replace the existing culvert.

131. Add a culvert or install a larger culvert.

132. Add a trash rack at the culvert inlet, or slightly upstream.

133. Add a downspout or energy dissipator to the culvert outlet.

134. Clean the culvert inlet or the culvert outlet.

135. Clean the ditch leading up to the culvert.

136. Excavate a rolling dip over the crossing fill or immediately down-road from the crossing (if the culvert is too shallow to dig the dip over the top). This crossing has a high diversion potential.

137. No treatment suggested at this site.

138. Other: List any other treatment not mentioned above.

139. Comment: Listed are any other comments associated with the Sheet 2 site. By definition, there should be no significant past or future potential for sediment delivery from this site.

SHEET #3 - Landslides and Other Erosion with NO significant potential for sediment delivery

140. Existing Debris Slide (Y,N): See discussion under Item #23. There should be no past or future delivery from this site.

141. Potential Debris Slide (Y,N): See discussion under Item #24. There should be no past or future delivery from this site.

142. Deep Seated Slide (Y,N): See discussion under Item #25. There should be no past or future delivery from this site.

143. Other (Y,N): If other types of erosion occurred but did not result in sediment delivery (such as gullying, rilling, etc.) this question is answered Yes. It is generally left blank if the answer is no.

144. Landing (Y,N): See discussion under Item #26. There should be no past or future delivery from this site.

145. Road Fill (Y,N): See discussion under Item #28. There should be no past or future delivery from this site.

146. Other (Y,N): This is answered Yes if the instability is located at a site other than the road or landing fill.

147. Active (Y,N): This describes the current activity level of the feature. See discussion under Item #62.

148. Waiting (Y,N): This describes the current activity level of the feature. See discussion under Item #63.

149. Inactive (Y,N): This describes the current activity level of the feature. See discussion under Item #64.

150. Slope (%): This is a measure of the hillslope gradient immediately beneath or downslope from the instability.

151. Springs (Y,N): See the discussion of this under Item #69.

152. Bedrock: See instruction for Item #70.

153. Inner Gorge (Y,N): See instructions for Item #77.

154. BIS (Break-in-Slope): See instructions for Item #78.

155. Steep Swale (Y,N): See instructions for Item #79.

156. Other: If the landslide is located in some other hillslope location, that location is described here.

157. Past Erosion (yds^3): See instructions for Item #84.

158. (WxDxL): Physical measurements of the past erosion. See also discussion under Item #86.

159. Erosion Potential (H,M,L): See instructions and description for Item #87.

160. Storm Dependent (Y,N): Is this potential instability dependent on a large storm to move? This is a subjective evaluation made in the field.

161. <u>Future Erosion (yds³):</u> See instructions and discussion for Item #91.

162. <u>(WxDxL):</u> The expected measurements of the future landslide. See also discussion under Item #86.

163-165: <u>Possible treatments</u> for this site are listed here.

163. <u>No Treatment:</u> Most of the Sheet 3 sites will require No treatment, since there is not expected to be any sediment delivery to stream channels. This question is answered either Yes or No.

164. <u>Pull Fill:</u> In a few circumstances, recommendations may have called for the excavation of unstable fill material. This question is answered either Yes or No.

165. <u>Other:</u> Listed are any other recommended treatments for the site.

166. <u>Comment:</u> Included here are any other comments regarding this Sheet 3 site.

SHEET #4 - Treatments for Sheet 1 Sites

Vol Saved (yds^3): This is an estimate of the volume of sediment that will eventually enter the stream system if treatments on Sheet #4 are not performed. This is often the same volume as listed as the "Future Volume" on Sheet #1, but may be slightly larger if stream diversion volumes are included with the site.

167. Treatment Type, answered with a "Y" (Yes) for all recommended treatments:
  - IPOS; In-Place Outslope
  - EOS; Exported Outslope
  - IPRX; In-Place Stream Crossing Excavation
  - ERX; Exported Stream Crossing Excavation
  - XRD; Construct cross-road drains or waterbars
  - RD; Construct (excavate) rolling dip over crossing
  - Other; if answered "Yes", the description is included under the comment section of the next Item (#168).

168. Comment: Included are any comments on the suggested treatments for this site.

Fillslopes - Questions related to the excavation of unstable fillslopes.

- Volume Generated per Foot of Road (yds^3): This value typically ranges from 0.5 to 3.5 yds^3 per foot of road for most fillslope excavations. This value is used to help determine the amount of material which needs to be removed.

- Total Excavated Volume (yds^3): This is the total volume of material which must be excavated from the unstable fillslopes at this site. This volume is used to help predict costs and equipment times needed to perform the excavation work. In addition, it is used to help determine whether endhauling will be necessary to dispose of spoil from the site.

- Available Storage Volume (yds^3): From measurements in the field, the available storage volume is calculated and compared to the total excavated volume to determine the need for endhauling equipment. If local storage is insufficient, additional storage sites will have to be found in nearby areas along the road.

- Comment: This space is used to comment on possible storage locations, endhauling needs, and fillslope excavation requirements.

Stream Crossings - Questions related to the excavation of fill crossings on abandoned roads.

- Estimated Volume of Fill Crossing (yds^3): This is actually the estimated volume of material that will have to be excavated from the stream crossing site to prevent future erosion and sediment delivery. In many cases, because the stream banks must be sloped back to a stable gradient, slightly more sediment will have to be excavated from the crossing than would eventually fail or be washed away by fluvial erosion.

- Is Local Storage Available (Y,N): From field measurements, the amount of local storage space is compared to the expected volume of the excavation to determine if endhauling of excess spoil will be necessary.

- Comment: This space is used to comment on possible storage locations, endhauling needs, and stream crossing excavation requirements.

Logistics - Labor Intensive and Heavy Equipment Needs at the Work Site.

- Post Treatment Exposed Area (ft^2): This is the expected area that will be bared by heavy equipment operations. This area may need mulching and seeding to control erosion after operations are complete. Many sites located away from stream channels will not need these treatments.

- Labor Treatment Needed: Answered Yes (Y) if straw mulch or grass seeding is suggested for this site. Further evaluation in the field, when site layout is being performed and just prior to heavy equipment operations, the need for mulching and seeding should be re-evaluated.

- Comment: Included are comments related to mulching, seeding and other hand labor work that might be needed.

- Equipment Needed:
  - Excavator - (Y or N) for the use of a hydraulic excavator.
  - Cat - (Y or N) for the use of a crawler tractor for earth moving work.
  - Other - (Y or N) for the use of other equipment, including backhoes, dump trucks or loaders.

- Equipment Time:
  - Excavator (hrs) - estimated hours of excavator time needed for direct excavation at the work site. This estimate does not include time for travelling or other miscellaneous tasks.
  - Cat (crawler tractor) (hrs) - estimated hours of tractor time needed for direct excavation at the work site. This estimate does not include time for travelling or other miscellaneous tasks.

- Comment - Included in this comment section are estimated equipment hours needed for backhoes, dump trucks, etc. In addition, details for equipment treatments may be outlined in this comment.

APPENDIX C

Completed Watershed Inventory Data Sheets (455)   C1 - C1335

Direct inquiries for this raw data to Hoopa Valley Fisheries Department.

APPENDIX D

Tabulated Computer Listing of Sites to Treat D1 - D5

Appendix D: SITES WHICH ARE RECOMMENDED FOR TREATMENT

PINE CREEK

Site	Photo	Sheet	TREAT?	EP	Immed.	Pot DS?	RX?	Exi DS?	Deep Sld?	Gully	Rill	Chan	Past Eros	Past del	Fut Eros	Fut. del	Yr Built
4.0	03-11	1,4	Y	L	M		Y						0	0	500	450	1990;(1980)
5.0	03-11	1,4	Y	M	M		Y						50	50	100	100	1990;(1980)
6.0	03-13	1,4	Y	H	H		Y						20	16	150	113	1990;(1980)
7.0	03-13	1,4	Y	H	H		Y						20	16	200	100	1990;(1980)
8.0	03-13	1,4	Y	H	H		Y			Y			40	40	225	225	1990;(1980)
9.0	03-13	1,4	Y	L	H		Y						0	0	450	225	1990;(1980)
11.0	03-13	1,4	Y	L	L		Y						0	0	100	20	1990;(1980)
16.0	03-13	1,4	Y	L	L		Y						0	0	100	100	1990;(1980)
17.0	03-13	1,2,4	Y	M	L	Y			Y				0	0	1,100	1,100	1990;(1980)
18.0	03-13	1,4	Y	L	L		Y						10	10	90	90	1990;(1980)
19.0	03-13	1,4	Y	M	M	Y							0	0	310	233	1990;(1980)
28.0	03-13	1,4	Y	H	H	Y							0	0	400	100	1990;(1980)
34.0	03-13	1,4	Y	H	H	Y							0	0	900	720	1990;(1980)
35.0	03-13	1,4	Y	H	M					Y			55	55	150	150	1990;(1980)
42.0	03-11	1,4	Y	L	L		Y						0	0	600	600	1990;(1980)
43.0	03-11	1,4	Y	M	M		Y						15	15	150	135	1990;(1980)
100.0	04-04	1,4	Y	H	M					Y			50	35	50	35	1962
100.1	04-04	1,4	Y	H	L					Y	Y		100	100	50	40	1962
106.0	03-05	1,4	Y	L	L		Y						0	0	100	60	1972
107.0	03-05	1,4	Y?	L	L		Y						0	0	-100	85	1972
111.0	03-05	1,4	Y?	L	L		Y						0	0	300	270	1972
113.0	03-05	1,4	Y	H	H		Y						0	0	2,100	2,100	1972
114.0	03-05	1,4	Y	L	M,L		Y						0	0	200	180	1972
116.0	03-05	1,4	Y	M	M					Y			50	45	30	27	1972
117.0	03-05	1,4	Y	H	H	Y	Y	Y					270	270	50	50	1972
118.0	03-05	1,4	Y	M	M		Y						0	0	1,200	1,200	1972
122.0	03-07	1,4	Y?	L	L		Y						0	0	100	100	1972
124.0	03-07	1,4	Y	L	L		Y						0	0	80	80	1972
128.0	03-07	1,4	Y	H	H	Y		Y					1,100	1,100	330	330	1972
140.0	03-09	1,4	Y	H	H		Y						1,500	1,500	200	200	1972
146.0	03-11	1,4	Y?	L	L		Y						50	50	30	30	1972
158.0	02-05	1,4	Y	M	H,M		Y						130	130	100	100	1972
159.0	02-05	1,4	Y	H	H		Y						1,000	1,000	300	300	1972
160.0	02-5	1,4	Y	H	H,M	Y		Y					250	225	130	78	1977

SITES WHICH ARE RECOMMENDED FOR TREATMENT
PINE CREEK

Site	Photo	Sheet	TREAT?	EP	Immed.	Pot DS?	RX?	Exi DS?	Deep Sld?	Gully	Rill	Chan	Past Eros	Past del	Fut Eros	Fut. del	Yr Built
168.0	02-5	1,4	Y?	M	M		Y						600	600	300	300	1972
170.0	02-5	1,4	Y	H	H		Y						50	50	50	50	1972
174.0	02-07	1,4	Y	L	M		Y						350	350	75	75	1972
178.0	02-07	1,4	Y	H	H		Y						100	100	100	100	1972
179.0	02-07	1,4	Y	L	L		Y						75	75	85	85	1972
180.0	02-07	1,4	Y	L	L		Y						0	0	85	85	1972
183.0	02-07	1,4	Y	L	L		Y						100	100	50	50	1965
186.0	2-7	1,4	Y	H	H		Y						0	0	400	400	1965
187.0	2-7	1,4	Y	L	M		Y						100	100	400	360	1965
196.0	3-15	1,4	Y?	L	L		Y						0	0	50	45	1965
197.0	3-15	1,4	Y	H	H,M		Y						0	0	300	300	1965
203.0	3-17	1,4	Y	L	L		Y						0	0	30	30	1965
204.0	3-17	1,4	Y	H	L		Y						0	0	20	20	1965
211.0	3-17	1,4	Y?	L	L		Y						0	0	100	100	1965
304.0	04-04	1,4	Y	M	M	Y	Y						20	8	500	400	1962
308.0	04-04	1,4	Y	H	H						Y		450	270	450	270	1962
309.0	04-06	1,4	Y	H	H		Y						25	25	150	150	1962
311.0	04-06	1,4	Y	H	H	Y							0	0	400	400	1962
312.0	04-06	1,4	Y	M	M		Y						60	54	150	150	1962
314.0	04-06	1,4	Y	H	M		Y						90	90	100	85	1962
317.0	03-05	1,4	Y	H	H		Y						25	25	250	250	1962
318.0	03-05	1,4	Y	M	M	Y							0	0	200	120	1962
319.0	03-05	1,4	Y	H	M		Y						110	110	50	50	1962
321.0	03-05	1,4	Y	H	M		Y						80	80	40	40	1962
322.0	03-05	1,4	Y	H	H		Y						95	95	50	50	1962
323.0	03-05	1,4	Y	M	M,L	Y							0	0	250	150	1962
324.0	03-05	1,4	Y	H	L		Y						200	200	50	50	1962
329.0	03-07	1,4	Y?	H	M		Y						110	110	60	60	1972
331.0	03-07	1,4	Y?	H	M		Y						25	25	60	60	1972
332.0	03-09	1,4	Y	LM	M,L	Y		Y					150	105	400	300	1972
334.0	03-09	1,4	Y	M	M		Y						5	5	35	35	1972
336.0	03-09	1,4	Y	M	L	Y		Y					300	150	70	0	1977
337.0	03-09	1,4	Y	M	M	Y							0	0	125	94	1977
338.0	03-09	1,4	Y	H	H		Y						835	835	590	590	1977

SITES WHICH ARE RECOMMENDED FOR TREATMENT
PINE CREEK

Site	Photo	Sheet	TREAT?	EP	Immed.	Pot DS?	RX?	Exi DS?	Deep Sld?	Gully	Rill	Chan	Past Eros	Past del	Fut Eros	Fut. del	Yr Built
348.0	02-03	1,4	Y?	H	H		Y						0	0	40	40	1977; RECONST 1990
352.0	02-05	1,4	Y	H	L		Y						0	0	25	25	1990
372.0	03-15	1,4	Y	H	M		Y						150	150	100	100	1965
373.0	03-15	1,4	Y	L	L	Y							0	0	200	200	1965
375.0	03-15	1,4	Y	L	L		Y			Y			50	50	80	80	1965
378.0	03-15	1,4	Y	H,L	M	Y	Y	Y					1,200	1,200	850	850	1965
381.0	02-07	1,4	Y	H	H,M		Y						200	200	200	200	1965
383.0	02-07	1,4	Y	H	H,M		Y			Y			350	210	200	150	1972
386.0	02-07	1,4	Y	H	L	Y							150	150	100	50	1972
387.0	02-07	1,4	Y	H	M		Y						200	200	100	100	1972
388.0	02-07	1,4	Y	H	M							Y	500	500	250	250	1972
503.0	03-17	1,4	Y?	L	L		Y						0	0	150	150	1962
507.0	03-17	1,4	Y	M	M	Y		Y?					200	200	220	220	1962
508.0	03-17	1,4	Y	L	M		Y						50	50	100	100	1962
521.0	01-05	1,4	Y	H	H		Y						250	250	75	75	1962
522.0	01-05	1,4	Y	M	M		Y						0	0	100	100	1990;(1988)
524.0	01-05	1,4	Y	H	M	Y							0	0	150	75	1962;1960'S ?
527.0	01-05	1,4	Y	H	H		Y						0	0	125	125	1962/76/86
528.0	01-05	1,4	Y	L	M		Y						250	250	600	600	1962/76/86
529.0	01-05	1,4	Y	H	H	Y		Y					250	250	160	160	1962/76
530.0	01-05	1,4	Y	H	M		Y						150	150	100	100	1962/76
532.0	01-05	1,4	Y	M,H	H,M	Y							0	0	300	180	1977
533.0	01-05	1,4	Y	H	H	Y							0	0	2,700	2,700	1977
536.0	01-05	1,4	Y	H	H	Y							0	0	350	350	1990
538.0	02-11	1,4	Y	M	ML		Y						30	30	300	300	1977
539.0	02-11	1,4	Y?	H	L		Y						150	150	40	40	1977
540.0	02-11	1,4	Y	M	M	Y							0	0	300	150	1977
541.0	02-11	1,4	Y	H	M,L		Y						200	200	100	100	1977
542.0	02-11	1,4	Y	H	M		Y						75	75	75	75	1962/77
543.0	02-11	1,4	Y?	L	L	Y							0	0	1,100	660	1962/77
544.0	02-11	1,4	Y	H	M,L		Y						20	20	125	125	1962/77
600.0	01-07	1,4	Y	L	M		Y						0	0	100	100	1944;(1946?)
601.0	01-07	1,4	Y	L	M		Y						0	0	200	200	1944;(1946?)

SITES WHICH ARE RECOMMENDED FOR TREATMENT

PINE CREEK

Site	Photo	Sheet	TREAT?	EP	Immed.	Pot DS?	RX?	Exi DS?	Deep Sld?	Gully	Rill	Chan	Past Eros	Past del	Fut Eros	Fut. del	Yr Built
605.0	01-07	1,4	Y	H	H,M		Y						100	100	150	150	1977
606.0	01-07	1,4	Y	H	H,M		Y						0	0	150	150	1977
607.0	01-07	1,4	Y	H	H,M	Y							0	0	180	162	1977
608.0	01-07	1,4	Y	M	M		Y						0	0	75	75	1977
609.0	01-07	1,4	Y	H	M		Y						0	0	100	100	1977
612.0	02-11	1,4	Y	M	M		Y						0	0	60	60	1962;(1958)
615.0	02-11	1,4	Y?	M	L		Y						250	250	70	70	1962;(1958)
619.0	01-05	1,4	Y?	L	L		Y						50	50	200	200	1962;(1958)
621.0	01-05	1,4	Y?	M	L		Y						25	25	50	50	1962;(1958)
625.0	01-07	1,4	Y	H	M		Y						5	5	100	100	1962
630.0	02-11	1,4	Y	H	H	Y							0	0	3,000	2,700	1977
634.0	02-13	1,4	Y	H	H	Y		Y					1,000	800	1,000	800	1962/77
636.0	02-13	1,4	Y	H	H,M	Y		Y	Y				600	240	1,800	1,620	1962/77
637.0	02-13	1,4	Y	MH	M	Y		Y					110	28	225	79	1962/77
638.0	02-13	1,4	Y	M	M	Y							0	0	600	210	1962/77
647.0	02-13	1,4	Y?	M	M	Y	Y						5,000	5,000	500	500	1962
651.0	2-13	1,4	Y	H	M		Y						550	550	200	200	1977
652.0	2-13	1,4	Y	H	H	Y							0	0	450	338	1977
653.0	2-13	1,4	Y	H	H,M	Y		Y					1,300	1,300	5,000	5,000	1977
654.0	2-13	1,4	Y	M	M,L		Y						625	625	275	275	1977
655.0	2-13	1,4	Y	H,M	H,M	Y		Y	Y				1,300	1,300	2,200	1,760	1977
708.0	03-17	1,4	Y	L	M,L		Y						0	0	150	150	1944
709.0	03.17	1,4	Y	L	M		Y						100	100	75	75	1944
712.0	03.17	1,4	Y	L	L					Y			0		30	30	1944
713.0	03.17	1,4	Y	H	M		Y						1,000	0	30	30	1944
714.0	3-17	1,4	Y?	L	L		Y						0	0	75	75	1944
715.0	3-17	1,4	Y?	L	L		Y						5	5	75	75	1944
717.0	3-17	1,4	Y	L	M		Y						0	0	75	56	1944
718.0	3-17	1,4	Y	L	M,L		Y						25	25	85	85	1944
719.0	3-19	1,4	Y	H	M		Y			Y			4,150	3,943	50	50	1962
720.0	3-19	1,4	Y	H	M,L		Y						15	15	35	35	1962
800.0	02-11	1,4	Y	L	L		Y						0	0	0	0	1962
803.0	02-11	1,4	Y	H	H		Y						0	0	100	100	1962
811.0	02-13	1,4	Y	H	H	Y							150		300	300	1962

SITES WHICH ARE RECOMMENDED FOR TREATMENT

PINE CREEK

	Site	Photo	Sheet	TREAT?	EP	Immed.	Pot DS?	RX?	Exi DS?	Deep Sld?	Gully	Rill	Chan	Past Eros	Past del	Fut Eros	Fut. del	Yr Built
	815.0	04-21	1,4	Y	M	H		Y						0	0	75	75	1962
	820.0	04-21	1,4	Y	H	H		Y						0	0	200	200	1965
	823.0	04-21	1,4	Y	L	L		Y						20	20	100	100	1965
	835.0	04-19	1,4	Y	L	M		Y						5	5	100	100	1972
	836.0	04-19	1,4	Y	L	L		Y						100	100	150	150	1990
	839.0	04-19	1,4	Y	L	M,L		Y						0	0	200	200	1990
	840.0	04-19	1,4	Y	H	H,M	Y							0	0	150	75	1990
	841.0	4-21	1,4	Y?	M,H	H,M	Y				Y			50	50	135	135	1965
	842.0	4-21	1,4	Y	M,H	H,M		Y						10	10	660	660	1965
	850.0	3-19	1,4	Y?	H	M,L		Y						85	85	75	75	1962
	851.0	3-19	1,4	Y?	L,M	M,L		Y						20	15	40	30	1962
	856.0	3-19	1,4	Y?	L	L	Y		Y					8,900	8,010	1,900	570	1962
	857.0	3-19	1,4	Y?	H,M	M,L		Y					Y	1,600	1,600	400	400	1962
	864.0	5-21	1,4	Y?	L	L		Y						10	10	25	25	1990
	865.0	5-21	1,4	Y	H	H	Y		Y					40	40	420	420	1990
Count:	150						40	107	15	3	10	2	2					
Total:														40,290	36,810	48,510	42,635	