East Branch North Fork Feather River Erosion Control Strategy

September 1994

Prepared For:
The East Branch North Fork Feather River
Coordinated Resource Management Group

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We cannot continue along our present path of dealing with the assured welfare of individual species as constraints and outputs of goods and services as objectives. The questions [issues] are more complex.,.

Leopold suggested an ethic in which "a thing is right when it tends to preserve the integrity, stability and beauty of the biotic community." This land ethic is still evolving, with the most vexing of problems trying to link the "forest-for-whom-and-for-what" question with the biological capabilities of the land. The evolving ethic, a human concept after all, must include the needs and desires of people. That implies the provision of goods, products, and services from the land. That seems a tall order, but we are further down that trail than ever be fore and the path not taken stretches ahead.

Jack Ward Thomas

Albright Lecturer Talk, University of California, 1993.

A sustainable society ensures the health and vitality of human life and culture and of nature, for present and future generations, by ending activities that destroy human life and culture and nature, by conserving what exists, restoring what has been damaged, and preventing future harm.

[W]e have learned, painfully, that the workings of the economy have had considerable impact on equity and on the environment and. that our concern for the environment can affect the economy. The challenge is to define an economic system that embraces and enhances equity and the environment rather than destroys them.

Stephen Viederman

Presentation to the Washington Round Table on Public Policy, 1993.

East Branch, North Fork Feather River Erosion Control Strategy

Signatories

We the undersigned do hereby agree that the East Branchy North Fork Feather River, Erosion Control Strategy is an acceptable process and support its use as written

Agricultural Stabilization and Conservation Service	
California Department of Fish and Game	
California Department of Forestry & Fire Protection	
California Department of Transportation	
California Department of Water Resources	
California Regional Water Quality Control Board, Central Valley	
Feather River College	6-4-96 President Date
Feather River Resource Conservation District	Melvin R. [illegible] 5/22/96 Director Date
North Gal-Neva Resource Conservation and Development Area	
Pacific Gas & Electric Company	10/20/94 Manager, Hydro-Generation Dept. Date
Plumas Corporation	
Plumas County	Date [illegible]/96 Chairman, Board of Supervisors Date
Plumas National Forest, USFS/USDA	3/19/96 Forest Supervisor Date
Plumas Unified School District	Superintendent Date

Soil Conservation Service, USDA	
US Army Corps of Engineers	
US Fish & Wildlife Services	
UC Co-operative Extension Service	5/17/9. Director Date
Plumas County Community Development Commission	6/4 Executive Director Date

EXECUTIVE SUMMARY

Purpose and Need

Since its inception in 1989 the Coordinated Resource Management Group (CRM) has completed numerous restoration and erosion control projects and studies within the Feather River Watershed. Originally, restoration and erosion control project proposals underwent prioritization based on sediment production information developed by CRM signatories in 1989. This provided a reasonable method for identifying and developing solutions to deal with high sediment yield areas within the watershed.

Yearly, the number of project proposals submitted to the CRM has risen. Many of these projects, although worthy of implementation, are classed as "projects of opportunity" and often are difficult to prioritize based on the single criteria method originally used during the CRM's early development and demonstration era.

Presently the CRM is developing a structure to facilitate a new era of systematized, coordinated, long-range resource restoration and management conducted on a sub-watershed, watershed, and landscape scale as opposed to an individual project scale. In order to accomplish this re-direction of effort, a new methodology and process is proposed to guide and prioritize CRM restoration efforts in priority areas while continuing to accept and implement "projects of opportunity" in the watershed.

The new direction the CRM will take follows in the wake of recent advances in scientific research that has increased our understanding of natural processes, biological diversity, and riparian ecosystem health. This has called attention to the need for a broad ecological approach to riparian area management in order to find solutions to common problems in the watershed.

CRM Structure and Guiding Principals

The FR CRM management and organizational structure of each of the Committees, Subcommittees, and Technical Assistance Committees and how action is coordinated in response to individual projects is described along with the guiding principals adhered to by CRM participants.

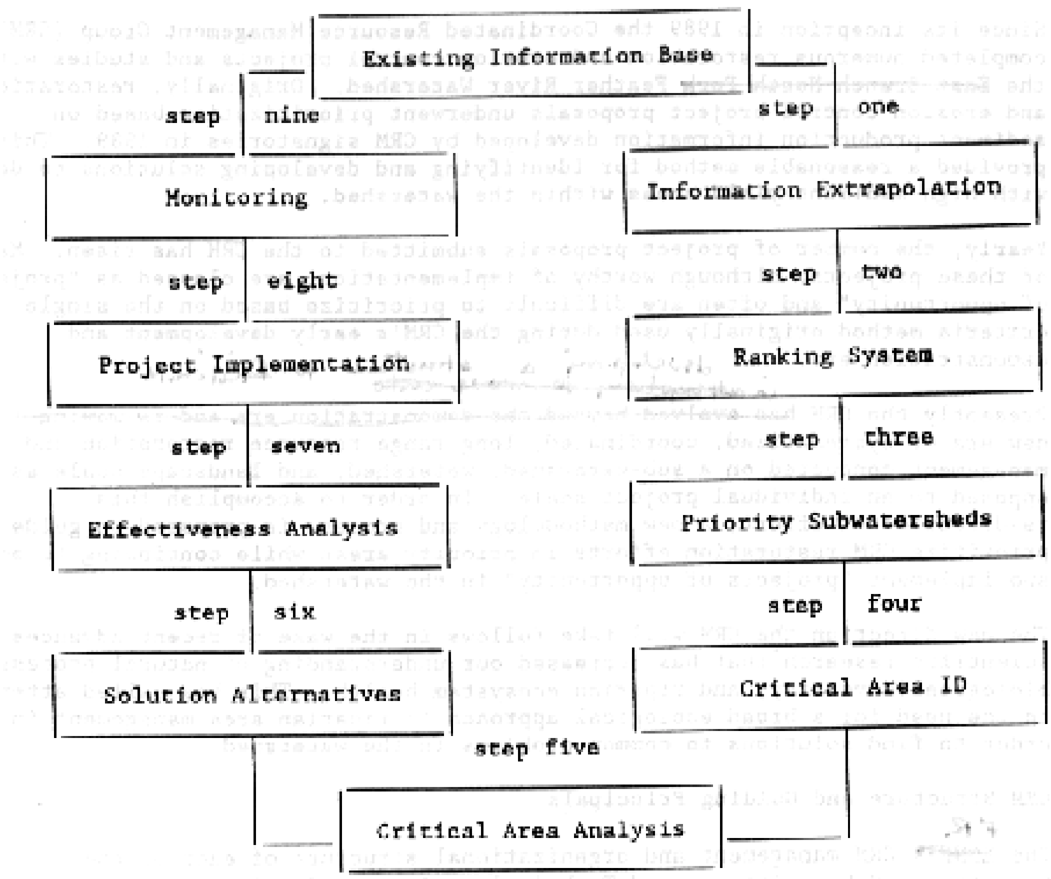
EBNFFR Watershed Description

The general topography, climate, geology, vegetation, and riparian areas are described for the FR watershed.

Proposed Erosion Control Strategy Process

A nine step process is proposed that will help guide CRM restoration efforts on private and public lands within the watershed.

Erosion Control Strategy_Process Diagram



Critical Area Analysis

This process begins with the extrapolation of existing watershed condition information (Step 1) into watershed areas covered by less intensive sampling and reconnaissance level surveys (See Appendix C, Information Extrapolation This will allow the use of condition information as a modifier when using a multiple criteria sub-watershed ranking system (Step 2, See Appendix D Proposed Watershed Priority Scoring and Ranking Table of Criteria by Category). The proposed ranking system uses six separate categories containing three to ten criteria to rank individual sub-watersheds as opposed to the old single criteria ranking system of the past (Draft Ranking results are presented in table 1. page 28).

Once ranked, priority sub-watersheds are chosen (Step 3), the Draft top 5 priority sub-watersheds are: Upper Spanish Creek, sub-watershed 24; Wolf-Round Valley, sub-watershed 15; Greenhorn Creek, sub-watershed 23; Little Grizzly Creek, sub-watershed 14; and Lower Spanish Creek, sub-watershed 22 (It should be noted that sub-watersheds 22, 23, and 24 comprise the whole of the Spanish Creek watershed). Once priority sub-watersheds are chosen, critical areas within the top ranked sub-watershed's) are identified (Step 4). These critical areas will become new CRM project areas. Once critical areas have been identified using an interdisciplinary team approach a Critical Area Analysis will be conducted to evaluate the extent and cause of the problems and the rehabilitation potential of the area(s) (Step 5).

A full range of solution alternatives will be developed for each critical area (Step 6). These alternatives will be based on objectives developed during the Critical Area Analysis. All environmental documentation will take place at this step in the process. Once the solution alternatives have been developed a Project Effectiveness Analysis (PEA) will be conducted for each Critical Area (Step 7). The PEA is divided into three analyses: 1. The Economic Efficiency Analysis, used to identify, and examine, over time, the dollar costs and benefits of the proposed project. 2. The Economic and Social Well-Being Analysis, used to identify and determine the effects of the project on the economics, infrastructure and social life of dependent communities. 3. The Environmental Quality Analysis, used to determine the effects created by a project on the characteristics of the environment that are often non-market and non-monetary **(See Appendix E Project Effectiveness Analysis)**

Project planning and implementation (Step 8) covers the process used by the CRM which govern Project submittal. Project funding. Project design and review responsibilities, Preconstruction environmental review, Project permits, approvals, and agreements. Project contracting. Project construction, and Project closeout, monitoring and maintenance.

Project Monitoring (Step 9) will included one or more of the following types: Trend; Baseline; Implementation; Effectiveness; Project; Validation; Compliance. The monitoring needs of each CRM project will be evaluated by the Monitoring Technical Advisory Committee in consultation with the appropriate regulatory agencies. In addition this committee also oversees monitoring implementation, data collection, analysis and reporting.

Benefits

A list of general on-site, off-site, functional and social-economic benefits are presented (No attempt, at this point, has been made to place dollar amounts with preconceived benefits from restoration on a watershed level. However this type of analysis will be conducted on a site and project specific basis when conducting the PEA in step seven). On-site benefits are benefits occurring at the project site where management changes and/or restoration has taken place. Off-site benefits are benefits that may be occurring at the project site but also extend outside the project boundary. Functional benefits are benefits derived when the natural ecosystem function (as we understand it) is maintained or restored. Social-economic benefits are benefits to the human aspect of the environment.

Problem Description

A general description of typical channel and riparian problems within the watershed is presented by stream type (See Appendix A). Two basic elements c evaluated.

1. Channel sensitivity to land use impacts, which is primarily function of channel particle size/distribution.
2. Channel stability, which is primarily based on channel gradient and degree of bed and bank protection.

Proposed Treatment

General treatment recommendations are proposed for unstable/sensitive channel (See Appendix B). Treatment is composed of three separate but interrelated approaches that can be used to restore stability in stream channels and riparian areas. (1) Changes in management to remove an impact or moderate land use that fosters instability; (2) Engineering and construction to stabilize impacted areas, re-configure normal channel geometry and halt or reduce further resource loss; and (3) Bio-technical erosion control and re-vegetation to sit degradation processes, speed site recovery and increase biodiversity using self-regenerating living systems **(Cost estimates have been developed by stream type, for priority sub-watersheds and are included in Appendix F).**

EAST BRANCH NORTH FORK FEATHER RIVER EROSION CONTROL STRATEGY

Introduction

The East Branch North Fork Feather River (EBNFFR) encompasses 661,884 acres the most northern and eastern watershed of the Sierra Nevada Bioregion and is located completely in Plumas county. The EBNFFR watershed straddles the Sierra crest and drains westerly to the Sacramento River in the California Central Valley. The downstream boundary of the EBNFFR watershed, the confluence of East Branch Feather River with the North Fork Feather River, is located approximately 80 miles northwest of Reno, Nevada (Great Basin Province), 60 miles northeast of Oroville, California (Central Valley Province) and 50 mil south of Lassen Volcanic National Park (Cascade Mountain Province).

The Plumas National Forest (USFS) manages 84 percent of the watershed. Industrial and Non-industrial private timberlands comprise II percent of the watershed and 4 percent of the lands are in private agricultural holdings which 0.8 percent of the watershed is in urbanized and other public ownership.

Watershed beneficiaries include the 4,363,414 electrical customers served by Pacific Gas and Electric Company's (PG&E) North Fork Feather River hydroelectric powerhouses. The benefits of hydropower generation are distributed to all served by PG&E, 12.8 million people. The EBNFFR watershed users also include the 19.7 million municipal and industrial users of State Water Project (SWP) water. The EBNFFR produces 25.4 percent of SWP water which provides 48 percent of the developed municipal and industrial surface water supplies in California. Users include an estimated 2.3 million recreational visitor days per year to streams, lakes, meadows, forests and rangelands of Plumas National Forest (PNF). Additional clients of the watershed include t users of the 85 to 200 million board feet of timber harvested annually from EBNFFR since the early 1900's.
Existing conditions in the EBNFFR watershed are a result of five major historical and current land uses. They are (1) mining, (2) wildfire, (3) livestock grazing, (4) timber harvest, with its associated roads, skid trail and log landings, and (5) railroad and highway construction and maintenance At least 60 percent of the watershed has been adversely impacted, resulting decreased soil productivity, degraded water quality, greatly reduced riparian plant and wildlife communities, lowered water tables and frequent damaging flood flows (Clifton, 1992). The EBNFFR Coordinated Resource Management (CRM group, an interagency consortium, has inventoried the EBNFFR for water quality problems. Based on this inventory, it is estimated that as much as 64 percent of all stream channels are in a degraded condition and as much as 152,000 ac of wetlands, meadows, and rangelands are in a similar condition (Benoit, 1987). In many areas, disturbance related to human activity has caused an estimated 6 to 12 inches, of top soil loss from meadows and upland areas. same disturbance has contributed to the formation of numerous large and small gullies that have formed in almost every meadow and run the full length of r valleys (Benoit, 1987 and Clifton, 1992). Annually, I.I million tons of sediment is delivered to Rock Creek Dam at the downstream end of the EBNFFR watershed, 80% of this yearly sediment yield is from "accelerated", human caused erosion in the watershed (USDA, 1989).

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In order to confront operational problems caused by enormous sediment yields hydroelectric reservoirs. Pacific Gas and Electric began working with state c federal water and wildlife regulators in 1984 to develop solutions to their sedimentation problems. During early 1985 a group of local citizens met to s if some local involvement was appropriate and in the Spring of 1985 a major gathering of twenty different entities (local, state, federal, and private) was held in the county seat to look towards possible cooperative efforts to improve conditions in the watershed. The forum decided upon two approaches: Begin the process of defining the dimensions of the problem. Where was the sediment coming from and in what quantities? What are the causes? What proportion is "natural" and what proportion is due to current and past land practices? What areas would respond best to treatment? Where and how should land use practices be changes? The second approach was to immediately develop a cooperative demonstration stream restoration project in the watershed and also seek to develop a formal working relationship between participants, with assigned roles and responsibilities in order to carry out further analyses, planning and improvement projects in the watershed.

PG&E took the lead in developing the subsequent "Memorandum of Understanding (MOU) which, when formally adopted in mid-1987, associated the following thirteen entities in the ongoing erosion control efforts in the EBNFFR watershed:

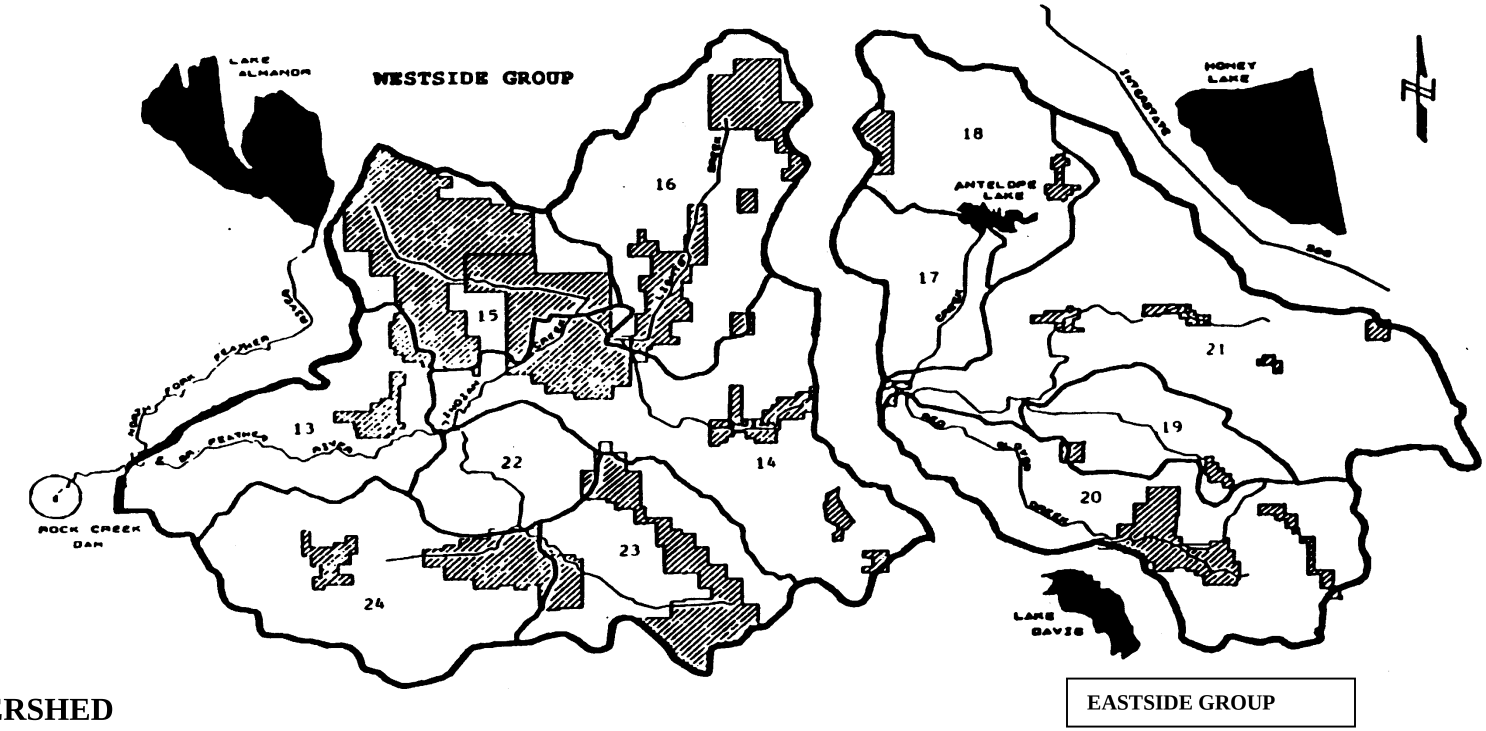
- U.S. Agricultural Stabilization and Conservation Service
- California Department of Fish and Game
- California Department of Forestry and Fire Protection
- California Department of Transportation
- California Regional Water Quality Control Board, Central Valley Region
- Feather River Resource Conservation District
- Pacific Gas and Electric Company
- USDA Forest Service, Plumas National Forest
- USDA Soil Conservation Service
- U.S. Fish and Wildlife Service
- U.S. Army Corps of Engineers
- Plumas County
- Plumas Corporation

Various responsibilities were agreed to by each of the participants and Plumas Corporation, a county non-profit, public benefit corporation, was assigned lead role to "coordinate the design and implementation of erosion control projects". The rational for assigning Plumas Corporation the lead role was that of all the often fractious parties, Plumas Corporation's motives were most transparent: to create jobs for county citizens. The Memorandum of Understanding (MOU) defined separate objectives for the effort that include:

- Identify erosion sources
- Develop a cooperative regional erosion control plan for the EBNFFR waters
- Design, fund and implement erosion control measures where cost-effective
- Coordinate with public and private landowners
- Assure that planned erosion control projects are cost effective for contributors funding the project.

Accomplish the above in a manner that will protect land values, natural resources, environmental values, and agricultural productivity.

EAST BRANCH NORTH FORK FEATHER RIVER



SUBWATERSHED
DRAINAGE
AREAS

TOTAL ~ 1034 SQ MI
TOTAL ~ 661,884 Acres
SCALE ~ 1 Inch ~ 7 Miles

13	Rush-Mill Creek	**19**	Squaw Queen
14	Lit Grizzly	**20**	Red Clover
15	Wolf-Round Valley	**21**	Last Chance
16	Lights-Cooks	**22**	Lower Spanish
17	Hungry-Middle Indian	**23**	Greenhorn
18	Antelope Lake	**24**	Upper Spanish

The organization has further evolved since 1987. Participants became aware, through the Soil Conservation Service, of an underutilized federal enabling framework (Coordinated Resource Management) that was established by the Forest Service, Bureau of Land Management, Cooperative Extension Service and the Soil Conservation Service. This CRM framework was formally adopted by the MOU signatories in mid-1989. The key benefits to using the CRM framework is the involvement of the local Resource Conservation District and CRM's ability to use federal resource staff normally limited to federal lands (e.g. Forest Service) on cooperative efforts on private lands. Since its inception, the CRM has been joined by five additional signatories:

- North Gal-Neva Resource Conservation and Development Area
- Plumas Unified School District
- State Water Resources Control Board
- California Department of Water Resources
- Feather River College

It is the goal of the CRM to optimize the beneficial uses of the waters of the EBNFFR. These beneficial uses are: domestic, municipal, agricultural, and industrial water supply; power generation; recreation; aesthetic enjoyment; navigation; and the enhancement of fish, wildlife, and other aquatic resources .

The CRM objectives are to maintain, protect, and improve, where possible, water quality and quantity in the EBNFFR.

The CRM Group emphasizes education to prevent future water quality degradation of the EBNFFR

The CRM Group cooperatively designs and assists with funding for water quality improvement projects to abate water quality degradation in the EBNFFR.

The EBNFFR CRM structure and process were developed to maximize local initiative and local control over resource management issues and to coordinate requests for Federal and State technical and financial assistance.

The CRM will not duplicate or interfere with the activities, agendas or roles of polarized interest groups or agency mandates related to current resource management practices. In practice, this meant developing consensus among all watershed stakeholders to implement innovative watershed restoration techniques on multiple -use lands on a voluntary basis using a variety of public and private grants.

Representatives from the 18 EBNFFR CRM signatory organizations serve on the steering committee, project technical assistance committees and staff to the CRM management committee and the CRM executive committee.

EBNFFR Coordinated Resource Management (CRM) Structure

Basic CRM structure is composed of three main committees; the Executive Committee, Management Committee, and the Steering Committee. In addition, four Subcommittees exist as arms of the Management Committee. These are the Projects, Finance, Design, and Monitoring Subcommittees. Technical Assistance Committees (TAG), interdisciplinary teams, are formed in response Co specific project needs.

The Executive Committee

The Executive Committee provides overall policy guidance, dispute arbitration and liaison with Washington, Regional, and State personal of signatory agency for the CRM. The Committee is composed of four members serving staggered two-year terms. Three of the four members are appointed. The Feather River Resource Conservation District (FRRCD), Plumas County Board of Supervisors, the USDA Forest Service, Plumas National Forest each appoint one representative to the Executive Committee. The three appointed members appoint a forth member at large.

The Steering Committee

The Steering Committee provides public access and program continuity to the effort from project to project and year to year. The Steering Committee head and approves project concepts for each project and forwards them to the Management Committee for referral to the CRM Subcommittees for financing, design and technical review. The Steering Committee is made up of at least voting member of each of the CRM MOU signatories, as well as non-voting representatives of interested organizations, community groups, and publics.

The Management Committee

The Management Committee is part of the Executive Committee and is chaired I one of its members. Its responsibilities are to provide ongoing management guidance of day to day, year to year CRM operations by establishing financial budgeting and project implementation priorities and procedures. The Manager Committee provides general direction to the Projects, Finance, Design, and Monitoring Subcommittees. The Vice-Chair is the liaison between Executive, Management and Steering Committees.

Project Subcommittee

The Project subcommittee is chaired by a representative of the Feather Rive Resource Conservation District (FRRCD) and is responsible for nominating perspective projects. All projects submitted to the CRM for consideration through the FRRCD. This helps to keep control of proposed projects, and implementation oversight at the local level.

Finance Subcommittee

The Finance Subcommittee is chaired by a representative of the California Dept of Forestry and Fire Protection. The subcommittee is responsible for identifying possible project funding sources as well as aiding in the preparation of funding applications when necessary.

Design Subcommittee

The Design Subcommittee is chaired by a representative of the Plumas Nation Forest. This Subcommittee analyzes available information at a watershed sc identifies and defines overall project and design objectives and principles develops design procedures that are acceptable to the CRM Steering Committee and that are workable for project level Technical Assistance Committees (TA and the participating Landowner/Land Manager. This subcommittee networks with the TACs (technical interdisciplinary team) at the project level to provide specific expertise in a variety of natural resource fields related to each specific project.

Monitoring Subcommittee

The Monitoring Subcommittee is chaired by a representative of the California Dept. of Fish and Game. The Subcommittee is responsible for designing pro-project and post-project monitoring programs to meet regulatory agency requirements and overall CRN objectives. In addition to producing monitoring designs the subcommittee members also collect or oversee the collection of monitoring data and produce or review reports of the results.

Technical Assistance Committees (TACs)

Technical Assistance Committees (TACs) are composed of interdisciplinary teams of resource specialists, landowners and managers as well as other interested individuals. It is the charge of these committees, whose makeup is defined in response to project needs, to provide technical expertise and direction throughout project implementation. TACs propose structural, vegetative, and management solutions, conduct pro -project and post-project infield evaluations and prepare or assist in the preparation of required environmental documentation for individual projects.

CBM Guiding Principals

CRM participants adhere to the following focus and process:

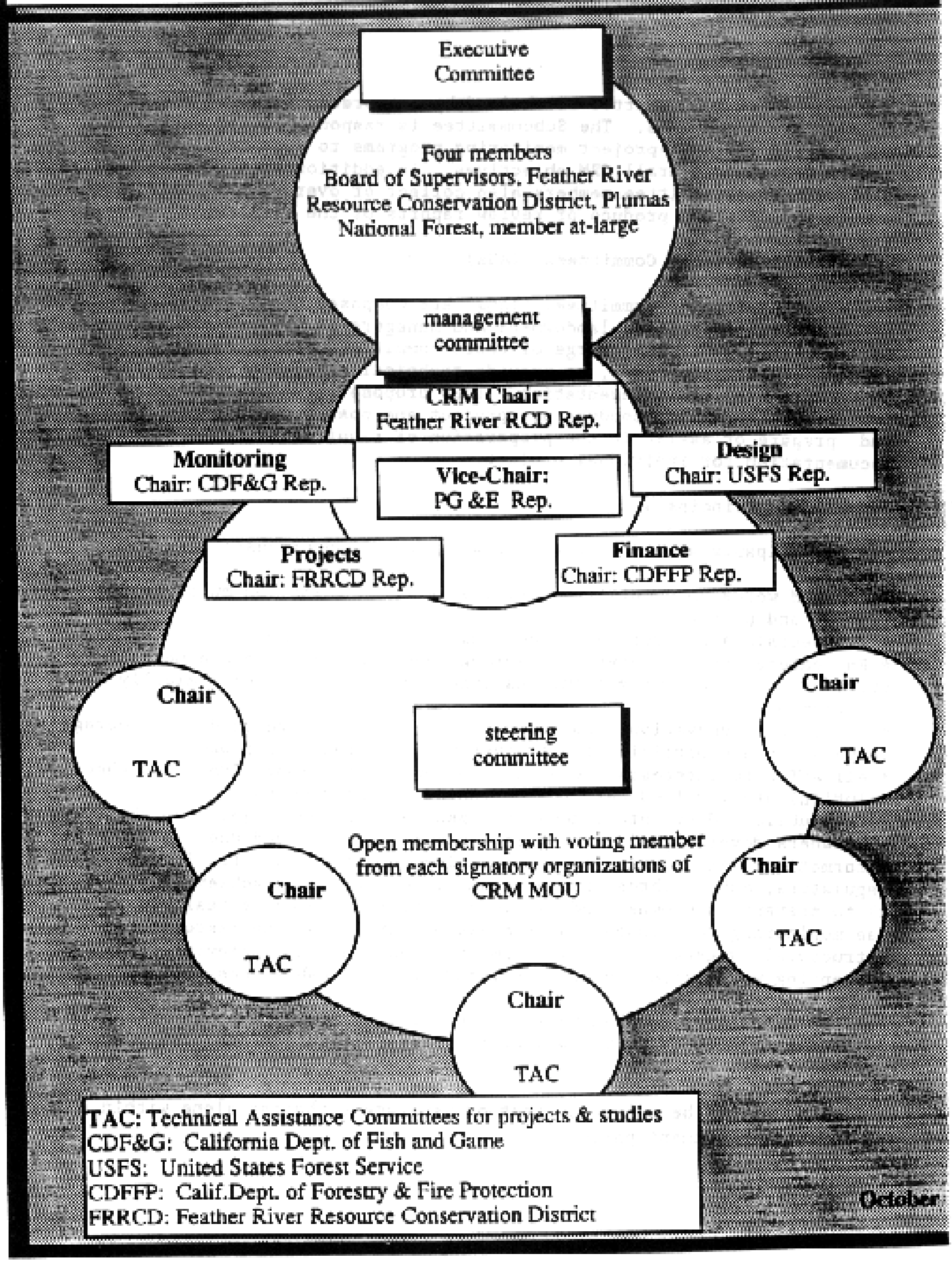
* The CRM works on cumulative watershed effects (CWEs) on multiple use lands (public and private)

- All decisions are reached by consensus within the CRM
- Enlightened self interest and a long investment horizon are necessary attributes for achieving solutions that are sustainable economically and environmentally
- Education, innovation, and demonstration projects are used to encourage cooperation and participation (rather than regulatory approaches)
- All affected interests (necessary to implement a long term, comprehensive solution) are involved near the beginning of the process
- The public and private landowners take the lead on projects on their lands. Landowners develop goals, worst case scenarios, and land use history information. All participants, including technical experts, investors and regulators, make a three part promise 1) to attempt to achieve shared goals, 2) to prevent land owner and participant fears from being realized and 3) to use monitoring to document the success or failure of the restoration (structural, vegetative and management) treatments in achieving goals and preventing worst case scenarios related to sustainable ecosystem management.

For the CRM Group, cumulative watershed effects (CWEs) are operationally defined as: water quality, fuel hazard, desertification and biodiversity problems that:

* Can not always be solved by rest or management changes alone within a reasonable investment period

Feather River Coordinated Resource Management (CRM)



- are caused by multiple and cumulative events over decades involving many people mostly whom are now gone
- are not solved without comprehensive long term strategies (instead of piecemeal or quick fix approaches)
- are causing rapidly increasing costs and conflicts among resource users
- involve solutions which can be monitored for ecosystem recovery using ecological function and succession criteria and
- involve solutions where monitoring will directly influence long term sustainable management strategies for restored resources.

Between 1989 and 1992 the EBNFFR CRM has successfully completed 33 restoration and erosion control projects and studies within the EBNFFR watershed. The majority of these projects were prioritized, planned and implemented based on a single criteria developed from information gathered in 1989. One of the original tasks set forth in the MOU is to develop a methodology that would identify and assess critical watershed areas and problems based on multiple criteria including, but not limited to sediment production, resource condition or financial constraint. This methodology is set forth in the EBNFFR Erosion Control Strategy (Plan) and will act to guide CRM restoration efforts on public and private land on a watershed basis instead of a project basis.

BBNFFR Watershed Description

The topography, climate, geology, soils, and vegetation for the EBNFFR have been described by the USDA-Soil Conservation Service, USDA-Forest Service (1989) and have been modified in part and reproduced for this report.

Topography

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

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

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

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

Climate

The FBNFFR Is comprised of two climatic zones. The Sierra Nevada crest acts a barrier to the moisture laden air coming from the Pacific Ocean and the cc dry air masses from the central United States in the winter. During the summer, the crest also acts as a barrier to the hot, dry air masses that develop over the central United States. This situation thus creates a high precipitation, cool summer, and mild winter climate on the western slope; ar-low precipitation, hotter summer, and colder winter on the eastern slope. Temperature decreases I degree F. for every 300 feet gain in elevation.

The western Sierra portion of the EBNFFR is within the Mediterranean Climate Zone which consists of cold, wet winters and warm dry summers. The average minimum temperature is 3.5 degrees F. and the average maximum is 96.1 degree F. Minimum temperatures occur in December to February with maximums in late July or August. The mean annual temperature is 47.1 degrees F. The average frost free period is 119 days. Precipitation falls primarily as snow above 6000 feet and a mixture of snow and rain below that elevation. Summer thunder storm occur, but not as frequent or severe as in the eastern portion of the EBNFFR. The average annual precipitation varies from 35 to 90 inches, yield from 16 to 65 inches of runoff. Most of the precipitation is from winter frontal disturbances enhanced by orographic uplift as storm systems move into the area from the Pacific (Harris, 1981).

Approximately 54 percent of the annual precipitation falls during December, January and February. Summer months receive approximately 3 percent of the annual amount, resulting in low natural runoff rates for this area during tl late summer and the early fall months. Surface runoff depends upon the snowmelt regime, which normally extends into late spring and early summer, sustained base flow from recharged ground water aquifers.

This means that wet meadows and perennial flows are very important for many the areas resources, especially during the dry season, which can last from through November, 6 months.

The eastern Sierra portion of the EBNFFR is in a "rain shadow" where less precipitation falls and drier conditions prevail. Precipitation falls primarily as snow, but summer thunder storms frequently occur, sometimes very severe. The average annual precipitation varies from 18 to 30 inches, yield from 2 to 8 inches of runoff. Most of the precipitation is from winter fro disturbances enhanced by orographic uplift as storms systems move into the from the Pacific (Harris, 1981).

Over 50 percent of the annual precipitation falls during December, January February. Summer months receive less than I percent of the annual amount, resulting in low natural runoff rates during the late summer and early fall months.

Geology and Soils

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

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

Vegetation

Within the western portion of the EBNFFR, vegetation changes depend on elevation and precipitation. The majority of the area is covered with mixed conifers of the yellow pine belt with red fir above 6000 feet. Dominate species include: ponderosa pine, sugar pine, white fir, Douglas fir, incense cedar, broadleaf maple, black oak, black cottonwood, alder, willow, ceanothus, and manzanita, with red fir and lodgepole pine at higher elevations (Munze and Keck, 1965., StorerandUsinger, 1963).

The eastern portion of the EBNFFR is, for the most part, characterized as a mixture of the Yellow Pine and Jeffrey Pine belts of the Northern Sierra Nevada east of the Sierra crest. This area contains open, broad meadows in valley bottoms with mixed east-side pine on the slopes. Dominate species include: Jeffery pine, ponderosa pine, white fir, douglas fir, incense cedar, lodgepole pine, aspen, mountain mahogany, juniper, sagebrush, rabbitbrush, and bitterbrush (Munz and Keck, 1965., Storer and Usinger, 1963).

Riparian Areas

Riparian areas are the interface between terrestrial and aquatic ecosystems, and can be defined as three-dimensional zones of direct interaction between these two ecosystems. This zone encompasses stream source, the active channel, (including perennial, intermittent and ephemeral), and side channels, floodplains, and portions of the upland areas that directly affect the aquatic system.

Riparian areas are limited to narrow strips of land and vegetation along most streams, but larger, alluvial meadows can be found throughout the watershed. These meadows act as floodplains, wildlife habitat and livestock pasture. Large meadows are associated with "C" and "F" type channels in the Rosgen Stream Classification System (Rosgen, 1985 and modified in 1991), while the narrower stringer meadows are usually associated with "B" type channels. The few headwater meadows are associated with the steeper "A" type channels. Each channel type reacts differently to runoff events and land use impacts.

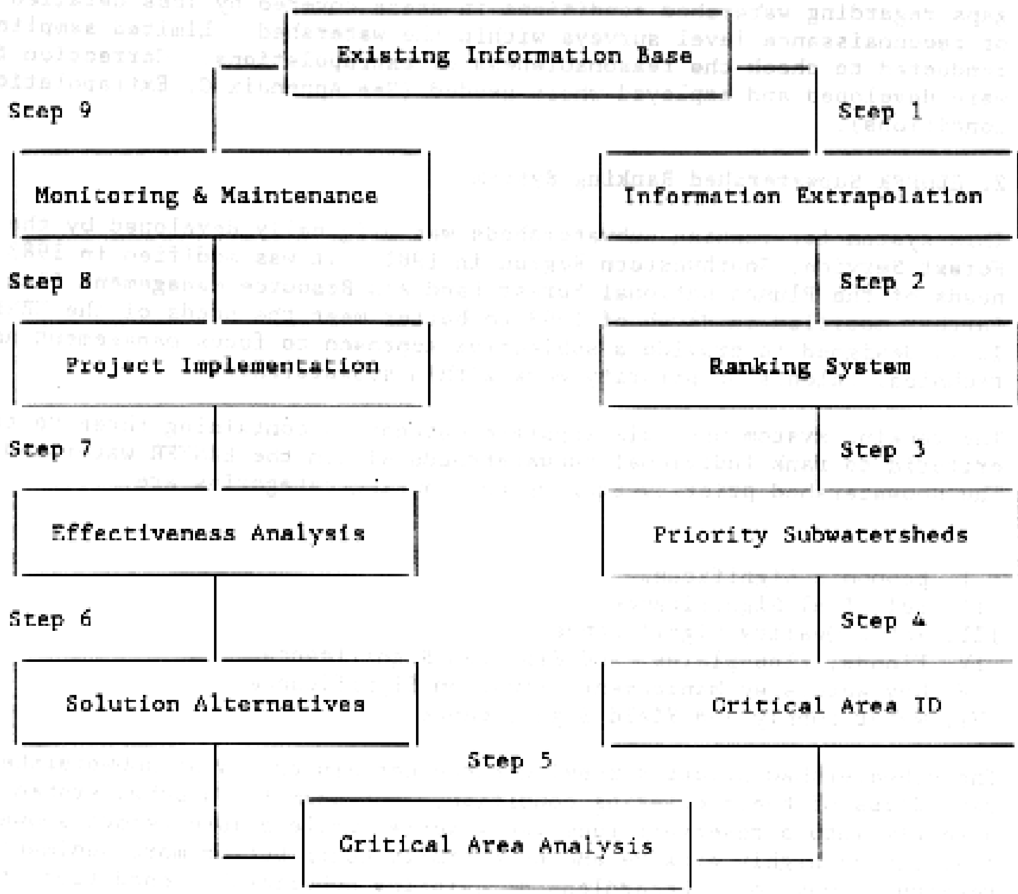
Proposed EBNFFR Erosion Control Strategy

Currently the EBNFFR CRM has completed 33 restoration and erosion control projects and studies within the EBNFFR watershed. Projects and proposed projects exist in 9 of the 12 subwatersheds of the EBNFFR. Many of these projects were prioritized and implemented based on a single criteria (sediment production) developed from information gathered in 1989. Other projects were "projects of opportunity". Regardless, the general thrust of the CRM has bee to demonstrate that a diverse coalition could function on a consensus basis t develop and modify restoration technologies, and gather a variety of information on watershed conditions within the EBNFFR. This was the CRMs development and demonstration era. Presently the CRM is moving into a new era of systematized, coordinated, long-range resource restoration and management strategies that will be conducted on a watershed scale. This new phase in the evolution of the CRM will require the full use of human coordination, scientific and condition information and new restoration technologies the CRM has worked to develop since 1985.

EBNFFR Information Base

The new methodology that will guide CRM efforts on public and private lands a nine step process (see figure 1.). This process begins with the existing base of information developed by the CRM signatories. This information deal^ primarily with watershed conditions such as sediment yield, stream type, channel condition, and problems related to water quality from roads and stream crossings. Intensive water quality and channel condition inventories have b conducted on approximately 40% of the 661,884 acres of the watershed. Because 84 percent of the land base in the watershed is public land, .information on water yield, road and channel density, land instability, as well as timber a fire history was extracted from the Plumas National Forest Land and Resource Management Plan Data Base.

Figure 1. Erosion Control Strategy Process Diagram



1. Information Extrapolation

The EBNFFR data base was used to develop extrapolations to fill information gaps regarding watershed conditions in areas covered by less detailed sampling or reconnaissance level surveys within the watershed. Limited sampling was conducted to check the reasonableness of extrapolations. Correction factors were developed and employed where needed (See Appendix C. Extrapolation and conditions).

2. EBNFFR Subwatershed Ranking System

This system for ranking subwatersheds was originally developed by the USDA, Forest Service, Southwestern Region in 1981. It was modified in 1983 to meet the needs of the Plumas National Forest Land and Resource Management Plan. It was further modified in March of 1993 to better meet the needs of the EBNFFR CRM It is designed to provide a subjective approach to focus management and technical talents on priority work within subwatersheds.
The ranking system uses six separate categories containing three to ten criteria to rank individual subwatersheds within the EBNFFR watershed. The subwatershed priority scoring and ranking categories are:

1. Economic Significance
2. Political Significance
3. Water Quality Significance
4. Floods, Floodplains, and Riparian Significance
5. Key Watershed Management Situation Significance
6. Water Supply and Yield Significance.

The subwatershed priority ranking rates certain traits of subwatersheds regardless of their existing condition. For Example, a subwatershed emptying directly into a reservoir receives a score, while a more remote subwatershed that may be highly erosive and potentially contributing more sediment to a reservoir, may not. Regardless of existing subwatershed condition, the closed subwatershed has more potential, when disturbed, to deliver sediment to the reservoir, with little intervening space or time to buffer the impacts.

The numerical score for each subwatershed is derived by identifying which criteria are appropriate for the subwatershed, multiplying the criteria significance number by the category weight, and summing the products from all appropriate criteria for the subwatershed (See Appendix D. Subwatershed Ranking System).

Once a subwatershed score is derived, a ranking list can be prepared (Table 1.). This becomes the initial ranking and should be modified by subwatershed condition criteria, such as sediment yield. It should also be modified by t CRM Steering Committee as needed (i.e. local conditions; changing political legal entanglements).

NOTE; During the preparation of this report the proposed ranking system was brought to forest (Plumas National Forest) wide attention and is at the time this writing being further modified as a ranking tool to facilitate an

Ecosystem Management approach to resource management on the Plumas National Forest (PNF). The first draft of the new, PNF modification to the ranking system is a short version of the existing system detailed in this report. The CRM may wish to adopt the final version that the PNF produces so that a standardized subwatershed ranking system is used by both the Forest Service and the CRM.

Table 1. First Draft Ranking of EBNFFR Subwatersheds.

RANKING HIGH TO LOW	SUBWATERSHED NAME	SUBWATERSHED NUMBER	SUBWATERSHED SCORE	SEDIMENT YIELD RANKING
1	UPPER SPANISH	24	578	3
2	WOLF-ROUND	15	447	2
3	GREENHORN	23	441	7
4	LITTLE GRIZZLY	14	439	9
5	LOWER SPANISH	22	431	4
6	ANTELOPE LAKE	18	401	1
7	LIGHTS-COOKS	16	361	11
8	LAST CHANCE	21	344	5
9	RUSH-MILL	13	307	10
10	MIDDLE INDIAN	17	295	6
11	RED CLOVER	20	293	8
12	SQUAW QUEEN	19	246	12

A sediment yield ranking (high priority - I, low priority - 12) is included to compare the original CRM single criteria ranking system with the new multi-criteria ranking. This ranking is draft and subject to change.

3. Choosing Priority Subwatersheds

Priority subwatersheds will be chosen from the top 5 subwatersheds in the ranking. Currently this includes all three subwatershed in the Spanish Creek watershed (Upper Spanish, Greenhorn Creek, and Lower Spanish) and 2 of the 4 subwatersheds in the Indian Creek watershed (Wolf-Round Valley and Little Grizzly).

These five subwatersheds represent an area extending from the northern boundary of the EBNFFR watershed at Dyer Mountain near Lake Almanor to the southern boundary at Claremont Peak south of Quincy. This area encompasses the population centers of Greenville, Indian Valley, Taylorsville, Crescent Mills, Genesee Valley, Indian Falls, Keddie, Butterfly Valley, Meadow Valley and Quincy. The area is composed of west-side subwatersheds and includes no east-side subwatersheds. Currently there are proposed or existing CRM projects in each of the top 5 ranked subwatersheds (Table 2).

Table 2.

Table of proposed and existing CRM projects in the top 5 ranked subwatersheds in the EBNFFR watershed.

RANKING HIGH TO LOW	SUBWATERSHED NAME	PROJECT PROPOSED	PROJECT EXISTING
1	UPPER SPANISH	Spanish Creek Wapunsie Creek	
2	WOLF-ROUND VALLEY	Wolf Ck Wetlands (Phase IV)	Wolf Creek Phase 1 11, III.
3	GREENHORN		Greenhorn Creek
4	LITTLE GRIZZLY	Ward Creek	Walker Mine Tailings Blakeless Creek Indian Creek
5	LOWER SPANISH		Butterfly Valley

4. Identifying Critical Areas Within Priority Subwatersheds.

The identification of critical areas within priority subwatersheds will be conducted by an interdisciplinary team (IDT). IDT members will possess skill in forestry, forest hydrology, soils, geology/geomorphology, fuels, fisherie biology, and botany (other specialists can be added as project needs dictate The primary objectives of the scientific team are: (1) to develop an understanding of past and present factors influencing watershed conditions a a comprehensive view of the cumulative effects of practices, and overall vulnerability of the watershed as a whole (producing an overview of current conditions) and (2) to locate and delineate critical areas sensitive to erosion, hydrologic and riparian function impairment, and habitat loss. The team will develop area-specific problem statements that will link forest practices, watershed processes, and resource effects. This type of investigation will not only produce current condition information, but help establish a future condition (Desired Future Condition) grounded in area-specific physical and biological constraints.

The delineation of critical areas should include a variety of information such as: land use pattern and history, fire history, stream channel density, channel type and condition, road density and condition, vegetative cover and condition, existing improvements, cultural significance, and fish and wildlife habitats Critical areas can be large (entire subwatersheds) or small (individual site within subwatersheds) depending on the recommendations of the IDT. Several methodologies to accomplish this task exist. The USDA Forest Service recent published A Federal Agency Guide for Pilot Watershed Analysis (1994) and the Draft Region 5 Ecosystem Management Guidebook (USDA Forest Service, Pacific Southwest Region 1994) Both offer detailed procedures to accomplish this task

5. Conducting Critical Area Analysis

Once critical areas have been identified, a cause and effect analysis will be conducted to evaluate the cause of the problems and the rehabilitation potential of the area. Rehabilitation objectives will be developed that are clearly stated in terms of resource condition. Individual projects within the critical area will be proposed. Although the identification and analysis of critical areas is presented as a staged process the boundary between phases will not necessary be sharp.

All proposed projects and project areas will be coordinated to function as a unit. For example: restoration of stream channel problems will be coordinated with road problems that effect the channel being restored, land use on upland areas within the drainage to be restored, such as timber stand improvement, compacted soils, or fuels reduction, will be taken into account. Proposed land use and/or restoration will be adjusted so that all efforts within the drainage are coordinated. This coordinated effort will ensure that the range of proposed treatments act in concert to efficiently identify problems and produce desired conditions.

6. Development of Proposed Solution Alternatives

A full range of solution alternatives will be developed for each critical area. These alternatives will be based on objectives developed during the Critical Area Analysis. Management and treatment alternatives will be evaluated in terms of the degree to which they will enable natural healing process and conditions to function and sustain themselves through proper land-use management. All environmental documentation will cake place at this step in the process.

7. Conducting A Project Effectiveness Analysis

A Project Effectiveness Analysis (PEA) will be conducted for each critical area. The PEA is divided into three analyses: 1. Economic Efficiency, 2. Environmental Quality, and 3. Social Well-Being.

The purpose of the <u>economic efficiency analysis</u> is to identify, and examine, over time, the dollar costs and benefits of a proposed project to determine whether the benefits outweigh the costs. The full economic analysis will be completed when the project designs and cost estimates are finished.

The <u>economic and social well-being analysis</u> is the identification and determination of the effect of the project on the economics, infrastructure and social life of dependent communities. Primary areas of social effects are variables such as security of life, health and safety, cultural values, property damage, local business activity, employment, vital community services, impacts to special sites, minority participation, and opportunity for technology transfer.

The <u>environmental quality analysis</u> is the determination of effects created by a project on the characteristics of the environment that are often non-market and non-monetary. Beneficial effects maintain, restore, or enhance one or more of the characteristics of the natural environment.

Project planners need to prepare a complete project effectiveness analysis for each action alternative of a proposed project. These analyses provide a useful tool to assist project planners in selecting a viable alternative for project implementation and to insure that each project integrates all necessary resource elements (See Appendix E for complete Project Effectiveness Analysis).

8. Project Planning and Implementation

Project Submittal

Prospective projects are brought before the Resource Conservation District (RCD) and the Steering Committee by local Landowner(s)/Land Manager(s). If Steering Committee accepts the project concept the project is referred to tl-Project Subcommittee.

The Project Subcommittee is chaired by a representative of the Feather River Resource Conservation District (FRRCD). This facilitates the ease of contact within the community for the identification of local projects and gives increased control of projects at the local level. The Project Subcommittee assists the local Landowner(s)/Land manager(s) in the development of a project Technical Assistance Committee. Each proposed project has a lead agency the assumes the lead responsibility to shepherd the project through the regulate process to implementation. Projects on private land may use the Resource Conservation District, local County Services Districts or The USDA Soil Conservation Service as the lead agency. CRM projects on public lands are by the land management agency (USDA Forest Service, BLM, CDF&G7 ect.) with jurisdiction. Projects with mixed ownership lands may have multiple lead agencies cooperating under cooperative agreements, joint powers, contracts, other instruments.

Project Funding

The Finance Subcommittee is composed of members from the Department of Fish Game, Department of Forestry and Fire Protection, Department of Water Resources, Feather River Resource Conservation District, North Gal-Neva Resource Conservation and Development Area, Pacific Gas and Electric Company, Plumas Corporation, USDA Soil Conservation Service and USDA Forest Service.

The Finance Subcommittee, working with other CRM signatories, identifies possible funding sources for projects as well as aids in the preparation of funding applications when necessary. The general funding categories sought the Finance Subcommittee depend on the type of project proposed.

All CRM signatories are encouraged to assist in the funding effort. However individual signatories are not required to provide funds for projects that not yield benefits to them.

Project Design and Review Responsibilities

The project lead agency is the responsible entity for project implementation The lead agency and Landowner/Land Manager may choose to do draft design concepts in-house with technical assistance from other CRM signatories or they can elect to use outside entities to do preliminary or final design work. A draft designs are submitted to the Design Committee for review and approval procedures and principles used. Once the draft is in the Design Committee, congruence of science takes place and designs are reviewed on the bases of type of technology employed and how well they meet CRM and project objectives Designs are only approved when consensus with all involved entities is reached.

Consensus on project design is the responsibility of the project TACs. Once designs and costs are completed and approved the Economic Efficiency Analysis begun in step 7 can be completed.

Design funding can be handled in several different ways depending on project type, size, and design funding needs. Design funding can come from "seed money" provided by different CRM signatories or from the Landowner/Land Manager where the project is located. All CRM projects require considerable donated time by the CRM, its staff at Plumas Corporation and other signatory organization staff.

Preconstruction Environmental Review

The project lead agency is the responsible entity for the necessary environmental documentation. The lead agency has the option to conduct the environmental review in-house or to contract with outside consulting firms or other entities for the needed work. Local representatives of the lead agency are also responsible for informing State review personnel on the progress of environmental documentation to ensure a timely review at all levels. CRM participants facilitate regulatory agency review by providing information and conducting field tours of project areas as needed.

On large projects with mixed public and private lands, differing environmental requirements require a concurrent process for developing and tracking the progress of environmental documentation for the multiple lead agencies and regulatory agencies. This coordination becomes critical to project scheduling. The task of coordinating environmental documentation is one of the responsibilities of Plumas Corporation in its roll as CRM staff.

Project Permits, Approvals, and Agreements

Permits, approvals, and agreements are the responsibility of the lead agency and Landowner/Land Manager on any CRM project. Federal and State agencies may prefer to conduct application processes in-house or to have Plumas Corporation prepare the documents for the lead agency. Check lists of the needed documents are constructed and the permit application process is tracked to ensure they are issued by the required date to keep projects on schedule. The permit tracking coordination is usually conducted as part of Plumas Corporation overall project coordination role. The RCD is responsible for ensuring timely implementation of projects and reports any delays to the Management and Steering Committees. Unresolved problems are referred to the Executive Committee for resolution.

All projects require the Landowner(s)/Land manager(s) full support as evidenced by agreements. These agreements can cover a wide variety of resource and land management issues, but generally revolve around overall stewardship goals and objectives as well as short and long term resource use in the project area. Management, maintenance and monitoring agreements are necessary to protect the restoration investment and to ensure grantors that post-project land and resource uses do not hinder project recovery or put restoration work at risk. Common subjects covered under management agreements include: livestock grazing. forest practices, mining, public access, fishing, hunting, and the kinds of structural and vegetative maintenance needed by the landowners (s)/land manager(s) to protect the project. Consensus is the key to these agreements and projects will be shelved unless all points are agreed upon by all involved parties. The length of time that the agreements remain in place vary from project to project depending on the needs of the project, regulatory agencies grantors and permit stipulations. Ten year stewardship agreements are common.

Contracting

The lead agency and Landowner/Land Manager are responsible for contracting c may administer all contracting in-house. The lead agency, Landowner/Land Manager may choose to enter into an agreement with Plumas Corporation to prepare all contracts for review by the lead agency, Landowner/Land manager. The lead agency opens all bids and awards the contract. Subsequently, the agency often enters into an agreement with Plumas Corporation to coordinate project implementation work under an umbrella project management contract oi agreement.

Project Construction

The lead agency, Landowner/Land Manager is responsible for project implementation and administration. The lead agency Landowner/Land Manager r choose to contract all or part of this activity to the CRM where Plumas Corporation, the coordinating arm of the CRM handles these project activities. The RCD is responsible for insuring that the project is implemented to the satisfaction of the landowner/land manager and that implementation occurs ii timely fashion. The project design Technical Assistance Committee (TAG) is responsible for insuring that the project is implemented as designed. All projects to date have been implemented under the Steering Committee, Project Committee/Plumas Corporation framework described above.

Project closeout. Monitoring and Maintenance

The lead agency, Landowner/Land Manager are responsible for insuring that project closeout activities, such as post project reports, audits, monitoring: and permit compliance are accomplished as specified in permits and contract.
Project monitoring, the responsibility of the lead agency, Landowner/Land Manager, is designed and scheduled by the Monitoring Subcommittee to meet C and regulatory requirements stipulated in permits and grants for the project The Monitoring Subcommittee oversees the performance of the required monitor activities and coordinates between regulators and project monitors.

Currently the CRM is working with the Army Corps of Engineers, The Environmental Protection Agency, The US Fish and Wildlife Service and California Dept. of Fish and Game to develop a program 404 permit for restoration/mitigation work in the EBNFFR watershed constructed under the CRM program. If and when this comes about it would greatly streamline the CRM process saving time and allowing more funds to be spent on the ground and less in the preparation a administration of required permits.

Project maintenance is the responsibility of the Landowner(s)/Land Manager(In the event of serious maintenance needs that occur as a result of natural disaster such as flood, fire or other unexpected events, the Landowners/Land Manager can resubmit the project to the CRM for project maintenance assistance.

including damage evaluation, repair design, and the seeking of additional funds to take care of project needs.

9. Monitoring

Over the last few decades, the forest industry has come under increased scrutiny. Considerable concern has been expressed over the impacts of land management activities on other designated us«s of water, such as domestic water supply, fisheries, recreation, *a.n4* other values of water bodies that may not be recognized, such as the health of aquatic and riparian ecosystems. The current trend is clearly towards increasingly stringent regulation of forest practices, and there are no signs that public concern will abate in the future. This same scrutiny is now being turned toward public land grazing and its impacts on water quality and public riparian areas and their associated plant and animal communities (See: Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangelands Streams, US Environmental Protection Agency, EPA 910/R-93-017, Region 10, 1200 6th Ave Seattle WA 98101).

Passage of the National Environmental Policy Act (NEPA) in 1969 provided the means for regulator^ agencies and the public to openly evaluate the potential environmental impacts of management activities and participate in federal" planning process. However, there is not a comparable, clearly defined process by which the public and regulatory agencies can evaluate the effects of management activities on the environment. This is particularly true in the forestry arena, as nonpoint source pollution is controlled primarily by the formulation and adoption of Best Management Practices (BMPs). Effective BMP evaluation can be done only by directly monitoring the effects of management activities on the designated uses of the water bodies of concern. The protection of streams through BMPs is an iterative process. An ideal parameter for monitoring the impacts of a land management active should

- be highly sensitive (responsive) to the management action (s),
- have low spatial and temporal variability,
- be accurate, precise, and easy to measure, and
- be directly related to the designated use of the water body.

This ideal parameter should then be monitored in the context of a project which (1) provides useful feedback to managers, (2) directly links management to the status of the designated uses both on-site and downstream, (3) allow statistical inferences to be made to larger populations, and (4) allow quantitative estimates of risk and uncertainty (MacDonald et al. 1991). Since such ideal parameters often do not exist and monitoring projects rarely are able to fulfill all these objectives the task of determining what to monitor and how to monitor may become difficult and confusing.

Often an assessment or inventory serves as the first step towards establishing a monitoring project. Knowledge of the spatial and temporal variability is essential to developing an effective monitoring plan. To the extent that inventory and assessment techniques overlap with monitoring procedures valid inventories and assessments can help with the conceptual problems of deciding what, where, and how to monitor.

Seven different types of monitoring are defined. It should be emphasized that these seven types of monitoring are not mutually exclusive. Often the distinction between them is determined more by the purpose of monitoring than by the type and intensity of measurements. Most water quality monitoring projects involve more than one of the types of monitoring defined. The integration of several types into one project usually is due to multiple objectives. Distinct objectives attained through different types of monitor do not necessarily require distinct and independent data collection effort. the monitoring objectives are clearly specified, one usually finds considers overlap in terms of data needs, and recognition of this can result in considerable cost savings.

Monitoring Types (Taken from MacDonald et al, 1991)

1. Trend Monitoring.

The use of the word "trend" implies that measurements will be made at regule well-spaced time intervals in order to determine the long-term trend in a particular parameter. Typically the observations are not taken specifically evaluate management practices, management activities, water quality models, water quality standards, although trend data may be utilized for one or all these purposes.

2. Baseline Monitoring

Baseline monitoring is used to characterize existing conditions' and to establish a data base for planning or future comparisons. The intent of baseline monitoring is to capture much of the temporal variability of the constituent(s) of interest, but there is no explicit end point at which baseline monitoring becomes trend monitoring. Those who prefer the term "inventory monitoring" and "assessment monitoring" often define them such tl they are essentially synonymous with baseline. Others use baseline monitor: to refer to long-term trend monitoring on major streams.

3. Implementation Monitoring

Implementation monitoring assesses whether activities were carried out as planned. The most common use of this type of monitoring is to determine whether BMPs were implemented as specified in an environmental assessment, environmental impact statement, other planning document, or contract. Typically this is carried out as an administrative review and does not involve direct environmental measurements, such as water quality. Many believe that implementation monitoring is the most cost-effective means to reduce nonpoint source pollution because it provides immediate feedback to the managers on whether the BMP process is being carried out as intended. On its own, however implementation monitoring cannot directly link management activities to environmental quality, as no measurements are being made.

4. Effectiveness Monitoring

While implementation monitoring is used to assess whether a particular activity was carried out as planned, effectiveness monitoring is used to evaluate whether the specified activities achieved the desired effects. Confusion arises over whether effectiveness monitoring should be limited to evaluating individual BMPs, or whether it also can be used to evaluate the total effect on an entire set of practices. Effectiveness monitoring should be used in the narrow sense of evaluating individual management practices, particularly BM: Monitoring the effectiveness of individual BMPs, such as the spacing of water bars on skid trails, is an important part of the overall process of controlling nonpoint source pollution. However, in most cases the monitoring of individual BMPs is quite different from monitoring to determine whether the cumulative effects of all the BMPs result in adequate environmental protection.

5. Project Monitoring

This type of monitoring assesses the impact of a particular activity or project. Often this assessment is done by comparing data taken upstream or downstream of the particular project, although in some cases, such as fish habitat improvement projects, the comparison may be taken on a before and after basis. Because such comparisons may in part, indicate the overall effectiveness of the BMPs and other mitigation measures associated with the project, some agencies consider project monitoring to be a subset of effectiveness monitoring.

6. Validation Monitoring

This type of monitoring will be discussed primarily with regards to the quantitative evaluation of a proposed water quality model to predict a particular water quality parameter. In keeping with the basic principal of modeling, the data set used for validation should be different from the data set used to construct and calibrate the model. This separation helps ensure that validation data will provide an unbiased evaluation of the overall performance of the model. The intensity and type of sampling for validation monitoring should be consistent with the output of the model being validated.

7. Compliance Monitoring

This is the monitoring used to determine whether specific water-quality criteria are being met. The criteria can be numerical or descriptive. Usually, the regulations associated with individual criterion specify the location, frequency, and method of measurement.
The monitoring needs of each CRM project will be evaluated by the Monitoring Technical Advisory Committee (see figure 2.) and the monitoring plans developed. In addition this committee also oversees monitoring implementation, data analysis and reporting.

Outputs and Benefits

On-site benefits are benefits occurring at the project site where management changes and/or restoration has taken place.

- Enhanced soil stability and productivity
- Improved water quality
- Enhanced fish and other riparian dependent wildlife habitat
- Improved native plant communities
- Improved forage
- Improved channel geometry

Off-site benefits are benefits that may be occurring at the project but also extend outside the project area.

- Improved flow conditions
- Enhanced water quality
- Enhanced channel stability
- Decreased sedimentation
- Enhanced aquatic habitats

Functional benefits are benefits derived when the natural ecosystem function (as we understand it) is maintained or restored.

- Elevated, enhanced or restored water table
- Maintained or enhanced nutrient development, capture and routing
- Enhanced flow timing for flood and late season flows
- Improved riparian and aquatic ecosystem health
- Improved habitat development
- Improved biological diversity

Social economic benefits are benefits to the human aspect of the environment

- Extended reservoir life
- Improved timing of water for beneficial uses (hydroelectric,
- irrigation, storage etc.)
- Long-term and short-term community stability (sustained resource use
- and jobs)
- Improved management and public acceptance
- Improved public participation
- Improved restoration using a more comprehensive (ecosystem) approach
- Improved transfer and development of restoration/monitoring/management
- technologies
- Improved cooperation/integration between public and private land
- management
- Increased monitoring of both project areas and management
- Improved data collection and analysis
- Education of both the resource manager and the resource user at all levels (increased awareness of natural systems, their form, function, health, and the commodities they produce).

APPENDIX A

Problem Description
Channel Stability Features by Stream Type

APPENDIX A

Problem Description, Channel Stability Features

Channel Stability Features by Stream Type, A Description of Stable/Sensitive and Unstable/Sensitive Stream Channels

Stream channels within the EBNFFR can be broadly classed as non-sensitive and sensitive based on the channel's resistance to erosion. Channel sensitivity can be based on an index of particle size and distribution. Channel bed and banks with a high degree of bedrock and boulder are relatively non-sensitive to impacts which cause accelerated erosion. Generally, as channel bed and bank particle size decreases, sensitivity to land use impacts increase.

Sensitive channels, those channels most susceptible to accelerated erosion, can be classed as stable or unstable based on channel gradient and the degree of bed and bank protection.

General Channel Descriptions (Adapted from Rosgen 1993)

A-Type Channels

General description: Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated.

Landform and channel features: High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step-pool bed morphology.

B-Type Channels

General description: Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan, profile, and banks in most cases.

Landform and channel features: Moderate relief, colluvial depositions and/or residual soils. Moderate entrenchment and width/depth ratio. Narrow, gently sloping valleys. Rapids predominate with occasional pools.

C-Type Channels

General description: Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains.

Landform and channel features: Broad valleys with terraces in association with floodplains and alluvial soils. Slightly entrenched with well-defined meandering channel. Riffle-pool bed morphology.

D-Type Channels

General description: Braded channel with longitudinal and transverse bars. Very wide channel with eroding banks.

Landform and channel features: Broad valleys with alluvial and colluvial fans. Glacial debris and depositional features. Active lateral adjustment with an abundance of sediment supply.

DA-Type Channels

General description: Multiple channels (anastomosing) narrow and deep with expansive well vegetated floodplain and associated wetlands. Very gentle relief with highly variable sinuosities. Stable streambanks.

Landform and channel features: Broad, low gradient valleys with fine alluvial and/or lacustrine soils. Multiple channel geologic control creating fine deposition with well-vegetated bars that are laterally stable with broad wetland floodplains.

E-Type Channels

General description: Low gradient, meandering riffle/pool stream with a lo" width/depth ratio and little deposition. Very efficient and stable with a meander width ratio.

Landform and channel features: Broad valleys and meadows. Alluvial material with floodplains. Highly sinuous with stable, well vegetated banks. Riffle-pool morphology with very low width/depth ratio.

F-Type Channels

General description: Entrenched meandering riffle-pool channel on low gradients with high width/depth ratio.

Landform and channel features: Entrenched in highly weathered material. Gentle gradients, with high width/depth ratio. Meandering, laterally unstable with high bank-erosion rates. Riffle-pool bed morphology.

G-Type Channels

General description: Entrenched "gully" step-pool with low width/depth rat on moderate gradients.

Landform and channel features: Gully system with a step-pool morphology. These channels have moderate slopes and low width/depth ratio. Common in narrow valleys, or deeply incised in alluvial or colluvial materials, such fans or deltas. Unstable with grade control problems and high bank erosion

Note: This report deals with A-type, B-type, and C-type channels description However it should be remembered that these three main channel types can exist in degraded form. As an example: C-types channels are common in the EBNFFR may degrade into a D-type or F-type and may experience an intermittent G-type stage. Each of these stages do exist within the EBNFFR and were evaluated included under the general A, B, or C Channel types for reasons of simplicity

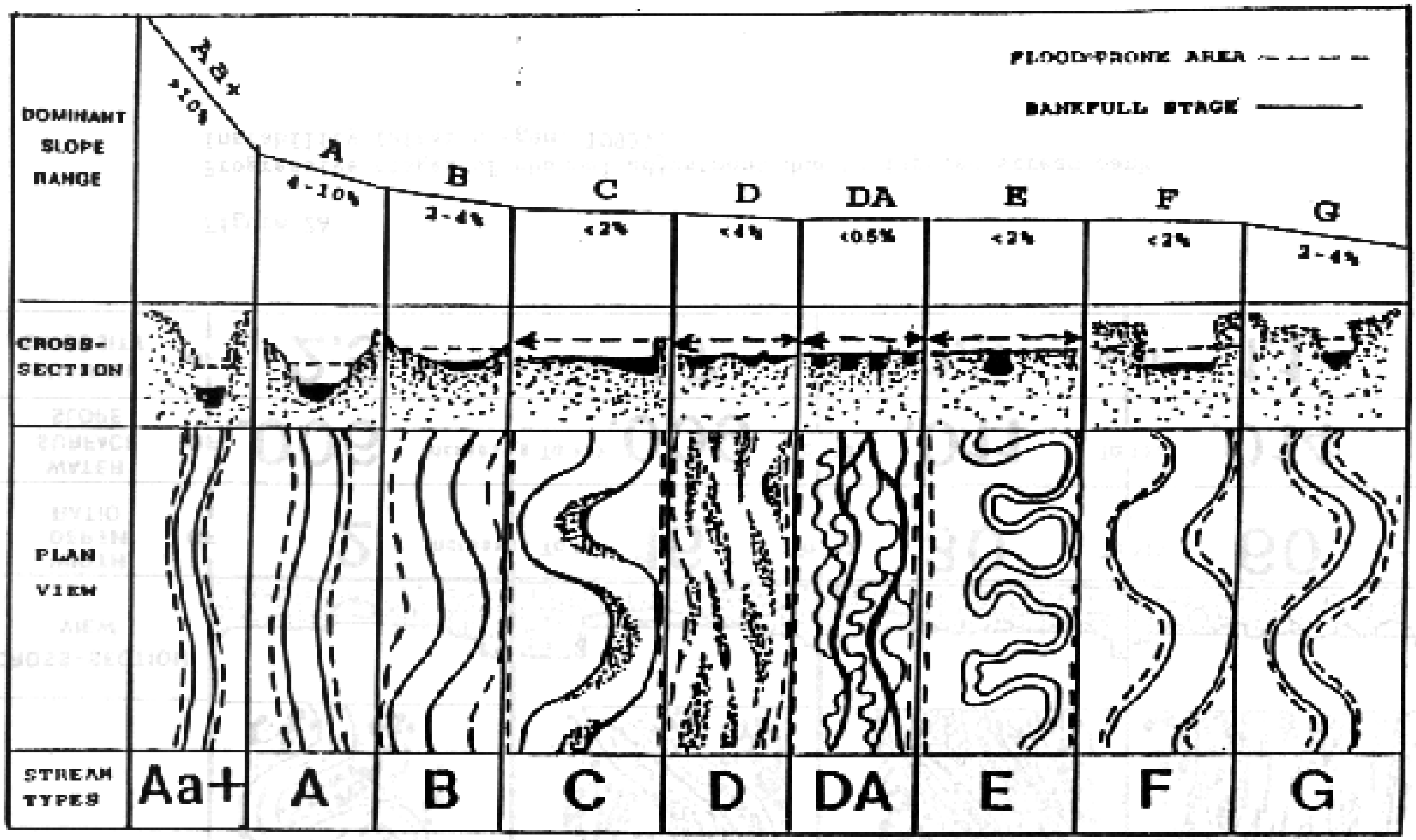


Figure l A   Progressive stages of channel adjustment due to imposed stream bank instability (after Rosgen, 1993).

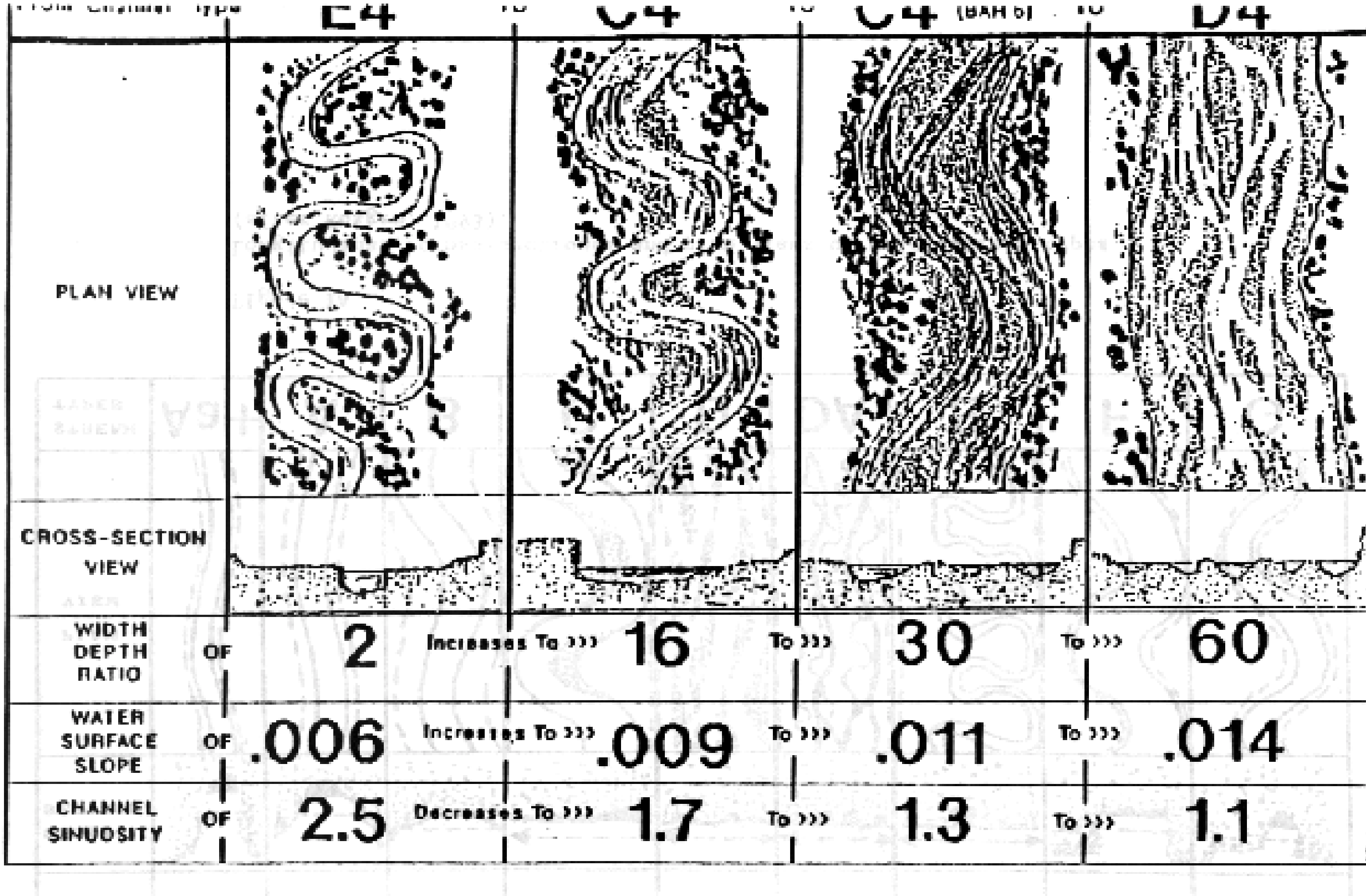


Figure 2 A Longitudinal, cross-sectional and plan views of major stream types (after Rosgen, 1993).

A-type Channels [High Gradient, Totally Confined Channels]

Non-sensitive A-type channels are the steep, well confined, bedrock and boulder channels. These are the Al and A2 channel types (as defined by Rosgen, 1985 and modified in 1991). Because these channels are resistant to rapid channel changes brought about by land use impacts they will not be considered beyond this point.

Sensitive A-type channels, the A3 cobble, A4 gravel, A5 sand, and A6 silt/clay stream types can be described as being stable/sensitive and unstable/sensitive. Stability in these stream types is primarily due to channel gradient and vegetative bank protection. Changes in one or both of these factors results in accelerated channel erosion.

Channel Description-Stable/Sensitive A-type Channels.

Stable A-type channels without bedrock and boulder features maintain an equilibrium that is determined by the relationship in which discharge and velocity balance the amount and size of the bedload. Channels with this relationship are at dynamic equilibrium (Morisawa 1968). Dynamic equilibrium in channels is a fluctuating balance, if a bar is swept away with rising water, it will be reestablished at low water; if a channel is filled, it will be scoured out again. Over-steepened profiles, common in A-type channels, are maintained by a pool-drop sequences in which large woody debris, or other grade control features play an important roll. Fallen trees and their large debris form log steps in these channels. These bed structures transform the potential (original) steep gradient into a stepped profile that dissipates energy and results in lower flow velocities, hence lower bedload movement. Where debris is insufficient, bars will form to create the pool-drop sequence. Heede (1976) found that the combined height of log steps and bars amounted to 76-90% of the total channel fall, substantially reducing potential energy and retaining the channel profile.

In addition to the stabilizing influence of large woody debris, stable/sensitive A-type channels support a complex riparian vegetation community. Not only is this important for the recruitment of large woody debris but also provides bank stability. Vegetation with woody root systems in combination with grasses, forbes, and other types of vegetation provide a physical barrier to the effects of high velocities and turbulence, creating banks with considerable roughness and relative stability.

Profile equilibrium and vegetative bank protection are the two most common features found on stable/sensitive A-type channels. Disturbance of the balance provided by these features will cause a corresponding adjustment in bed form, bed armor, channel width, alignment, and bank vegetation, all resulting in a rapid downstream transport of bedload and sediment into lower gradient channel systems.

Channel Description-Unstable/Sensitive A-type Channels.

In most all cases sensitive A-type channels that are unstable and degrading have lost one or both of the stabilizing features mentioned above. Heede (1985) found that the removal of large woody debris that provided a pool-drop sequence in a high gradient channel resulted in the formation of gravel bars offset the loss of log steps. This requires an increase in bedload movement When the pool-drop profile of a channel is altered or lost the primary energy dissipaters have also been lost. The channel has more energy for reworking channel banks and bed material. In order for the channel to replace the lost log steps with bars it needs to erode material from the channel banks and bottom until it has reestablished an equilibrium. This generally results in increased bank erosion, channel downcutting, and downstream sediment deliver Platts (1985), found that when large organic debris no longer entered the stream, channel banks became unstable and a period of accelerated streamside erosion soon followed.

Detrimental changes in the productivity and composition of riparian vegetation brought about primarily by a variety of land use practices, can cause bank erosion, increasing stream width, decreasing stream depth, higher stream temperatures in summer and colder water temperatures in winter. Dynamic equilibrium in channel systems is a complex interrelationship between physic and biological factors working together to maintain a condition of balance between erosion and deposition. Even with improved conditions and management a heavily disturbed channel would not be expected, under natural recovery, t reestablish equilibrium for at least 100 years. This natural recovery time be lengthened- for disturbed channel areas experiencing multiple resource extraction or entries occurring along the stream and adjacent forest.

B-Type Channels: [Moderate to Low Gradient, Moderately Confined Channels]

B-type channels are transition channels between the high gradient, totally confined A-type channels and the low gradient unconfined C-type channels. Characteristics of both channel types are expressed in B-type channel. Non-sensitive B-type channels are those channels which are composed of bedrock(boulder, and large cobble. These are the Bl, B2, and B3 channel types. These channel types remain relatively stable under moderate land use impacts.
Sensitive B-type channels, the B4 gravel, B5 sand, and B6 silt/clay channel: can be described as being stable/sensitive and unstable/sensitive. stability in these stream types, as with the A-type channels is a function ' channel grade and vegetative bank protection.

<u>Channel Description-Stable/Sensitive B-type Channels.</u>

Dynamic equilibrium in stable B-type channels is maintained by a combination pool-drop sequence and pool-riffle (meander) sequence. As with A-type channels, large woody debris and other grade control features play an important roll in the stability of B-type channels. This is especially true in the B-type cobble gravel, and sand channels that tend to occupy the upper gradient range for B-type channels. The pool-drop sequence in these channels function in the same manner as explained for the A-type channels. As slope and confinement decreases a pool-riffle sequence comes into play. I" general, bedload particle size decreases with slope in the downstream direction. If channel slope exceeds that required to transport the bedload, the stream will meander to lengthen its course and decrease its grade.

In a meandering stream, according to Beschta and Platts (1986), riffles are located between successive pools at the inflection point of the channel thalweg. Their form represents a balance between the frequency and magnitude of flow, sediment transport, erosion, deposition and channel obstructions. The pool-riffle sequence, like the pool-drop sequence acts to dissipate energy and maintain channel grade.

In the pool-riffle system, water moving out of a turbulent pool encounters a lower effective slope at the head of the riffle. This encounter causes reduced stream power and deposition of the coarse bedload in transit. As the water continues to pass over the riffle, which has a steepening slope, it accelerates until again expending most of its energy, as turbulence, at the next pool. Over time the discharge and sediment load entering the system are balanced by that leaving the system.

As with A-type channels, stream bank protection is important to the stability of the channel. Riparian vegetation supplies a variety of woody and fibrous root systems that not only bind the bank soil but add roughness to the channel banks. This roughness, at the water/bank interface reduces shear stress on the bank while the roots which bind the soil increase the shear strength of the bank. The combination of pool-drop and pool-riffle features with vegetative bank protection reflect the balance of bank and bed resistance to side and bottom velocity and shear.

Channel Description-Unstable/Sensitive B-type Channels.

Unstable/sensitive B-type channels have encountered occurrences that have reduced or eliminated grade control and/or bank stability. Generally this disturbance results in an increase in energy gradient and a corresponding increase in channel grade. Once the energy dissipating features in the channel are disrupted the channel has an excess of energy to transport its load. It expends this energy by scouring its channel at the point of excess power. The result is a decrease in slope below the given point but, at the same time, an increase in slope above it. A nickpoint in the channel is formed and a wave of erosion proceeds upstream.

With the increase in slope and bedload transport, is a corresponding decrease in channel depth and an increase in channel width. A wide, shallow channel has a higher velocity, a straighter channel, and a greater rate of shear near the bed than the channel sides, which aids entrainment and transport of bedload. The result is that the channel downcuts (reduces the elevation of its bed), transporting large amounts of bed and bank material downstream until a new equilibrium can be established.

During the channel widening process the shear stress on the banks will often remove the soil from among the roots of riparian plants causing a substantial loss in the riparian vegetation community. Many riparian plants recover quickly from disturbance but full recovery of the riparian ecosystem is not likely to occur until a new equilibrium is reached and riparian tree species have matured to the point where recruitment of large organic debris can be expected.

Alluvial B-type channels, the B-5 and B-6, are associated with meadow ecosystems. When disruptions in channel slope result in channel downcutting and widening the soil moisture of the meadow decreases. This results in an overall decrease in meadow productivity and, in extreme cases, a change in the vegetation community from mesic to xeric.

C-Type Channels: [Low to Very Low Gradient, Unconfined Channels]

Non-sensitive C-type channels are those channels composed of bedrock, boulder and cobbles. These are the Cl, C2, and C3 channels. Because of the dominate material size, they remain relatively stable under moderate land use impacts.

Sensitive C-type channels, the C4 gravel, C5 sand, and C6 silt/clay channels exist in both the stable and unstable condition. As with both A-type and B-type channels, stability is a function of channel grade and the condition • the vegetation which protects the channel banks.

Channel Description-Sensitive/Stable C-type Channels.

Dynamic equilibrium in stable C-type channels is maintained by the pool-riff meander sequence. As channel grade decreases, so does sediment load and grain size. With a reduction in the amount of sediment and grain size, less energy hence, less slope is needed to move the sediment. When the channel slope exceeds that required to transport the grains on the bed, the stream will meander to lengthen its course and thus decrease the grade. As sediment gravel size decreases so does the channel width to depth ratio. The channel narrow and deepens. These channels maintain a higher rate of shear near the banks than on the channel bed.

No one explanation fully satisfies as the cause of meandering. It is most likely a result of a number of interacting factors such as slope, discharge, sediment particle size, bed load, and variations in the flow pattern within water column. Once the initial bend develops it is propagated and other bend develop as water impinges on one bank and is deflected to the other. Channel bank material is removed from the outside of the meander bend, the area of greatest shear, and deposited, as a point bar, on the inside of the downstream meander.

In this type of alluvial channel, pools which exist at the meander bends are scoured during high flows and are centers of sedimentation at low flow. On other hand, the riffles (crossovers) are scoured at low flow but are covered with deposition at high flow. In this manner channel bank and bottom erosion and deposition are balanced and sediment transport through the system remain. fairly low and constant.

Bank stability in this channel type is achieved by tough sod produced by plants that thrive in moist conditions found along the channel. Besides providing cohesiveness to otherwise erodible alluvium, vegetation provides roughness t increases friction, decreases stream velocity and dissipates energy. It also acts to trap and stabilize sediment deposited on bars and flood plains.

Channel Description-Unstable/Sensitive C-Type Channels.

Unstable/sensitive C-type channels have encountered occurrences that have increased the sediment load of the channel. The primary cause of the increase is usually bank instability in the main and tributary channels. Meandering channels In alluvial deposits maintain their meander with a balance of erosion and deposition. Erosion at the land/water interface is buffered by the stabilizing effects provided by vegetation. A lack of bank stability, afforded by riparian vegetation results in accelerated bank erosion which delivers additional sediment to the channel. Unstable C-type channels experience a cycle of bank cutting, down cutting, channel widening, straightening, shallowing, and pool-riffle reduction as well as additional riparian vegetation loss.

Channel width is directly proportional to discharge and sediment load (Morisawa, 1968). Because of this physical characteristic, accelerated inputs of fine sediments from the banks, or other sources, results in channel widening. Channel gradient is inversely proportional to discharge and directly proportional to sediment load (Mackin, 1943. Morisawa, 1968. Simons and Senturk, 1977). The channel will steepen its grade, generally by shortening its length through meander reduction, in response to additional sediment. Channel depth is directly proportional to discharge and inversely proportional to bed material discharge (Leopold and Haddock, 1955. Horisawa, 1968). As additional sediment from the banks enters the channel, the channel must reduce its depth in order to move the material.

Under stable conditions the active channel dimensions conform to bankfull flow that typically represent the normal high water line. On average, this is the discharge with a 1.5 year recurrence interval. This discharge is instrumental in forming the channel that conveys it because it represents the greatest cumulative energy level. Flood flow events, being of short duration, do not generate much effect on channel dimension, even though their energy level is extreme. Base flow, the low flow events lack the necessary energy to have an effect on channel dimensions (Swanson, 1988).
When unstable conditions occur, flood flow begins to exert more influence than bankfull discharge on channel dimensions. This occurs because of two conditions. First: stream channel materials, such as bank material have become weakened. This is generally a result of disturbance to the riparian vegetation, and second: the hydraulic forces impinging on the channel have increased because of conditions that concentrate runoff and sediment load, reduce stability and roughness created by riparian vegetation, and create conditions of accelerated bank cutting that confine flows to a gully where the channel's ability to access flood plains and reduce energy is diminished (Van Havern and Jackson, 1986).

Succession of states for ailuvial/nongraded valley-bottoms common to the East-side of the EBNFFR watershed

(See Figure 3A)

Adapted from Prichard, D. et al, 1993. Riparian Area Management: Process for Assessing Proper Functioning Condition. US Dept. of the Interior, Bureau of Land Management, TR 1737-9 1993, pp 51, BLM Service Center, PO Box 25047, Denver, CO. 80225-0047.

State A (Fig. 3A) represents a high degree of bank stability, floodplain, and plant community development, and would be classified as having a proper functioning condition. Important attributes and processes for this state are:

Hydrogeomorphic - Channel has an active floodplain with functioning floodplain storage and release, a narrow bankful width with a low width/depth ratio (channel is narrow and deep), sinuosity is high, channel gradient and stream power are low and hydraulic controls are in place and functioning.

Vegetation - Multiple community types at mid-to-late seral stage, potential natural community, vegetation community with a high root density, recruitment/reproduction and survival. Very stable.

Erosion and Deposition - Low with a high degree of bank stability.

Soils - Mesic, anaerobic, stable, productive.

Water Quality - High, water temperature and sediments are low. Nutrients and dissolved oxygen are at levels that maintain productivity and water quality

State B may be properly functioning or functional-at risk. It would be classified as functional if bank stabilizing vegetation is dominant along the reach and other factors such as soil disturbance are not evident. It would classified as at risk if bank stabilizing vegetation is not dominant even though it is in an improving trend from prior conditions, non-desirable species are present, soil disturbance is evident (e.g. caving banks from livestock and vehicle use), or hydrologic factors such as degraded watershed condition exists, increasing the probability of extreme flow event. The following changes in attributes/processes are likely:

Hydrogeomorphic - Bankfull width is increasing, width/depth ratio is increasing, no change in depth, active floodplain frequency is decreasing

.

Vegetation - Community types and distribution are changed, root density and canopy loss is occurring, recruitment/reproduction and survival impaired for some species.

Erosion/Deposition - bank erosion is increasing, bank stability is decreasing. Channel bedload may be greater.

Soil - Drier soil conditions along the margin of the meadow.

Water Quality - Slight changes in temperature and sediment are taking place Aquatic cold water habitat begins to degrade.

States C and D - Would be classified as non-functional. State C represents incisement of the stream channel to a new base level. There is little or no bank stabilizing vegetation and no floodplain. Channel widening exhibited in State D must occur to restore floodplain development. Vegetation, if present, is often only temporary (and held at an early seral stage) due to the large adjustment process occurring. The following changes in attributes/processes are likely:

Hydrogeomorphic - Bankfull width continues to increase, channel width/depth ratio continues to rise (increasing width with increasing depth), active floodplain frequency continues to decrease.

Vegetation - Riparian community types have been lost; community type distribution has changed; root density, canopy, recruitment/reproduction, and survival have all decreased. Declines in riparian dependent species have occurred.

Erosion/Deposition - Bank stability continues to decrease, surface erosion on the meadow increases due to a decrease in vegetation density.

Soil - Soil has changed from moist to a well drained condition due to lowered water table, caused by channel incision.

Water Quality - Temperature and sediment continue to increase. Aquatic cold water species are being replaced by warm water species (or cold water species that are better adapted to deal with warmer temperatures) .

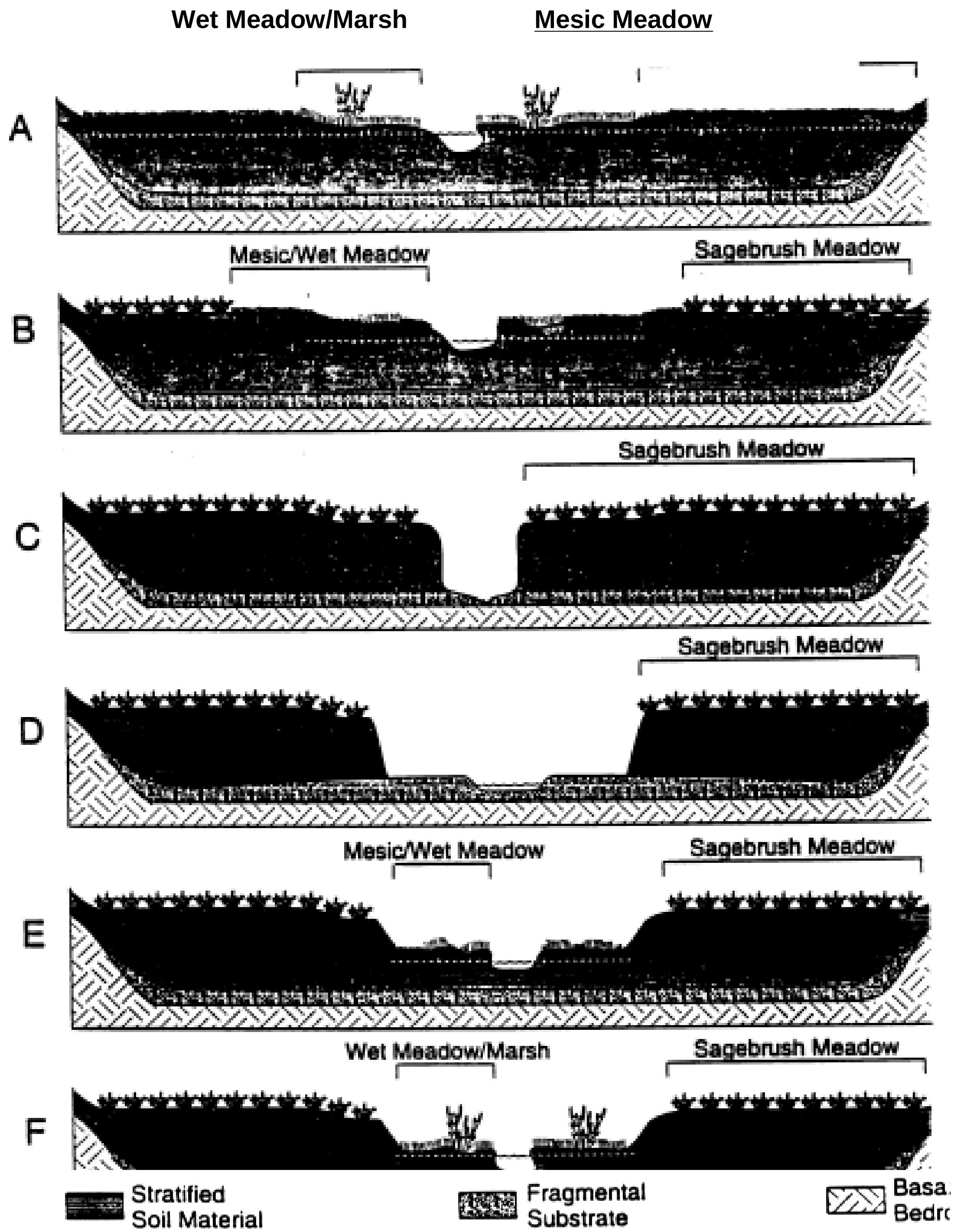
State E may again be classified as functional-at risk or functional depending on vegetation, soil, and hydrologic attributes. Establishment of the floodplain and bank stabilizing vegetation indicate reestablishment of functional conditions. However, stream segments In this state are usually at risk for the same reasons described for State B. Attributes and processes begin to revert back to those that appear in State B.

State F is classified as functioning properly even though the riparian area may not have achieved the greater extent exhibited in State A. The mesic meadow area, along with extensive meadow soil has been lost. Banks are stabilized and exhibit channel geometry similar to State A. The floodplain has widened to the extent that confinement of peak flows is only occasional and the aggrading processes are slowed because of the surface area available. The largest difference between States A and F occurs in size and extent of hydrologic influence, which regulates the size and extent of riparian area. The process described can result in extensive resource loss (i.e. vegetation, forage, soil, water quality, wildlife and fish habitat, as well as ground water recharge and storage capacity).

NOTE: Channel States A-F do not represent Channel Types A-F as described by Rosgen.

Figure 3A

Succession of states for alluvial valley-bottoms common to the EBNFFR Watershed (Adapted from Prichard, D. et al, 1993).



APPENDIX B

General Treatment Recommendations For Unstable/Sensitive Channels by Stream Type

APPENDIX B

General Treatment Recommendations For Unstable/Sensitive Channels By Stream Type

(Costs associated with treatment recommendations can be found in Appendix F)

Central Concepts:

There are two central concepts that need to be kept in mind when considering the management and restoration of all streams, regardless of the type:

1) The key to proper management is to evaluate the cause of the problem and the rehabilitation potential of the site. Evaluate management alternatives in terms of the degree to which they will enable natural healing processes and conditions to function and sustain themselves through proper land-use management. And to recognize that ultimately, healthy stream and riparian conditions will be keyed to proper vegetation management in the riparian zone as well as its associated watershed.

2) It is the physical attributes of the stream channel that act as a template for biological expression. If the template is in poor condition, biological expression will remain low.

Recommendations:

The following treatment recommendations cannot address all site specific conditions and variables encountered in unstable riparian areas across the EBNFFR. Instead it is intended to represent "typical" treatment options by channel type that deal with the primary influences contributing to the degraded conditions of these channels.

Advances in scientific research have increased our understanding of natural processes, biological diversity, and riparian ecosystem health, and called attention to the need for a broad ecological approach to riparian area management. Riparian areas and wetlands are some of the most diverse and productive areas in the EBNFFR. Often these key areas reflect the quality and success of land management activities in the watershed.

Our current scientific understanding of riparian areas relies on a conceptual model that "integrates the physical processes that shape valley floor landscapes, the succession of terrestrial plant communities on these geomorphic surfaces, the formation of habitat, and the production of nutritional resources for aquatic ecosystems". This new ecosystem perspective provides an "ecological basis for identifying riparian management objectives, evaluating current land-use practices and developing future resource alternatives" (Gregory et al. 1991).

It is crucial, with this type of management approach, to analyze the whole system by pulling individual system components together and then evaluating all important influences, interconnections, and interactions in order to gain an ecosystem perspective on riparian management; (Naiman et al. 1992).

Based on these principals, Sidell and Reeves, (1993) have developed a list o riparian management objectives that speak directly to many of the problems identified in the EBNFFR watershed.

1. Maintain or restore water quality to the degree that provides for stable productive riparian and aquatic ecosystems. Water quality parameters that apply to these ecosystems include timing and character of temperature, sediment and nutrients.

2. Maintain or restore the stream channel integrity, channel processes, and sediment regime under which the riparian and aquatic ecosystems developed. Elements of the sediment regime include the timing, volume, and character of sediment input and transport.

3. Maintain or restore instream flows to support desired riparian and aquatic habitats, the stability and effective function of stream channels, and the ability to route flood discharges.

4. Maintain or restore the natural timing and variability of the water table elevation in meadows and wetlands.

5. Maintain or restore the diversity and productivity of native plant communities in riparian zones (Sedell and Reeves included "desired non-native plants" as well as natives, but considering the current emphasis that the El and USFS have put on natives as apposed to non-natives we should be considering only natives plant communities at this time).

6. Maintain or restore riparian vegetation to provide an amount and distribution of large woody debris characteristic of natural aquatic and riparian ecosystems.

7. Maintain or restore habitat to support populations of well-distributed native plant, vertebrate, and invertebrate populations that contribute to the viability of riparian-dependent communities (again the authors include non-natives).

8. Maintain or restore riparian vegetation to provide adequate summer and winter thermal regulation within the riparian and aquatic zone.

9. Maintain or restore riparian vegetation to help achieve rates of surface erosion, bank erosion and channel migration characteristic of those under wt the desired communities developed.

10. Maintain and restore riparian and aquatic habitats necessary to foster unique genetic fish stocks that evolved within that specific geo-climatic ecoregion.

There are three separate but interrelated approaches that can be used to restore stability in stream channels. (1) Changes in management; (2) Engineering and construction; (3) Bio-technical erosion control and revegetation (Gray and Leiser, 1989). Of the three, changes in management, far, plays the most important role. The best engineering work and bio-technical revegetation efforts that technology and money can provide will be for naught without a firm commitment to corrective management. Management changes are the first step in any restoration process. Corrective management must be applied to all project areas and stream types. Changes in the current land-use pattern can, in cases where channel impairment is not severe, provide the necessary conditions that promote stability. When management changes a. will not provide recovery within a reasonable time frame, or will not halt additional resource loss, engineering solutions can be applied to halt channel degradation and solve or minimize additional problems.

Bio-technical applications entail the use of mechanical elements in combination with biological elements to arrest and prevent erosion and enhance natural biological recovery of the project site. Live plant material and engineers structures can function together in mutually reinforcing or complementary roles. Additionally, bio-technical structures constructed of living material can be used to augment, and in some cases replace the more conventional geo-technical (engineered) structure. Live plant structures have the added advantage of being self-regenerating once established and therefore require less maintenance over time. The use of living structures will also provide eroded areas with enhanced habitat for wildlife species as well as soil stability to encourage colonization by additional plant species.

Treatment Description For Unstable/Sensitive A-type Channels

Management Solutions in A-type Channels

Riparian zone management should provide a high quality stream environment t maintains the key structural and functional features that promote dynamic channel and riparian stability. Key structural features deal more with cha slope, hydrology, energy dissipation, soil character, sediment transport, geomorphic processes and topography while the functional features include p succession, energy flow, nutrient cycling, microclimate modifications, organic material inputs and retention, biotic variables and biological community shifts. Each of these features are functioning components of the ecosystem There retention requires a departure from the concept of riparian zones as narrow strip of land independent in form and function from the surrounding landscape and its management. Riparian and aquatic ecosystems, like all ecosystems are thermodynamically open systems, and are not independent from adjacent ecosystems. What is coming into one system, from an adjacent system and what is leaving the system are just as important as what is occurring within the system. Adjacent ecosystems often supply support functions (sue sources of energy) to the target (riparian) ecosystem (Odem, 1983). Often adjustments in land-use pattern both in the riparian zone and adjacent upland influence zones are all that is necessary to remove an impact causing changes in channel stability.

The relative stability of sensitive A-type channels is closely related to t integrity of the channel pool-drop sequence and the health of associated riparian vegetation. These headwater channels depend on inputs of large we debris (LWD) to maintain the channel pool-drop sequence for energy dissipation and gradient control. The recruitment of LWD also plays an important role channel bank stability. Large logs that have fallen on the banks become incorporated, creating stable areas for the growth of vegetation with woody root systems in combination with other riparian plants to provide physical barriers to the effects of high velocity and turbulence.

MANAGEMENT INTERPRETATION OF VARIOUS STREAM TYPES (ADAPTED FROM ROSGEN 1993)

STREAM TYPE	SENSITIVITY TO DISTURBANCE	RECOVERY PONTENTIAL	SEDIMENT SUPPLY	STREAMBANK EROSION POTENTIAL	VEGETATION CONTROLING INFLUENCE
HIGHEST GRADIENT, ENTRENCHED, CASCADING, STEP/POOL STREAMS					
Al Bedrock	VERY LOW	EXCELLENT	VERY LOW	VERY LOW	NEGLIGIBLE
A2 Boulder	VERY LOW	EXCELLENT	VERY LOW	VERY LOW	NEGLIGIBLE
A3 Cobble	VERY HIGH	VERY POOR	VERY HIGH	HIGH	NEGLIGIBLE
A4 Gravel	EXTREME	VERY POOR	VERY HIGH	VERY HIGH	NEGLIGIBLE
A5 Sand	EXTREME	VERY POOR	VERY HIGH	VERY HIGH	NEGLIGIBLE
A6 Silt/Clay	HIGH	POOR	HIGH	HIGH	NEGLIGIBLE
MODERATE GRADIENT, MODERATELY ENTRENCHED, RIFFLE DOMINATED CHANNELS					
Bl Bedrock	VERY LOW	EXCELLENT	VERY LOW	VERY LOW	NEGLIGIBLE
B2 Boulder	VERY LOW	EXCELLENT	VERY LOW	VERY LOW	NEGLIGIBLE
B3 Cobble	LOW	EXCELLENT	LOW	LOW	MODERATE
B4 Gravel	MODERATE	EXCELLENT	MODERATE	LOW	MODERATE
B5 Sand	MODERATE	EXCELLENT	MODERATE	MODERATE	MODERATE
B6 Silt/Clay	MODERATE	EXCELLENT	MODERATE	LOW	MODERATE
LOW GRADIENT, MEANDERING, POINT-BAR, RIFFLE/ POOL, ALLUVIAL CHANNELS					
Cl Bedrock	LOW	VERY GOOD	VERY LOW	LOW	MODERATE
C2 Boulder	LOW	VERY GOOD	LOW	LOW	MODERATE
C3 Cobble	MODERATE	GOOD	MODERATE	MODERATE	VERY HIGH
C4 Gravel	VERY HIGH	GOOD	HIGH	VERY HIGH	VERY HIGH
C5 Sand	VERY HIGH	FAIR	VERY HIGH	VERY HIGH	VERY HIGH
C6 Silt/Clay	VERY HIGH	GOOD	HIGH	HIGH	VERY HIGH
BRAIDED CHANNELS, LONGITUDINAL AND TRANSVERSE BARS, WIDE CHANNEL, ERODING BANKS					
D3 Cobble	VERY HIGH	POOR	VERY HIGH	VERY HIGH	MODERATE
D4 Gravel	VERY HIGH	POOR	VERY HIGH	VERY HIGH	MODERATE
D5 Sand	VERY HIGH	POOR	VERY HIGH	VERY HIGH	MODERATE
D6 Silt/Clay	HIGH	POOR	HIGH	HIGH	MODERATE
MULTIPLE CHANNELS, NARROW & DEEP, EXPANSIVE VEGETATED FLOODPLAIN, ASSOCIATED WETLANDS					
DA4 Gravel	MODERATE	GOOD	VERY LOW	LOW	VERY HIGH
DA5 Sand	MODERATE	GOOD	LOW	LOW	VERY HIGH
DA6 Silt/Clay	MODERATE	GOOD	VERY LOW	VERY LOW	VERY HIGH
SLIGHTLY ENTRENCHED, HIGHLY SINUOUS, LOW GRADIENT, LOW WIDTH/DEPTH RATIO CHANNELS					
E3 Cobble	HIGH	GOOD	LOW	MODERATE	VERY HIGH
E4 Gravel	VERY HIGH	GOOD	MODERATE	HIGH	VERY HIGH
E5 Sand	VERY HIGH	GOOD	MODERATE	HIGH	VERY HIGH
E6 Silt/Clay	VERY HIGH	GOOD	LOW	MODERATE	VERY HIGH
ENTRENCHED, MEANDERING RIFFLE/POOL, LOW GRADIENT, HIGH WIDTH/DEPTH RATIO CHANNELS					
Fl Bedrock	LOW	FAIR	LOW	MODERATE	LOW
F2 Boulder	LOW	FAIR	MODREATE	MODERATE	LOW
F3 Cobble	MODERATE	POOR	VERY HIGH	VERY HIGH	MODERATE
F4 Gravel	EXTREME	POOR	VERY HIGH	VERY HIGH	MODERATE
F5 Sand	VERY HIGH	POOR	VERY HIGH	VERY HIGH	MODERATE
F6 Silt/Clay	VERY HIGH	FAIR	HIGH	VERY HIGH	MODERATE
ENTRENCHED GULLY STEP/POOL, MODREATE GRADIENT, LOW WIDTH/DEPTH RATIO CHANNELS					
Gl Bedrock	LOW	GOOD	LOW	LOW	LOW
G2 Boulder	MODERATE	FAIR	MODERATE	MODERATE	LOW
G3 Cobble	VERY HIGH	POOR	VERY HIGH	VERY HIGH	HIGH
G4 Gravel	EXTREME	VERY POOR	VERY HIGH	VERY HIGH	HIGH
G5 Sand	EXTREME	VERY POOR	VERY HIGH	VERY HIGH	HIGH

Sensitivity to disturbance includes increases instreamflow magnitude and timing and/or sediment Increases. Recovery potential assumes natural recovery once the cause of instability is corrected. Sediment supply includes suspended and bedload from channel derived sources and/or adjacent streamside slopes. Vegetative controlling influences is the vegetation that Influences width/depth ratio-stability.

High gradient A-type channel riparian zones need large standing trees that can fall into the stream and near stream area. In order to safeguard future sources of large woody debris, Chapel et al, (1992) in a recommendation to the Tahoe National Forest, suggested that in addition to the Streamside Management Zone (SMZ), an area extending into the upland forest at least as far as the potential maximum height of the tallest tree capable of growing on the site have the same, or increased, management focus as the SHZ. Others (Thomas, 1993) have recently recommended a standard three hundred feet on each side of the channel. Regardless of which expanded riparian management zone adopted the effect would be similar. This would expand the area of recruitment for natural sources of large debris and limit the introduction of logging debris which tends to be less stable. Woody debris from logging activities is generally smaller in size, highly mobile, because it lacks branches and rootwads, and tends to cause transitory debris dams that destabilize channel banks. Large debris have both a positive and negative effect on bank stability, lateral channel mobility, and on the stability of aquatic habitats. Changes in channel condition and position can occur as a stream bypasses a debris accumulation and cuts a new channel. On balance, however, large debris generally stabilizes small streams by its roles in stream energy dissipation and bank protection (Swanson et al, 1982).

Hillslope process in the terrestrial ecosystem determine the rate and supply of sediment and large organic debris to the riparian and aquatic ecosystem. The process of material transfer from the terrestrial to the aquatic plays an important role in the control of channel geometry, streambed substrate, riparian vegetation character, and habitat development for a variety of organisms. This transfer of material represents the lateral link between upslope processes and the fluvial corridor. In addition to the lateral linkage, an upstream-downstream link also occurs. Fluvial corridors connect headwater montane areas with lowland areas, providing avenues for the transfer of water, nutrients, sediment, particulate organic matter, and organisms. Material inputs in the headwaters have an effect on lower reaches. For example, the productivity of large rivers is, in part, dependent upon receiving quantities of fine particulate organic matter from the upstream, headwater processing of dead leaves and woody debris.

Providing a wider zone of management geared to riparian health and stability will provide either resistance or resilience of this zone to most external factors. For example, riparian plant communities slow flood waters, trap sediment and nutrients, retard erosion, act as buffers to upslope processes, and provide seasonal habitat for many aquatic and terrestrial organisms. Riparian zones are the boundary between terrestrial and aquatic ecosystems. Boundaries perform a function for the resource patches (ecosystems) they separate. Niaman et al (1988) suggests that there is increasing evidence that boundaries may act as semipermeable membranes between ecological systems modifying the direction, character, and magnitude of materials and information exchanged by the adjacent ecological systems. Within boundaries, such as riparian communities, some species are characteristic of those areas while others perform activities there essential for their survival. The abundance and survival of these species are related to the amount and quality of boundary (riparian) space. Many species require more than one ecological system in which to complete their life cycle. For example, amphibians breed and lay eggs in water but live as adults on land; waterfowl and fish often feed in one ecological system but rest, nest, or hide from predators in another. Many species either pass through boundaries or require them during critical period of their life cycle (Niaman et al, 1988).

Chapel et al (1992) point out that the health of the aquatic/riparian/terrestrial landscape is regulated by abiotic factors, biological processes, and disturbance. Important abiotic factors range from fine-scale soil conditions to regional geomorphology. Important biological processes vary in scale from individual organism interactions to community dynamics. Disturbances range from the death of an individual plant to large-scale catastrophic events. Vegetation evolves and adapts to these factors, processes and events at different scales and rates resulting in a dynamic equilibrium in space and time. Atypical disturbances (those most generally associated with human influence) may greatly alter or break down t landscape function. Such disturbances can disrupt nutrient cycling, channel morphology and species interactions such that the ecosystem cannot return to previous states of equilibrium. In these situations, the regenerative properties of the system may be seriously impaired or lost.

Engineering Solutions in A-type channels

Channel Grade: Serious impairment or loss of dynamic equilibrium or the regenerative properties in sensitive A-type channels may require engineering solutions to regain the stability of the channel and riparian zone within an acceptable time frame. If it has been judged that natural recovery under favorable management conditions will stabilize the channel only after the current erosion cycle comes to completion, engineering solutions may be used halt further resource loss to the channel and riparian zone and hasten recovery rates.

. The most easily identified consequence of excessive disturbance to the channel system is a reduction in the stabilizing pool-drop features which control channel grade. Engineering solutions can be used to reestablish these features based on channel geomorphology. Channel condition evaluations conducted in EBNFFR (Clifton, 1992), indicate that A-type channels found to be in fair to poor condition generally need a re-establishment of the pool-drop (energy dissipating) features on approximately 10-50% of any given channel length in order to facilitate enhanced recovery and reduced instability. This would entail the design and placement of rock and/or log structures that mimic the natural pool-drop feature and sequence based on site specific conditions.

Problem Roads: Additional engineering may be necessary to lessen the impacts caused by problem roads and channel crossings. It has long been known that most sediment in forested lands that reach stream channels originate on fore access roads. Headwater channels are highly impacted by roads and channel crossings that transect the side slopes where these channels typically exist Sediment from the road prism may end up in road drainage structures to be removed by flowing water. A percentage of this sediment may be deposited downslope in a buffer of forest litter, behind logs or other obstructions, I a significant amount finds its way into stream side riparian areas or direct into the stream.

Low levels of sediment delivery to channels is a natural and beneficial process, but increased sediment delivery has a deleterious effect that can be felt throughout the channel system and far from the point of initiation. Controlling sediment delivery may entail redesigning or relocating a road or road section that encroaches too closely on the channel or it may entail road obliteration, a reduction in the overall road density of a sensitive headwater drainage.

Channel Crossings: Besides being subject to the same erosion processes at work on roads, crossings are subject to stream channel forces. Any natural stream that has flowing water at some point in the season is subject to water pressure, velocity, and centrifugal forces. Depending on the amount of flow, the channel slope, and sinuosity, these forces can be significant and result in a dynamic interplay of erosion, sedimentation and debris movement. Inserting a crossing into this dynamic environment requires special attention to the effects of the crossing on the channel as well as the effects of the channel on the crossing.

Crossings can disrupt channel stability, forcing the channel to readjust. Culvert outlets may cause the formation of scour holes, culvert inlets set lower than the channel bed can cause head cutting which will move up the channel causing a change in channel grade and disrupting the pool-drop sequence. Culvert placement can disrupt natural fluctuations and minor adjustments in channel grade over time. Stream crossings often receive water and sediment from the road surface by way of the road drainage system. Since channel gradient is inversely proportional to discharge and directly proportional to sediment load, inputs of this nature will result in changes in the channel grade and an overall loss in stability.

Crossings can also act as channel obstructions causing deposition to occur upstream of the culvert entrance. This can force the channel to migrate laterally (to move around the deposition), accelerating bank erosion and adding to the down stream sediment problem. Another type of obstruction that occurs at culverts is blockage to fish and aquatic macro-invertebrate migrations. Many fish and macro-invertebrates migrate upstream and downstream during their life cycle seeking a variety of aquatic habitats which might include spawning, rearing, feeding, or hiding habitats. Although these migrations may be short. for some species, they can be important for the long term survival of the species and maintenance of the population.

Stream crossing approaches are a major problem for the headwater streams. Two basic types of crossing approaches create two types of problems. First: crossing approaches that slope down <u>away</u> from the crossing, known as "positive approaches" and second, approaches that slope down <u>to</u> the crossing, known as "negative approaches". Of the two, the positive approach is the most hazardous to the channel. During high flows the culvert can become obstructed by natural debris movement. This causes ponding above the culvert. If the flow is high enough the crossing will be over-topped. All or part of the channel flow becomes captured by the road surface (which slopes down away from the crossing). The result is excessive erosion to the road surface and sediment delivery to the channel as the captured flow eventually returns to its natural bed. On negative crossings high flows that top the crossing may remove the crossing fill which generally is a smaller sediment input to the channel than occurs on a road capture.

Diagram of a "positive" approach to a stream crossing. The down arrows show the routing of water should the crossing overtop. The arrow on the right shows a stream capture by the roadway. This often causes severe gullying to the road surface and increase sedimentation to the stream channel when the captured flow eventually returns to the stream channel.

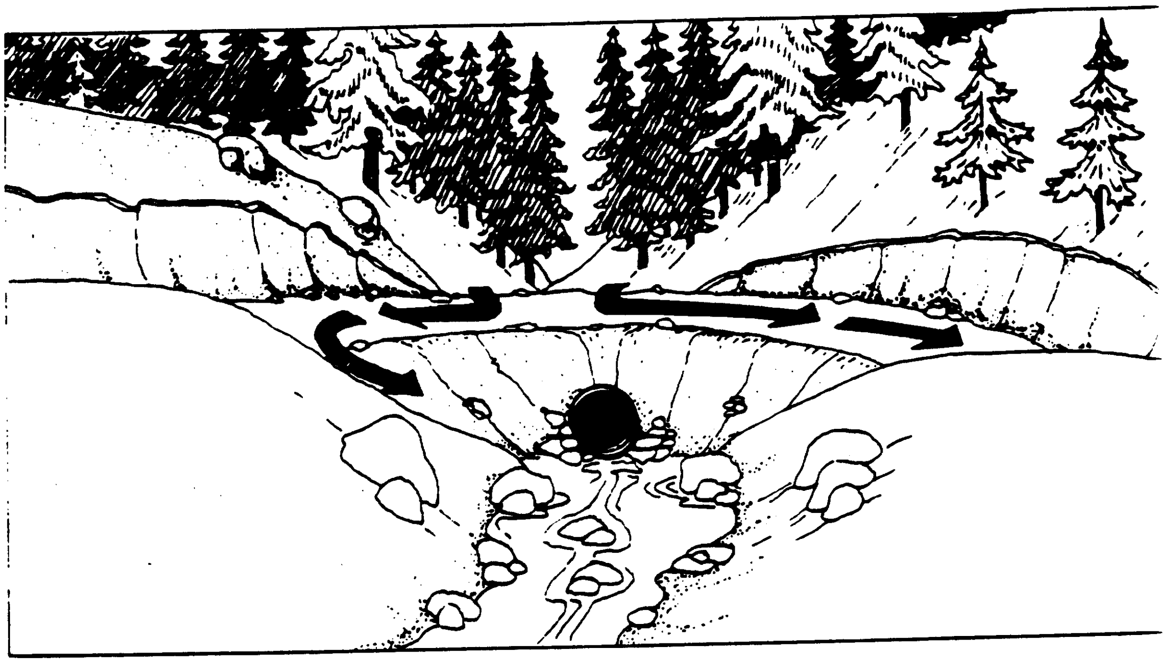
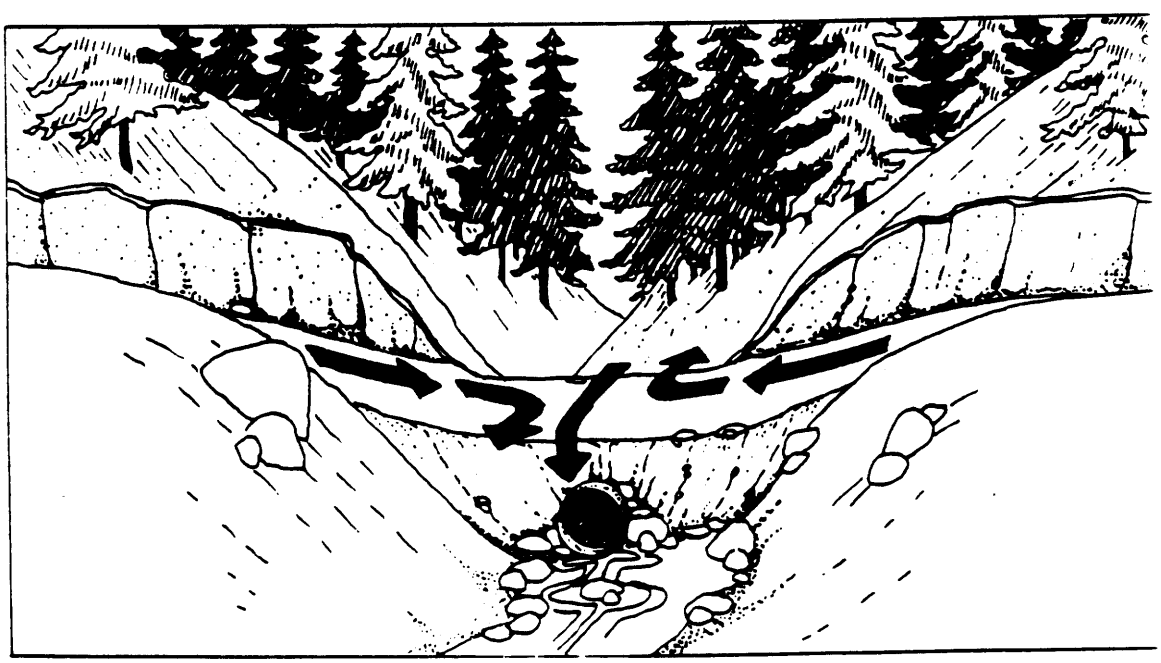


Figure 5A

Diagram of a "negative" stream crossing. Should the crossing overtop, the flow would take the shortest route over the cross fill, minimizing the amount of sediment delivered to the channel.



All stream crossings are designed to fail at some flood recurrence interval. The majority of culvert crossings cannot tolerate more than a 25-year flow event without failure. The chance of a 25-year flow event is about 34 percent in 10 years and 70 percent in 30 years. This is an economic balancing act that all road engineers encounter. Stream crossing designs need to take failure into account and minimize the amount of material that would be added to the channel when the crossing fails. Obviously, too many crossings in a watershed or on a particular stream can cause extensive channel damage when roost fail during a large flood event.

The problem which occurs on approaches that slope down to the crossings is soil movement to the channel from the approaches whenever a runoff event occurs. This type of soil movement can be greatly reduced by rocking or paving these approaches (See Figure 4A and 5A). Crossing related problems need to be considered in terms of density. Reducing the number of times a road crosses a channel, or reducing the total number of crossings in the headwater drainage. Dendritic stream patterns generally consist of a larger number of headwater, A'type channels than downslope areas. Increased channel densities generally mean that roads in these areas will cross channels more often than lower slope areas. Investigation in the EBNFFR indicates that there is an average of 1.4 crossings causing water quality and riparian damage per mile of road. If a problem crossing cannot be removed then it needs to be re-installed or upgraded to reduce impacts to the channel, aquatic habitats and riparian vegetation.

Bio-technical Solutions in A-type Channels

Bio-technical applications (Grey and Leiser, 1989) entail the use of mechanical elements (structures) in combination with biological elements (native plant material) to arrest and prevent erosion. Plants and structures function together in complementary roles.

A variety of live plant structures can be used to enhance bank stability and add to the naturally occurring riparian plant community using native species from the same headwater drainage. In high gradient channels riparian plant communities tend to narrow and closely resemble those of the upslope forest (Gregory et al, 1991). In this type of riparian corridor woody root and stem species are most useful in maintaining bank stability. Plantings of native tree and shrub species that match the existing riparian matrix is the first priority. Planting and engineering solutions can be used together. Soil disturbed during the placement of pool-drop structures can be stabilized using live plant structures, then interplanted with rooted container stock or live stakes. Additional plantings of trees, shrubs, and grass species can be utilized to promote stability on stream crossing fill material. Terrestrial plant species can be used to revegetate obliterated road surfaces and skid trails that encroach on the riparian zone.

<u>Treatment Description Unstable/Sensitive B-type Channels</u>

Management Solutions in B-type Channels

The three-dimensional zone of direct interaction between terrestrial and aquatic ecosystems is basically the same for B-type channels as for A-type channels. Because of this, management solutions are the same as used for A-type channels. However, additional considerations are necessary where these channels are part of a livestock grazing allotment, as is common for the eastern portion of the EBNFFR.

Livestock Grazing: Traditional livestock management has dealt with forage production and health on the uplands and meadows while riparian health has largely been ignored. Clary and Webster (1989), found that grazing conflict with riparian-dependent resources are usually not severe in A-type channels, nor in B-type channels with course textured soils (B2 boulder, B3 cobble and some B4 gravel channels). The greatest conflict occurs in the medium-to fine-textured, easily eroded soils. These are the alluvial B-type channels sand, and B6 silt/clay channels) associated with stringer meadows. According to the Environmental Protection Agency, rangelands are second only to crop lands in total sediment production (Moore, 1979).

Stability in these channels is closely tied to channel grade and the integrity of the pool-drop, pool-riffle sequence as well as channel and floodplain roughness and soil protection provided by riparian vegetation. Livestock grazing is a major streamside use affecting riparian vegetation, proper sediment transport, stream channel morphology, shape and quality of the water column, instream temperature, wildlife habitat, and the structure of the soil portion of the stream bank (Platts, 1981).

Changes in grazing management will be necessary in order to provide a high quality stream environment that maintains the key structural and functional features that promote dynamic channel and riparian stability. Livestock grazing in riparian areas, may not always be entirely compatible with other resource values. Where riparian areas contain unstable soils, fragile vegetation complexes, threatened, endangered or sensitive species, high value fisheries, or municipal water uses are involved, special management prescriptions which call for utilization reductions, rest or non-use may be required. In extreme cases, the exclusion of livestock grazing may be the n logical and responsible course of action (Kinch, 1989).

The compatibility of grazing in riparian areas depends on the extent to which grazing management considers and adapts to certain basic riparian area ecological relationships. These include: the natural function of riparian ecosystems, growth, and reproduction of both woody and herbaceous plants on site specific bases; dependency on riparian areas by other animals such as mammals, fish, birds, reptiles and amphibians; and the hydrologic and geomorphic conditions and processes as well as soils and water quality.

Engineering Solutions in B-type Channels

Channel Grade: Disturbances in the riparian zone and the adjacent upland terrain can result in the disruption of the pool-drop and pool-riffle sequence of sensitive B-type channels. This type of disruption generally results in increase in grade, channel width, water velocity, channel bed and bank erosion and bedload transport. As these factors increase there is a corresponding decrease in channel depth, meander, riparian vegetation, and habitat opportunities.

Engineering solutions can be used to reestablish the pool-drop sequence just recommended for A-type channels. The meandering of a pool-riffle section can be maintained or enhanced to mimic natural channel geometry using log and revetment on outcurve banks and "vortex" rock weirs, placed instream, to facilitate sediment transport and maintain channel grade. At areas of accelerated channel erosion, such as headcutting and excessive bank scour, eroding banks can be shaped in preparation for planting, and loose rock headcut structures can be designed to stop headward movement and reduce instream erosion. Other well known engineered structures such as check dams, flow deflectors, and dikes can also be used to treat site specific problems.

Problem Roads: Surveys conducted in EBNFFR subwatersheds during 1989 and 1990 (Clifton, 1992) identified B-type channels, more than any other channel type, as being most impacted by the location of roads in or near riparian zones. The relatively gentle topography of B-type channel riparian zones make attractive roadways to access upper watershed areas. The close proximity of impervious surfaces caused by roads, skid trails and log landings cause serious changes in the form and function of this zone. During road construction, riparian vegetation complexes are altered, causing changes in the microclimate upon which many species of plants and animals depend. Removal of vegetation which shade the channel results in higher water temperatures in summer and colder temperatures in winter. Aquatic habitats, primary production, biotic structure, and energy pathways shift in response to this change (Triska et al, 1882). Road drainage structures concentrate runoff and channel it into the riparian zone, or directly to the stream channel. Filter strips, natural buffers created by organic ground litter and the roots and stems of plants in the riparian zone, are disrupted. The channel reacts to new relationships of water and sediment discharge (See Figure 6A and 7A).

The first step in dealing with problem roads in or near the riparian zone is to assess the total transportation system to determine which roads are needed and which are less vital. Problem roads or road segments that are no longer needed can be obliterated. This involves ripping or subsoiling the road surface to break up compaction and increase infiltration. In some cases the entire road prism may need to be returned to preconstruction conditions. Roads selected to remain on the transportation system that encroach on the riparian zone can then be evaluated for relocation away from the riparian zone or redesigned to meet the special needs of the riparian zone. All existing skid trails and log landings in or near this zone need to be obliterated.

Channel Crossings: During the assessment of the transportation system, roads in the riparian zone that cross and recross the channel should rate high on the obliteration/relocation list. Channel crossings should be treated the same as for A-type channels. Reduce the overall number of crossings, and the amount of material entering the channel from the crossing. Redesign "positive" approaches and rock and adequately drain "negative" approaches. Install crossdrains to divert road and crossing approach drainage to stable buffer areas where sediment is unlikely to enter the riparian zone.

Bio-technical Solutions in B-type Channels

Bio-technical applications can be used in conjunction with each of the major solution categories. Once management changes are in place, bio-technical work can be done on channel banks to increase soil stability and add roughness to the channel and flood plains. This may include planting of conifers in upland areas, deciduous riparian trees on flood plains and banks, and riparian shrubs, sedges, and grasses in the near channel area. As engineering solutions are

Figure 6A

Healthy riparian zone with diverse vegetation layers, fish and wildlife habitat, distinct microclimate, and functioning filter strip and floodplain. This combination of characteristics make riparian zones sensitive to management activities.

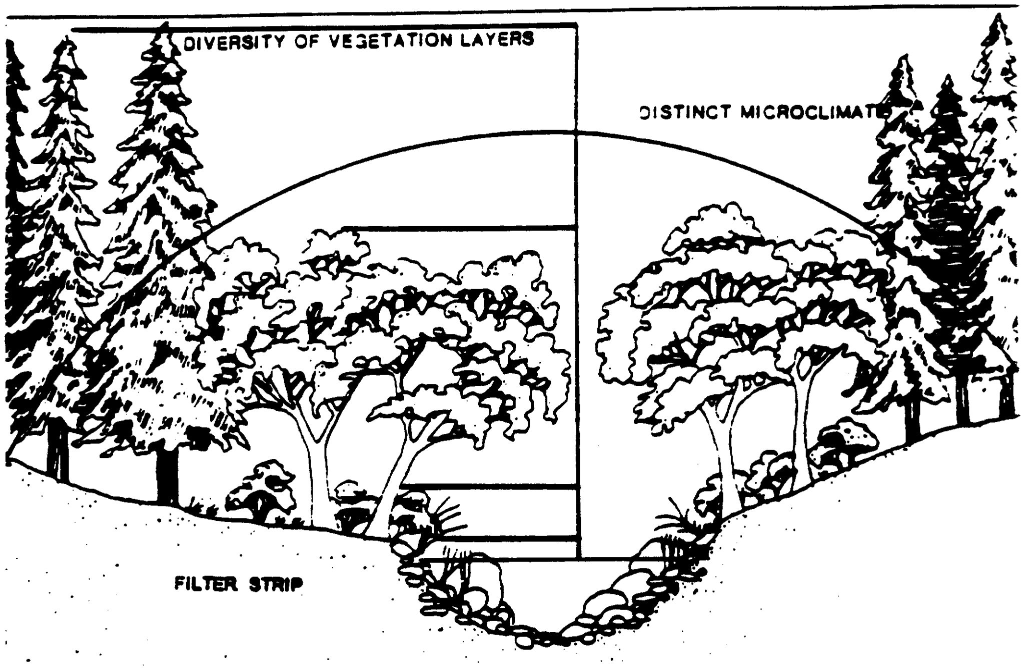
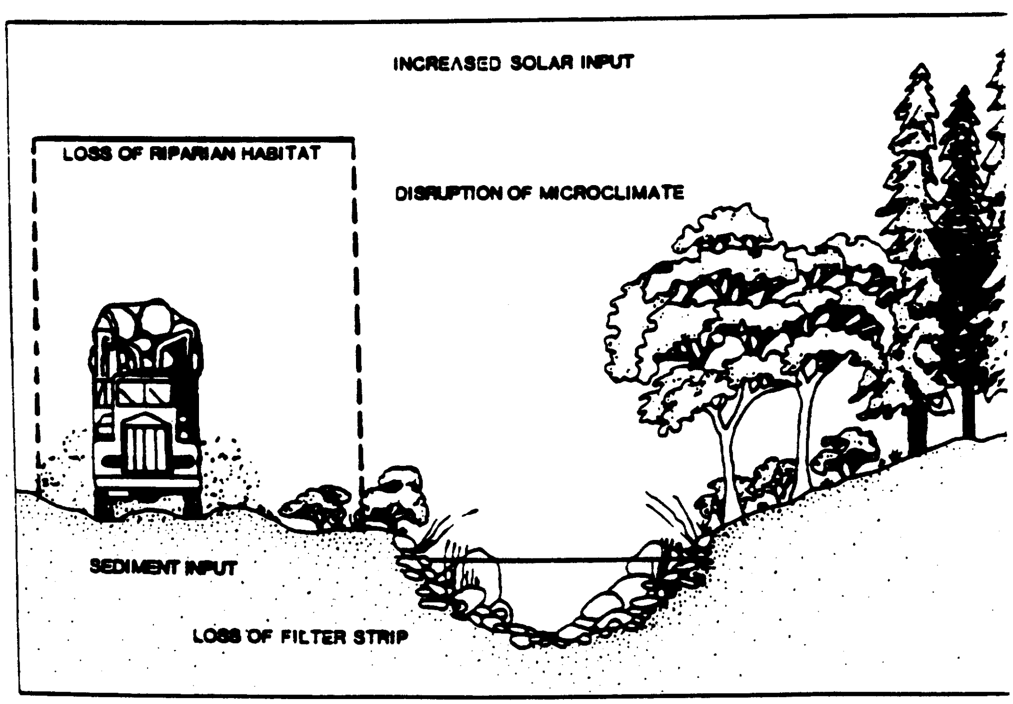


Figure 7A ,

Diagram showing the effects of road location within the riparian zone. The removal of riparian vegetation decreases structural diversity and wildlife habitat. Vegetation removal causes increased solar radiation to reach the channel, warming the water and disrupting the microclimate, changing the habitat on which numerous organisms depend. Road construction has removed the litter layer that acts as a filter strip and compacted soil adjacent to the channel causing Increased runoff and sediment to enter the stream.



constructed, live-plant structures, such as brush wattles, and brush matting can be used to stabilize shaped upper banks. Brush trench packing and live-plant rolls can be used to stabilize the lower bank zone to the waterline. Sedge and grass plugs can be used to interplant live-plant or bank revetment structures on the upper and lower banks. Bio-technical applications can also be used to help stabilize obliterated road prisms and channel crossing fill material.

Treatment Description-Unstable/Sensitive C-type Channels

Management Solutions in C-type Channels

Management solutions in C-type channels are much the same as for A-type and B-type channels. The Streamside Management Zone (SMZ) should be extended to include the 100 year floodplain and an area extending into the upland forest. In many cases C-type channels have been degraded to confined F-type channels with reduced flood plains. The 100 year flood plain protected by the SMZ needs to be the historic flood plain even if it has been abandoned because of the current degraded condition of the channel.

Livestock Grazing: When considering all the factors that can and do influence the present condition of riparian areas in the west, livestock grazing is unquestionably a significant factor (Elmore and Beschta, 1987). All sensitive C-type channels in the EBNFFR are alluvial channels associated with meadow ecosystems. Most are, or at some time have been, subject to agriculture or livestock grazing. Livestock grazing remains a primary use of these meadows and associated channels. It is estimated that as much as 86% of all C-type channels in the EBNFFR are in a degraded condition. Much of this degradation is directly due to cumulative livestock grazing. Conditions in the upper watershed areas, although not a direct cause, do exasperate conditions in these downstream degraded areas by causing further degradation.

Channel stability in alluvial systems is closely tied to discharge, sediment load, bank and flood plain stability (usually provided by vegetation) and floodplain size or confinement of the channel. Of each of these factors, bank and flood plain stability provided by plants is the most critical. Naturally occurring riparian plant species are diverse in their requirements and their responses to grazing, and our understanding of how these species interact and function as' communities is limited. We do know that yearly heavy grazing in the riparian area, as well as uplands, can cause long-lasting detrimental effects (Platts, 1978). The improper grazing of this vegetation increases the amount, and concentrates and accelerates the speed of overland runoff to streams. Doubling the velocity of water in a channel can increases its erosive power by 4 times and its bedload and sediment carrying power by 64 times (Chaney, Elmore, and Platts 1993).

Livestock grazing management that is not specifically designed to promote the health of the riparian area and associated meadow and upland influence zones will disrupt stability in alluvial systems. Over time, vegetation removal and soil compaction diminishes permeability and increases surface runoff. Bank trampling by livestock mobilizes soil to the channel and reduces vegetative cover. As sediment load in the channel increases and vegetative bank protection decreases the channel grade will steepen. The normal pool-riffle sequence is diminished as the channel cuts off its meanders to shorten its length and increase its velocity to move excess sediment. The result is a wide, shallow channel that has become confined by near vertical gully walls c has a greatly reduced, or nearly absent riparian community.

A riparian literature review by Skoviin (1984) showed evidence of improved riparian and aquatic habitat following 4-7 years of total non-use by livestock Woody plants (shrubs) recovered following 5-8 years of total rest, and a doubling of fish Biomass following 3-5 years of total non-use of the riparian zone. Duff (1983) found that a minimum of 6-8 years of non-use was necessary to restore a deteriorated streamside riparian area to the point where reduce(levels of livestock grazing could be resumed. In cases of severe channel impairment or extensive rehabilitation work, livestock exclusion for an indefinite period may be indicated.

Currently, livestock management changes are occurring on selected public lan((USFS) grazing allotments within the EBNFFR drainage. Grazing systems that favor riparian dependent species and limit disturbance by livestock in the riparian zone are being put into place as Allotment Management Plans are updated to reflect Standards and Guidelines in the Plumas National Forest La: and Resource Management Plan. Several years of monitoring will be necessary determine if new grazing management changes are sufficient in reducing livestock disturbance in this zone. In addition to the changes occurring on public land the CRM has initiated a Grazing Technical Assistance Committee t deal with the question of livestock grazing on CRM restoration projects on private lands within the EBNFFR. The objective of the Grazing Technical Assistance Committee is to develop Standards and Guidelines to be applied to project areas.

Engineering Solutions in C-type Channels

Channel grade and stability: Not all degraded C-type channels will respond t management changes alone. Active restoration procedures may be necessary to shorten recovery time or to halt further resource loss. Van Haveren and Jackson (1989) describe two basic types of riparian impairment (degradation) that occur in alluvial systems. The first condition is characterized by excessive channel incision and subsequent de-watering of the riparian zone. The second involves a direct destruction of riparian vegetation with the subsequent loss of channel bank and floodplain integrity and the acceleration of lateral channel adjustments.

The early stages of channel incision can be halted by the placement of grade control structures that are designed to restore the original base level immediately or over time by aggradation. Vertical banks can be shaped in preparation for seeding or container stock planting. The middle to late stage of channel incision will require extensive engineering to stabilize the char at its new reduced base level. This may require both grade and meander cont structures as well as additional bank shaping. In severe cases complete meander reconstruction may be necessary in order to halt resource loss and restore the natural geometry of the system.

Engineering solutions may also be necessary on laterally unstable channels. This is particularly true when riparian conditions are no longer amenable to rapid revegetation by passive means. In these situations, structural techniques, including channel bank erosion controls and proper grading of flood plains, may be necessary. In extreme cases, channels may actually be reconstructed using proper hydrologic, hydraulic and geomorphic criteria to establish conditions that renew proper hydraulic response and encourage establishment of healthy vegetation. The objective in any sort of structural solution should always be to provide the conditions necessary for natural revegetation and channel evolution to occur so the stream riparian system can function properly and stably on its own, independent of rigid man-made structures.

Range improvements: Proposed restoration sites on rangelands can use a variety of structures and improvements to protect the site from further disturbance by livestock. At any site where active or passive restoration will occur, exclusion fencing to protect the restoration investment and enhance recovery time will be necessary. Because eliminating livestock access and utilization of the riparian area would also limit availability of livestock water, off site water development will be necessary where no alternative water is available. All methods used to control livestock at a project site are best developed on a site by site bases.

Problem roads: As with the previous stream types, roads are also a problem on C-type channels. The problem is less one of road encroachment on the near stream environment as one of encroachment on the meadow ecosystem associated with alluvial C-type channel systems. Roads built in the 1940* s, 50's, and 60's, under less effective standards were often placed on meadow edges or commonly cut across large meadows instead of being built above them on the toe slope of the valley. One effect of road placement on meadow edge is the disruption of edge habitat for wildlife and plant species. Natural edge habitats such as the forest/meadow ecotone (the transition area between two adjacent ecological communities) supports a relatively high biological diversity and is a very dynamic zone of activity. These boundaries are also thought to be important as genetic pools or sites for active microevolution. Boundaries such as these, that contain a larger number of species or diverse genomes (when compared with the surrounding patches) are important for maintaining landscape biodiversity (Odum 1982, Turner 1988, Wilson 1988). Another effect that roads located in this area may have deals with moisture and nutrient exchange between upland forest and meadow. Roads act as ribbons of deeply compacted soil between the forested uplands and meadow environment. This compaction may act as a barrier to the natural downslope, sub-surface movement of water and nutrients into the meadow ecosystem. It is known that these material exchanges do occur, but little is known about the possible long term effects a road may have on them.

The recommendations for dealing with roads that encroach on the meadow ecosystem or channel area are basically the same as recommended for B-type channels. First assess the total transportation system. Identify those roads causing the greatest amount of impairment. Determine which problem roads are not vital to the transportation system and obliterate them. Assess opportunities for relocating problem roads which are vital to the transportation system. In addition, all skid trails and log landings that may be causing impairment need to be obliterated and restored to a condition that matches the preconstruction environment.

Channel and meadow crossings: C-type channels within the EBNFFR, generally contain a lower density of channel crossings than any other channel type.

Crossing problems that do occur are usually located on smaller C-type channel and should be treated In the same way as recommended for B-type channels.

Roads that traverse the meadow ecosystem often disrupt meadow hydrology. Ma of these smaller meadows (stringer meadows) do not have well defined channel under natural conditions; instead water moves down the meadow, both across a below the surface. Roads that cross the meadow tend to interrupt this flow. The result is water concentration where it did not exist prior to the placement of the road. The concentration of sheet flow usually causes headcutting upslope of the crossing and gullying below. Headcutting is also initiated by culverts placed below the natural base level of the meadow. These problems be mitigated by using a multi-culvert system and providing enough fill so that culverts are not placed below grade (See figures 8A and 9A).

Bio-technical Solutions in C-type Channels

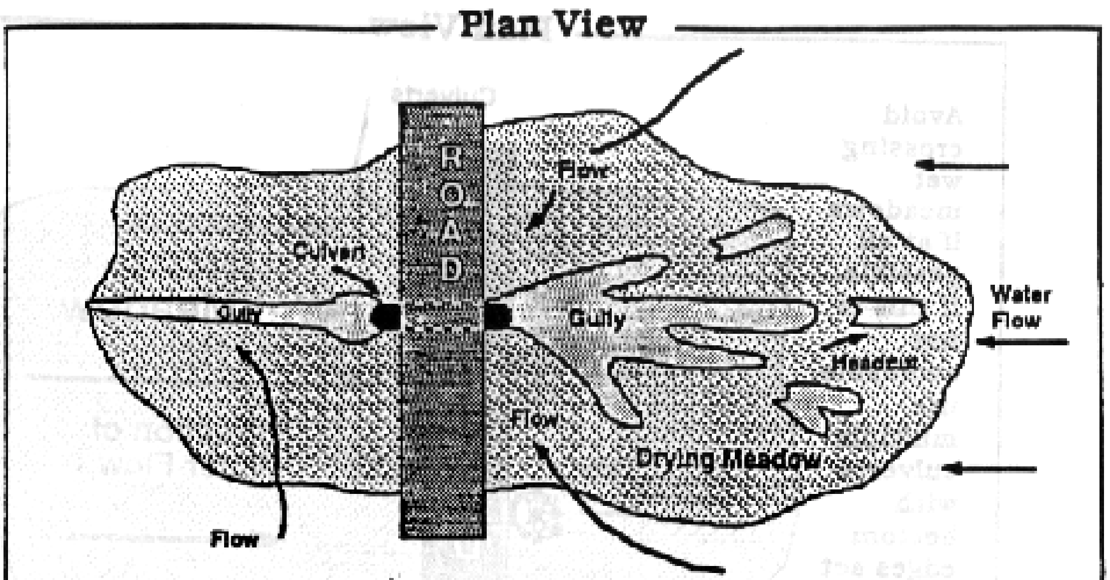
As with B-type channels, bio-technical applications can be used in conjunction with both management and engineering solutions. Because of the heightened importance of vegetation to the stability of alluvial C-type channels, bio-technical applications will play a significant role in restoration.

Channel grade and stability: The use of bio-technical applications in conjunction with sound management changes is likely to provide recovery in c relatively short time frame, where impairment is light. In cases where impairment is more extensive, channel characteristics may not lend themselves to passive restoration. In cases such as this, engineering solutions will \ necessary to restructure the physical attributes of the channel, while bio-technical applications can be used in concert, to fortify the engineering work and jump-start the biological processes. The most important role of revegetation efforts in C-type channels is the stabilization of channel bank and terraces. This, in turn, provides long-term stability to restored channel shape and form.

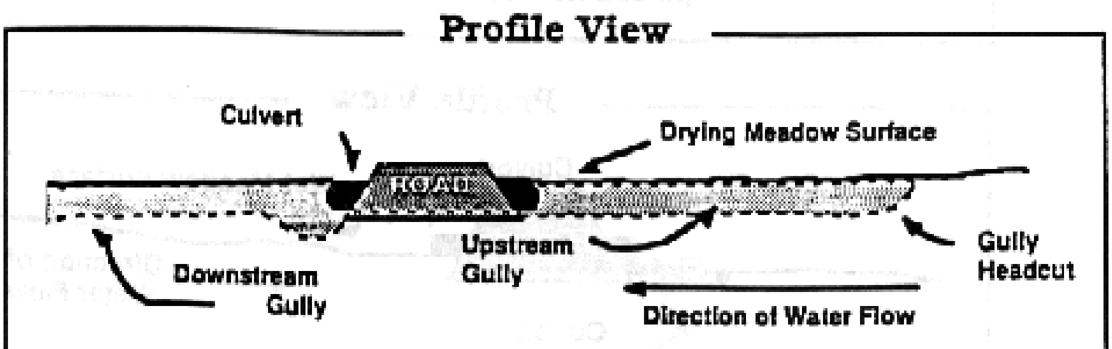
Range improvements: Bio-technical applications can be used to enhance infiltration and limit soil loss on upland sites being treated for soil compaction. Live plant structures can be used to enhance soil stability an slow overland flows.

Problem roads and meadow crossings: Bio-technical applications can be used restore disturbed meadow areas using a variety of seeding and live planting natives species from the same meadow or drainage area.

Figure 8A

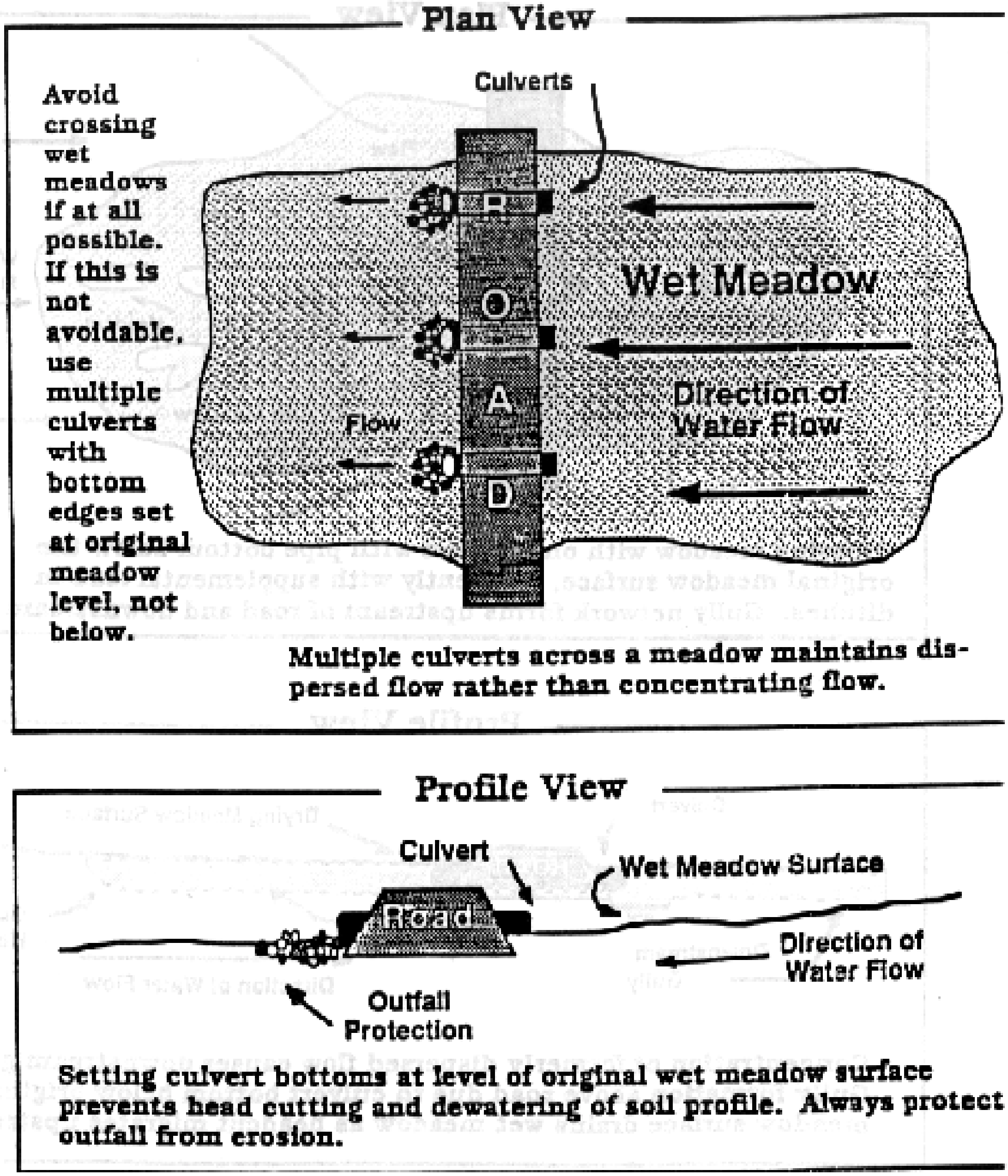


Crossing meadow with one culvert with pipe bottom below the original meadow surface, frequently with supplemental lead-in ditches. Gully network forms upstream of road and downstream too.



Concentration of formerly dispersed flow causes downstream gully. Gully formation above road due to culvert bottom below original meadow surface drains wet meadow as headcut migrates upstream.

Figure 9A



Multiple culverts across a meadow maintains dispersed flow rather than concentrating flow.

Setting culvert bottoms at level of original wet meadow surface prevents head cutting and dewatering of soil profile. Always protect outfall from erosion.

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APPENDIX C

EBNFFR Erosion Control Strategy Information Extrapolation

APPENDIX C

EBNFFR EROSION CONTROL STRATEGY
INFORMATION EXTRAPOLATION

The EBNFFR data base was used to develop extrapolations to fill information gaps regarding conditions in subwatersheds covered by less intensive sampling or reconnaissance level surveys. Limited sampling was conducted to check the reasonableness of extrapolations and correction factors were developed where needed.

Table I displays the relationship between subwatershed size, water yield, drainage density and road density. No extrapolations were used in this table. All information is derived by direct measurements.

Division of the 12 EBNFFR subwatersheds into East-side and West-side subwatersheds was determined on the based on geomorphology, climate, vegetation types, and rainfall/runoff relationships developed by Linsley (1955).

Subwatershed size was determined using a compensation planimeter on 15 min. USGS topographic maps.

Land instability (Area Unstable) information was taken from the Plumas National Forest Land Instability Risk Maps.

Water yield was developed from gage station information using the area method.

Drainage density was measured on USGS 15 min. quadrangle maps using a line intercept method. Direct (map) measurements of channel miles were taken on a sample bases for representative East-side and West-side subwatersheds to develop correction factors.

Road density figures were taken from the Plumas National Forest Land and Resource Management Plan Data Base (LRMPDB). The LRMPDB figures were a combination of forest system and non-system roads many of which are not shown on USGS topographic maps. Data base figures were compared with measured figured in two subwatersheds where a concerted effort was made to investigate the entire road network. The figures from the LRMPDB were found to be a reasonable estimate of existing road densities.

Table 2 compares total road miles, miles of eroding road (this is the miles of road identified as causing direct water quality problems) with figures for total road erosion developed by the USDA Soil Conservation Service and Plumas National Forest in 1989. Total road erosion is for all roads in the subwatersheds, and is not limited to problem eroding roads.

Miles of eroding road are direct measurements for subwatersheds 19, 21, 22, 23, and 24, and are an extrapolation for the remainder of the subwatersheds. Extrapolations were developed bases on measurements in the above east and West-side subwatersheds and applied to the remainder. This extrapolation represents an estimate and may be higher of lower.

Table 3 is a comparison of total channel miles, total channels miles broken into channel type with miles of channel by type in fair to poor condition with sediment yield from channel banks. Sediment yield from channel banks was developed by the USDA Soil Conservation Service and Plumas National Forest i 1989. Direct measurements for channel miles, type and condition were conducted in the same subwatersheds as eroding road measurements in table 2, information for the remainder of the subwatershed, with the exception of the stream sediment yield, are extrapolations and represent an estimated condition.

Table 4 compares average annual water yield with total annual sediment yield Total annual sediment yield is from roads, streams, and upland areas and was developed by the USDA Soil Conservation Service and Plumas National Forest : 1989.

Table 5 displays the total road miles with the number of problem crossings. Problem crossings are actual encounters for subwatersheds 19, 21, 22, 23, & 24 and are extrapolations for the remainder. No separate sediment figures exist for crossings.

Table 6 gives acres burned by watershed for the last 20 years. The information was taken from the PNF Fire Data Base and GIS system on the 'Plumas National Forest. For definitions and methodology used to determine channel type and condition eroding road and problem crossings see Clifton, 1992.

TABLK I

PLUMAS NAT'L FOR SUB-NTSD NUMBBR	PLUMAS NAT'L FOREST SUB-WTSD NAMB	(SIZE) TOTAL ACRES	ACRES UN-STABLE	AVB. ANNUAL WTR. YIBLD AC.- FT/AC	AVE. ANNUAL WTR. YIBLD AC.- FT.	DRAINAGE DENSITY Mi./ Mi.Sq	ROAD DENSITY Mi./ Mi.Sqj
13 West	RUSH-MILL	49,024	18,210	2.42	118,638	5.2	1.6
14 West	LIT. GRIZZLY	94,272	21,368	1.67	157,434	5.0	1.4
I5 West	WOLF-R.VALLY	46,016	6,536	1.67	76,847	5.0	1.5
I6 West	LIGHTS-COOKS	75,136	9,047	1.33	99,930	4.1	1.7
17 East	MID. INDIAN	26,368	2,701	1.00	26,368	3.8	2.4
18 East	ANTELOPE LK	44,352	3,189	0.67	29,716	4.4	2.2
19 East	SQUAW QUEEN	26,112	422	0.67	17,495	3.1	1.8
20 East	RED CLOVER	74,752	8,293	0.67	50,086	3.5	1.4
21 East	LAST CHANCB	99,072	1,327	0.42	41,610	3.9	2.3
22 West	L. SPANISH	21,109	5,105	2.17	45,806	3.6	3.2
23 West	GRBBNHORN	44,695	3,674	1.67	74,641	3.9	2.7
24 West	U. SPANISH	60,976	6,246	2.83	172,562	5.5	2.8

ROAD MILES AND TOTAL ROAD EROSION IN TONS PER YBAR FOR THE EBNFFR WATERSHED

PLUMAS NAT'L FOR. SUB-WTSD NUMBER	PLUMAS NAT'L FOREST SUB-NTSD NAME	TOTAL ACRES	AREA IN Sq Miles	ROAD DENSITY Mi./ Mi .Sq	ROAD MILES	MILES ERODING ROAD	TOTAL ROAD EROSION Tons/yr.
13 West	RUSH-MILL	49,024	76.6	1.6	123	44	61,200
14 West	LIT. GRIZZLY	94,272	147.3	1.4	206	74	68,100
15 West	WOLF-R.VALLY	46,016	71.9	1.5	105	39	172,800
16 West	LIGHTS-COOKS	75,136	117.4	1.7	205	72	91,000
17 East	MID. INDIAN	26,368	41.2	2.4	99	35	41,500
18 East	ANTELOPE LK	44,352	69.3	2.2	152	53	87,600
19 East	SQUAW QUEEN	26,112	40.8	1.8	73	26	16,600
20 East	RED CLOVER	74,752	116.8	1.4	164	57	69,800
21 East	LAST CHANCB	99,072	154.8	2.3	372	130	89,600
22 West	L. SPANISH	21,109	34.8	3.2	112	40	52,700
23 West	GREENHORN	44,695	70.0	2.7	224	81	93,300
24 West	U. SPANISH	60,976	95.0	2.8	276	99	88,600
TOTALS		661,884			2111	750	932,800

NOTB: TOTAL ROAD EROSION WAS DEVELOPED BY THB USDA SOIL CONSERVATION SERVICE, RIVER BASIN PLANNING STAFF AND USDA FOREST SERVICB, PLUMAS NATIONAL FORBST, 1989.

Table 3

A COMPAIRISON OF TOTAL CHANNEL MILES BY TYPE WITH MILES OF CHANNELS IN FAIR-POOR CONDITION AND STREAM CHANNEL SEDIMENT YIELDS IN TONS PER YEAR FOR INDIVIDUAL SUBWATERSHEDS IN THE EBNFFR

PLUMAS NAT'L FOR. SUB-WTSD NUMBER	AREA Sq.Mi.	DRAINAGE DENSITY MI./Mi.Sq	TOTAL CHANNEL MILBS	MILES BY CHANNEL TYPE			CHANNELS IN FAIR-POOR COND.			TOTAL MILES ERODING CHANNEL	STREAM SEDIMBN* YIELD Tons/Yr
				MILBS A-TYPB	MILBS B-TYPE	MILBS C-TYPB	MILBS A-TYPE	MILES B-TYPE	MILES C-TYPB		
13 W	76.6	5.2	398	231	139	28	118	86	19	224	33,800
14 W	147.3	5.0	737	427	258	52	218	160	36	413	89,900
15 W	71.9	5.0	360	209	126	25	106	78	17	202	37,500
16 W	117.4	4.1	481	279	169	34	142	105	23	270	42,500
17 E	41.2	3.8	157	91	55	11	64	38	10	112	26,000
18 E	69.3	4.4	305	122	107	76	85	75	70	230	127,400
19 E	40.8	3.2	131	38	39	54	27	27	49	103	21,600
20 E	116.8	3.5	409	119	123	168	83	86	154	323	110,100
21 E	154.8	4.2	650	189	195	267	132	137	245	514	94,500
22 W	34.8	3.6	125	73	44	9	37	27	6	70	16,200
23 W	70.0	3.9	273	158	95	19	81	59	13	153	31,300
24 W	95.0	5.2	494	297	173	35	146	107	24	*V"*	99. m
TOTALS	1035.9		4519	2221	1522	776	1239	985	667	2891	729,200
							56% A-TYPE	65% B-TYPE	86% C-TYPE	64% OF TOTAL EBNFFR CHANN.	

NOTE: SEDIMENT YIELDS FOR STREAM CHANNELS WERB DEVELOPED BY THB USDA SOIL CONSBRVATION SERVICE, RIVER BASIN PLANNING STAFF, AND USDA FOREST SBRVICB, PLUMAS NATIONAL FORBST, **1989.**

TABLE **4**

AVERAGE ANNUAL WATER YIELD IN ACRE-FEET PER ACRE AND ACRE-FEET WITH TOTAL SEDIMENT YIELD IN TONS PER YEAR FOR THE EBNFFR WATERSHED

PLUMAS NAT'L FOR SUB-WTSD NUMBER	PLUMAS NAT'L FOREST SUB-WTSD NAMB	TOTAL ACRES	ACRES UN-STABLE	AVB. ANNUAL WTR. YIELD AC.- PT/AC	AVB. ANNUAL WTR. YIELD AC.- FT.	DRAINAGE DENSITY Mi./ Mi.Sq	TOTAL SEDIMBNT YIELD IN 1 Tons/year
13 West	RUSH-MILL	49,024	18,210	2.42	118,638	5.2	100,400
14 West	LIT. GRIZZLY	94,272	21,368	1.67	157,434	5.0	164,600
I5 West	WOLF-R.VALLY	46,016	6,536	1.67	76,847	5.0	215,800
16 West	LIGHTS-COOKS	75,136	9,047	1.33	99,930	4.1	143,800
17 East	MID. INDIAN	26,368	2,701	1.00	26,368	3.8	72,400
18 East	ANTFLOPF LK	44,352	3,189	0.67	29,716	4.4	217,900
19 East	SQUAW QUEEN	26,112	422	0.67	17,495	3.1	39,900
20 East	RED CLOVER	74,752	8,293	0.67	50,086	3.5	184,600
21 East	LAST CHANCE	99,072	1,327	0.42	41,610	3.9	193,600
22 West	L. SPANISH	21,109	5,105	2.17	45,806	3.6	71,000
23 West	GREENHORN	44,695	3,674	1.67	74,641	3.9	128,600
24 West	U. SPANISH	60. 967	6,246	2.83	172.562	5.5	193,290
TOTALS		661,884	86,118		911,133		1,715,800

NOTE: TOTAL .SEDIMENT YIELD WAS DEVELOPED BY THE USDA SOIL CONSERVATION SERVICE, RIVER BASIN PLANNING STAFF AND USDA FOREST SERVICE, PLUMAS NATIONAL FOREST, 1989. AVB. ANNUAL WATER YIELD WAS DEVELOPED FROM GAGE STATIONS USING THE AREA METHOD.

TABLE 5

STREAM AND MEADOW CROSSINGS CAUSING WATER QUALITY PROBLEMS

SUB-WTSD NUMBER	PNF SUBWATERSHED NAME	MILES ROAD	MILES ERODING ROAD	NUMBER PROBLEM CROSSINGS
13 W	RUSH-MILL	123	44	209
14 W	LIT. GRIZZLY	206	74	350
15 W	WOLF-R. VALLEY	105	39	183
16 W	LIGHTS-COOKS	205	72	339
17 E	MID-INDIAN	99	35	168
18 E	ANTELOPE LK.	152	53	91
19 E	SQUAW QUEEN	73	26	44
20 E	RED CLOVER	164	57	279
21 E	LAST CHANCE	372	130	219
22 W	L. SPANISH	112	40	70
23 W	GREENHORN	224	81	321
24 W	U. SPANISH	276	99	621
TOTALS		2111	750	2893
			36% OF TOTAL ROADS CROSSINGS PER MILE	

1.37 AVG Problems

TABLE 6

SUB-WTSD MEMBER	SUB-WTSD NAME	SUB-WTSD SIZE IN ACRES	ACRES BURNED IN THE LAST 20 YEARS
13	RUSH-MILL	49,024	912
14	LIT. -GRIZZLY	94,272	1.578
15	WOLF-R. VALLEY	46,016	2,513
16	LIGHTS-COOKS	75,136	0
17	MID.-INDIAN	26,368	1,400
18	ANTELOPE LK	44,352	10
19	SQUAW QUEEN	26,112	129
20	RED CLOVER	74,752	122
21	LAST CHANCE	99,072	30,122
22	L. SPANISH	21,109	3,820
23	GREENHORN	44,695	525
24	U. SPANISH	60,976	35
TOTALS		661,884	41,166

* Note fire information in this table does not include fires under 5 acres and does not included controlled burns.

APPENDIX D

Proposed Watershed Priority Scoring and Ranking

APPENDIX D

PROPOSED WATERSHED PRIORITY SCORING AND RANKING TABLE OF CRITERIA BY CATEGORY

Category I. Economic Significance (Category Weight - 10)

Criteria	Criteria Significance Number
A. Municipal-supply Watershed Watershed contributes to a major water diversion for municipal or industrial use that is in or immediately below* the watershed.	3
B. Complex Land Ownership Watershed contains intermingled ownership patterns, containing 50-90% government land.	2
C. Contributes to Major Reservoir Watershed contributes to a reservoir in or immediately below* the watershed.	3
D. Contributes to Hydroelectric Site Watershed contributes to an existing or potential hydropower site that is in or immediately below* the watershed.	3
E. Land Use - Timber More than 25% commercial timber stands.	2
F. Land Use - Grazing More than 25% suitable for livestock grazing.	1
G. Land Use - Farming . More than 10% tilled crops, irrigated pasture, etc.	2
H. Land Use - Residential More than 5% in residential parcels.	3
I. Land Use - Commercial More than 5% in commercial parcels.	3
J. Land Use - Industrial More than 2% in industrial parcels.	2

Immediately below: Within a distance downstream equal to the watershed length (straight line distance from mouth to remotest point on watershed boundary).

Category II. Political Significance (Category Weight - 10)

	Criteria Signi- Criteria ficance Number
A. Existing or Planned Watershed Projects Ongoing watershed projects or those identified in the 5-yr. plan such as instream flow surveys and restoration projects. The total of all projects should affect at least 5% of the watershed.	3
B. Complex Land Ownership Watershed contains intermingled ownership patterns, containing 50-90% government land.	2
C. High Public Interest Watershed receives high interest from State or Federal agencies or the public.	3
D. Contributes to Malor Reservoir Watershed contributes to a reservoir constructed by a government entity. Reservoir is in or immediately below* the watershed.	3
E. Contains Specially Designated Areas Watershed contains other specially designated management areas, i.e. wild trout stream.	2
F. Contributes to a Wild and Scenic River Watershed contributes to a Wild and Scenic River system.	3

Category III. Water Quality (Category Weight - 9)

Criteria	Criteria Significance Number
A. Streams Do Not Meet State Standards Watershed contains State or Federally identified stream reaches that do not currently meet State water quality standards as a result of current or past management activity.	3
B. Has WDR Order Watershed contains a site with State ordered Waste Discharge Requirements (WDR) . *i*	3
C. Road Density is 2 mi/mi or Greater The density of all roads within a watershed is 2 miles per square mile or greater.	3
D. Contains High Impact Abandoned Mines Watershed contains high impact abandoned mines.	3
E. Wildfire Frequency is High Watershed is in an area of repeated large burns.	1
F. Contains a Valley Inner Gorge Watershed contains an identified valley inner gorge that is not composed of bed rock.	3
G. 25% or More Mapped Erosive or Unstable Watershed is mapped as unstable or containing highly erodible soil on 25% or more of its area.	3
H. High Storm Flow Concentration Potential This is a morphological determination of flow concentration based on drainage density and time of concentration (Tc)*.	1

* Time of Concentration (Kirpick): Tc - 0.0078 $L^{0.77}$ $S^{-0.385}$
where L - maximum watershed length
S - H/L
H - elevation difference

Category V. Floods. Floodplains. and Riparian (Category Weight - 8)

Criteria	Criteria Significance Number
A. Watershed directly contributes to flooding that causes damage to private or municipal improvements.	2
B. Contains Critical Riparian Habitat For T & E Watershed contains critical riparian or aquatic habitat for threatened or endangered species.	3
C. Contains High Value Riparian Habitat Watershed contains riparian or aquatic habitat associated with perennial streams, and plant or animal species that are totally dependent on such habitat for their existence.	2
D. Contains Marginal Instream Flows The instream flows are approaching or below that required for maintaining a healthy fishery.	2

Category V. Key Watershed Management Situation (Category Weight - 7)

Criteria	Criteria Significance Number
A. Contains Highly Productive Soils Watershed contains highly productive soils and productive climatic conditions.	3
B. Contains Research Activities Watershed includes a watershed research activity or natural area that is historical and currently underway.	3
C. Proposed Management Will Alter Runoff Watershed contains other resource management activities or developments that exist or are proposed within the next five years. They cumulatively produce a 10% change in annual water yield from the watershed, compared with the yield without the activities or developments. Type conversions, timber harvest, ski areas, weather modification, and grazing are considered.	3
D. Contains Leasable Minerals or Geothermal Watershed contains major leasable mineral or geothermal resources. Economic values are sufficient to provide for a large scale operation.	2
E. Contains Locatable Minerals Watershed contains locatable minerals that are economically exploitable.	1
F. Contains Highways or Utility Corridors Watershed contains major State or Federal highway or utility corridors including pipelines.	3
G. Contains High Recreation Value Areas Watershed contains areas that have a history of high recreation usage.	3

Category VI. Water Supply and Yield (Category Weight = 6)

Criteria	Criteria Significance Number
A. Contains Water Yield Increase Potential Watershed has an average water yield increase potential of 100-acre feet or more per square mile (2"/acre).	3
B. Receives 40 Inches or More Precipitation per Year The average annual precipitation is 40 inches or more.	3
C. Contains Adjudicated or High Number of Diversions Water rights within the watershed have been adjudicated or there are more than 15 diversions.	3

WATERSHED PRIORITY RANKING SCORE SHEET

Watershed Name:	Date: Watershed Number:	Analysis By:		
Category Criteria	Presence or Absence	Significance Number	Category Weight	Factor Weight
I. Economic Significance				
A. Municipal-supply .Watershed		3		
B. Complex Land Ownership		2	10	
C. Contributes to Major Reservoir		3	10	
D. Contributes to Hydroelectric Site		3	10	
E. Land Use - Timber		2	10	
f. Land Use - Grazing		1	10	
G. Land Use - Farming		2	10	
H. Land Use - Residential		3	10	
1. Land Use - Commercial		3	10	
J. Land Use - Industrial		*2*	10	
				Total =
II. Political Significance				
A. Existing or Planned Watershed Projects		3	10	
B. Complex Land Ownership		2	10	
C. High Public, Interest		3	10	
D. Contributes to Major Reservoir		3	10	
E. Contains Specially Designated Areas		2	10	
F. Contributes to a Wild and Scenic River		3	10	
			Total =	
III Water Quality				
A. Streams Do Not Meet State Standards		3	9	
B. Has WDR Order		3	9	
C. Road Density is, 2 mi/mi sq or Greater		3	9	
D Contains High Impact Abandoned Mines		3	9	
E Wildfire Frequency is High		1	9	
F. Contains a Valley Inner Gorge		3	9	
G. 25% or More Mapped Erosive or unstable		3	9	
H. High Storm Flow Concentration Potential		1	9	
			Total =	
IV. Floods, Floodplains, and Riparian				
A. Contributes Flooding to Improvements		2	8	
B. Contains Critical Riparian Habitat for T & E		3	8	
C. Contains High Value Riparian Habitat		2	8	
D. Contains Marginal instream flows		2	8	
			Total =	
V. Key Watershed Management Situation				
A. Contains Highly Productive Soils		3	7	
B. Contains. Research Activities		3	7	
C. Proposed Management Will Alter Runoff		3	7	
D. Contains Leasable Minerals or Geothermal		2	7	
E. Contains .Locatable Minerals		1	7	
F. Contains Highways or Utility Corridors		3	7	
G. Contains High Recreation Value Areas		3	7	
			Total =	

VI. Water Supply and Yield		
A. Contains High Water Yield Increase Potential	3	6
B. Receives 40 Inches or More Precipitation per year	3	6
C. Contains Adjudicated or High Number of Diversions	3	6
		Total =

APPENDIX E

Project Effectiveness Analysis

APPENDIX E
PROJECT EFFECTIVENESS ANALYSIS

Introduction

Three analyses are necessary for determining project effectiveness: economic efficiency, environmental quality, and social well-being. All proposed watershed improvement projects shall have a completed project effectiveness analysis. For smaller, individual project areas, the cost and complexity of the analysis should be commensurate with project importance and size.
The purpose of economic efficiency analysis is to identify, and examine, over time, the dollar costs and benefits of a proposed watershed improvement project to determine whether the benefits outweigh the costs.

Economic and social well-being analysis is the identification and determination of the effect of the project on the economics, infrastructure and social life of dependent communities. Primary areas of social effects are variables such as security of life, health and safety, cultural values, property damage, local business activity, employment, vital community services, impacts on special sites, minority participation, and opportunity for technology transfer.

Environmental quality analysis is the determination of effects created by a project on characteristics of the environment that are often nonmarket and non-monetary. Beneficial effects maintain, restore, or enhance one or more of the characteristics of the natural environments.

Project planners need to prepare a complete project effectiveness analysis for each action alternative of a proposed project. These analyses provide a useful tool to assist the project planners in selecting a viable alternative for project implementation.

1. Scope and Standards

I.I Scope. The project effectiveness analysis can apply to an entire watershed, or individual project areas within watersheds. When applied to entire watersheds, all costs of improving the watershed to a different condition can be balanced against the total benefits from the completed projects. This gives proper and balanced consideration to all treatments proposed within the watershed. Individual treatment activities, such as a head cut structure, considered out of context with the total needs of the project may not seem cost-effective. In fact, such treatment activity may be a vital component and can only receive proper evaluation in the total project context.

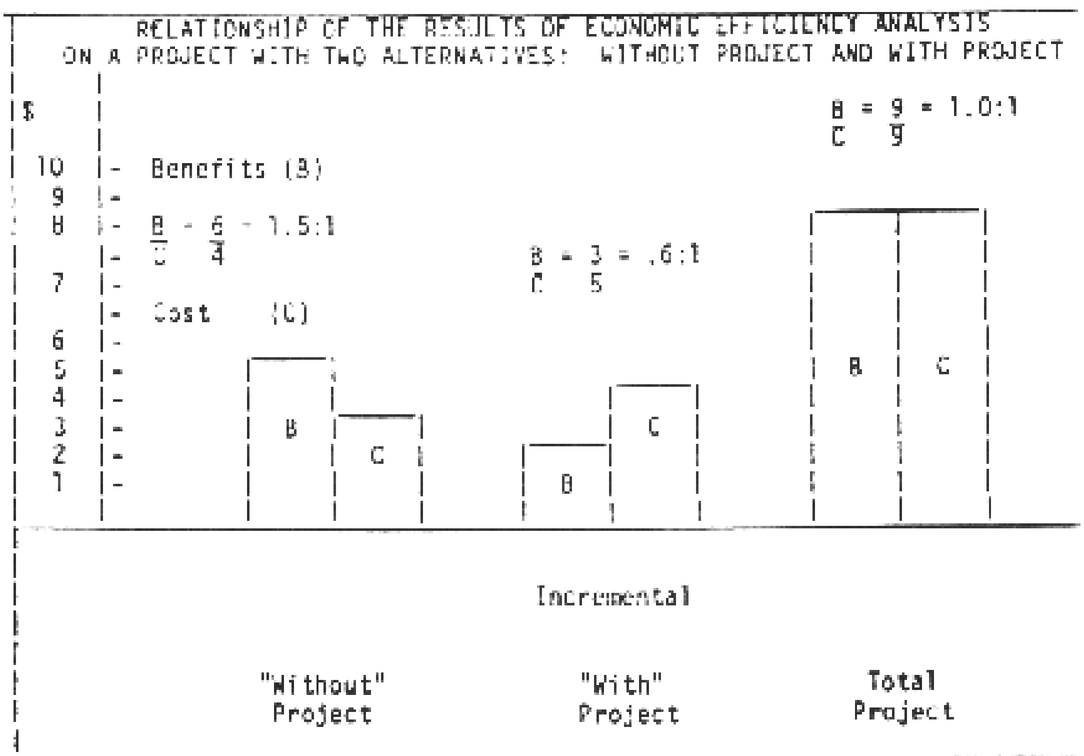
1.2 "Incremental" ("With" and "Without") Project Analysis. The standard for analyzing project effectiveness is the "with" and "without" project relationship. In this approach, the physical effect of what is expected to result with the project is compared to existing and expected results without the project. A before and after comparison that does not recognize potential changes over time without the project is inadequate. Economic, environmental, and social conditions are not static and changes are to occur even without a project.

Exhibit 1 illustrates the results of an economic analysis using the Incremental project approach.

The without project alternative has generated total benefits of $6 . costs of $4. The with project alternative has generated incremental benefits of $3 and incremental costs of $5. These incremental cost benefits accrue as a result of implementation of the project. The costs and benefits in the without project alternative would have expanded regardless of whether the project would have been implemented.

The total project displays the total benefits and costs of the incremental with project alternative combined with the without project alternative Total project benefits are the sum of the with and without or $9 ($ $9). Total project costs are the sum of the with and without or $9 - $9). Even though the total B/C - 1.0:1, this example displays a which is not economically feasible because there had been a $5 added incurred for $3 added benefit.

Exhibit 1



2. Economic Efficiency Analysis

Use the procedures and guidelines as described in the section 2.1 through 4.9 in preparing economic efficiency analysis. An understanding of basic engineering economics principles is required.

2.1 Costs (Inputs). Identify all costs associated with the "with" alternative. Document costs for action alternatives incrementally in relation to the "without" alternative. You may analyze the without alternative, but the primary concern is with the incremental costs over time accrued by implementation of one of the with alternatives.

a. Budget Costs. Budget costs are costs for labor, services, supplies, and equipment. They are made up of fixed and variable costs.

al. Fixed costs are expected to continue regardless of project implementation. They cover the management of noncontrolled outputs, thus they do not vary by alternative and therefore do not affect alternative selection. Examples include watershed planning, watershed inventory and watershed monitoring.

a2. Variable costs differ with various project alternatives. The costs may affect project selection. Examples include project operations, materials and supplies, additional planning costs, and future maintenance costs.

b. Economic Costs. Economic costs are the contributed costs incurred by private parties and cooperating agencies, including both operation and investment costs over the life of the project. An example of an economic cost is the additional expense incurred by the public for taking alternate travel routes because of a road closure necessary to protect water quality.

2.2 <u>Benefits (Outputs).</u> The benefits from watershed improvement fall into two classes: (1) watershed benefits and (2) related resources benefits. Although realization of watershed benefits is the primary of watershed improvement projects, benefits usually accrue to related resources as well. In the analysis, consider benefits for both water and related resources. Examples of watershed benefits are: reduces sedimentation, increased water yield, and longer reservoir life. In the economic efficiency analysis, benefits must be quantifiable unit of the benefits must have an assigned dollar value. Analyzed benefits that do not have assigned dollar values in the environmental qualify as social well-being analyses.

Techniques are available for calculating dollar values of fish, wildlife, etc. See Forest Ecosystem Management: An Ecological, and Social Assessment, Report of the Forest Ecosystem Management A. Team (FEMAT Report).

Document benefits for the with alternative incrementally in relation to the without alternative. One also may analyze the without alternative primary concern lies with the incremental benefits over time accrue implementation of one of the with alternatives.

Use benefit values from approved environmental analyses. Use Reso Program and Assessment values only when more accurate local values exist.

2.2a <u>Reduced Sediment.</u> When evaluating the potential sediment re resulting from the project, consider the permanence of the reduction benefits associated with the absence of accumulating sediment fall main classifications:

1. <u>Increased Storage Capacity.</u> If sediment is accumulating at or points downstream and reduces the amount of storage capacity av a reservoir, then the annual identifiable value of the water lost foot of sediment is the benefit value. This value can be a weight if more than one significant use of water takes place. Develop th based on projected water loss by use. For example, if one-half of loss is projected to be allocated to crops at $10 per acre foot an to municipal use at $50 per acre foot, use a weighted average of $ acre foot. For a realistic analysis, obtain and keep current local values. Also, if sediment reduces water storage in a reservoir ab planned sediment pool, it has an impact cost.

2. <u>Sediment Removal.</u> In the economic efficiency analysis, co mitigation of the cost of removing sediment from downstream sites, reservoirs, debris basins, irrigation canals, highways, and develop as a benefit. If the reservoir is going to be cleaned later, include cost for removal of the sediment. For reservoirs, two costs are IT and become benefits--the annual cost of sediment displacing water reservoir and the cost to clean the reservoir.

3. <u>Fish Habitat.</u> If sediment gets into and covers sections of channels where fish spawn, expect lower production rates. In other of channel that furnish resting holes and rearing habitat, expect

to cause additional fisheries losses. These losses represent opportunity costs to the sport fisheries. One can value these prevented losses based on the estimated amount of recreation visitor days (RVDs) lost. A recreation visitor day is one continuous 12-hour day of recreation activity by one person.

Both the quantity of fish and the quality of the fishing experience are affected. This loss in fish numbers, catch rates, and quality represents an opportunity cost to the stream resource. Quantify mitigation of this loss by project implementation in RVD'S. Then value the prevented loss and use it as a benefit in the economic efficiency analysis.

4. Water Quality Impacts. Losses because of degradation of water quality occur when municipal-industrial water must undergo additional treatment to remove suspended sediments, to lower mineral concentrations, to overcome the effects of higher water temperatures or nutrient loads, or to remove chemicals resulting from the use of certain types of fire retardants. Higher salt and mineral concentration also affect the value of irrigation water. Murky water in recreation areas lowers water-associated recreation values. The change in value of the recreation visitor day is a loss or social cost resulting from sediment.

State water quality agencies may develop additional restrictions and monitoring requirements if they determine that Watershed Management practices are not adequately protecting water quality. One measurable benefit of soil and water improvement projects may be that of avoiding the costs associated with these additional restrictions and monitoring requirements. You can identify the mitigation of costs associated with these additional treatments and value it as a benefit in the economic efficiency analysis. However, take care to avoid crediting a project with both benefits of improved water quality and the reduced costs for the same, which is double counting of benefits.

The benefits of the watershed improvement project in reducing sediment damages are measurable by the difference in sediment damages that are expected to result with the installation of the project compared to that which would occur without the project over time.

2.2b Flood Damage Prevented. The analysis may include an evaluation of the flood damage probably prevented as a result of the project. This evaluation should consist of factual and deduced information. The factual information is based on local physical, flood, and statistical data. Deduced information is inferred from factual information, for example, the potential damage prevented to an existing facility both with and without installation of the upstream watershed improvement project.

The valuation of benefits involves establishing and relating monetary values to the physical flood characteristics and to the frequency of flood occurrences. For projects designed to prevent large financial losses, the Economics Guide for Watershed Protection and Flood Prevention published by the Soil Conservation Service in March 1964 describes the mitigation of flood impacts. The economic benefit of the watershed improvement project is the estimated reduction in flood damages resulting from application of treatment measures or the difference in flood damages that is likely to result with the installation of the project compared to that which occur without the project over time.

Potential floodwater damages are generally estimated for two categories-tangible and intangible. Examples of tangible damages a of land by erosion, slides, and similar occurrences; loss of crops, and plantings; loss of use of transportation systems and utility co and loss of the use of the land. Tangible damage to improvements of loss of physical structures and their use, as well as loss of go services. Costs of cleanup, repair or replacement, and the cost of fighting or emergency action are tangible private and public losses advisable to value as many of these tangible damages as can be mitigated by the project and include as benefits in the economic efficiency analysis.

The potential intangible damages include loss of life, human anguish inconvenience, damage to wildlife, and damage to the environment. potential intangible damages are difficult to evaluate in terms of so express then in qualitative terms and measure by the environment social well-being analysis.

2.2c Water Yield Increase. One may determine values .for increased yield on a local basis. In determining water values locally, it is advisable to document the method of determination. Projected changes to agriculture to municipal and industrial uses of water are likely to affect water values, as well as the added value of hydroelectric generation.

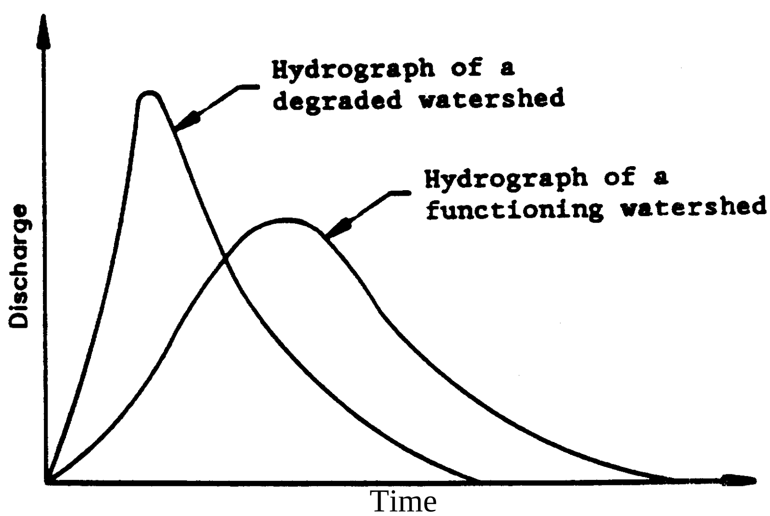


Figure 1. Effects of watershed degradation on a discharge hydrograph. Watersheds in good functioning condition exhibit lower peak flows and extended discharge over time.

2.2d Related Resource Benefits Estimation and Valuation. The primary objective of a watershed improvement project is watershed stabilization prevention of future onsite and offsite damages. However, the analysis should consider potential resource-related benefits. Watershed improvement projects may, for example, enhance related range, timber, wildlife, and recreation. When the watershed improvement project is likely to enhance other resource values, include these related resource benefits in the economic efficiency analysis.

1. Range. Watershed improvement projects involving such measures as seeding may increase the amount of forage available for livestock over what would have been available without the additional project investment. Measurement of this increased output should be in terms of increased animal unit months of forage. The Forest Service's Fair Market Value Appraisal of Public Rangeland Grazing provides values for estimating range forage benefits. However, if the project includes limitation or reduction of permitted grazing, it may not be appropriate to count the benefit value of increased forage.

2. Wildlife and Recreation. If the number of Recreation Visitor Days (RVDs) lost or gained over time can be quantified, one may derive other dollar benefits or losses, such as increased or lost recreation/wildlife values. Identify and value RVDs by type of recreation because there is considerable difference in the value of recreation, depending on the activity. For Values see: Valuing Watershed Restoration Projects, by Wes Ingran and John Loomis, UC Davis 1989.

3. Timber. Watershed improvement projects may result in changes over time in production of timber, firewood, and other woodland products. If production of these products is projected to increase as a result of a watershed improvement project, you may count this increase as a benefit. If production is projected to decrease, this would be an opportunity cost to treat in the same manner as any other cost. Opportunity cost is defined and explained in section 2.4b.

2.3 Formulation of Alternatives. Always consider at least the following two alternatives:

2.3a "Without" Project. This alternative of no change reflects the current management trend projected through time without implementation of the project alternatives. This alternative forms a baseline from which to analyze the costs and benefits of the with project alternatives over time.

2.3b "With" Project. The number of alternatives developed for the "with" project depends on existing opportunities. In some cases, one "with" project alternative is adequate. Evaluate several alternatives if different improvement practices and techniques are available.

2.4 Preparation of the Economic Efficiency Analysis. To prepare the economic efficiency analysis, use the following general steps, which illustrate the procedure and products of the analysis:

> 1. Identify resources needed to carry out the project together with their associated cost, and identify when the cost is likely to occur during the economic life of the project.

2. Identify outputs (benefits) of the project during the economic portion of the project. When possible, give outputs a dollar value. When dollar values are not possible, one may include the output value, environmental quality or social well-being analysis.

3. Discount costs and benefits to the present time.

4. The difference between the sum of the discounted benefits a sum of the discounted costs is the net present value. The rat sum of the discounted benefits to the sum of the discounted co the benefit/cost ratio. A benefit/cost ratio greater then uni necessary for a project to be economically justified.

2.4a <u>Economic Life - Analysis Period.</u> The expected life of waters improvement projects varies by practice and geographic areas. During first planning period a suggested analysis period is 25 years. Plan to adjust the length of this analysis period based on local conditions proposed watershed improvement project includes practices that have economic life of less than 25 years, repeat the project costs to th necessary to maintain the flow of outputs over the analysis period. alternatives should be compared for the same analysis period

2.4b <u>Opportunity Costs.</u> Opportunity costs represent direct benefits may be lost with or without project implementation. They are foregoing benefits and the value of these benefits becomes a cost of the project example of opportunity cost is the cost of water purification. The benefits are the costs of cleaning up the water, as well as those *i* treating the watershed area.

2.4c <u>Inflation.</u> The analysis must take into consideration inflation same manner for all alternatives or projects under consideration. costs and benefits in real terms, net of inflation. Costs and benefits usually exposed to the same rate of inflation, thus inflation is nc consideration in the economic efficiency analysis.

2.4d <u>Comparison Factors.</u> Use discounting to compare projects on i of costs and benefits that occur differently over time.

<u>2.5 Discounting.</u> Discount watershed improvement projects using percent real discount rate. Use the analysis with the 4 percent < rate for alternative selection. The 4 percent discount rate is used by the Federal Government. Pr: entities may need a somewhat higher discount rate. The Pacific Gas Electric Company uses 9 percent, but also includes inflation at 3 ′• percent for a net discount rate of 5 to 6 percent.

2.5a <u>Cost/Benefit Analysis Through Time.</u> Classify cost/benefits . time" or "recurring." For example, the initial investment for a p: generally made once. However, operation and maintenance costs usually increase each year. The discounting procedures differ for the two classify The annual cost to operate and maintain a large dam is an example of recurring cost.

2.5b Discounting Recurring Costs and/or Benefits Through Time. Use standard economic Cables for selected discount rates.

2.5c Adjustment for Real Dollar Value. Before their inclusion in the economic efficiency analysis, costs and benefits must be consistent in time; that is, the economic efficiency analysis should use present year costs with present year benefits values. The Gross National Product (GNP) price deflator is available from economists for adjusting costs and benefits through time. To adjust past costs and prices, generally use the GNP implicit price deflator as given in the Economic Report of the President each year and published in the Department of Commerce's Survey of Current Business.

2.5d Discounting Costs and Benefits Occurring Once in Time. One time future costs or benefits are reduced to present value by multiplying by the single payment present worth factor from a compound interest table for the selected discount rate. Without a table the following formula is applicable:

$$P = S X 1/(1+I)n$$

Where P is the present value, S is the value of future year, i is the discount rate divided by 100, and n is the number of years in the future.

2.6 Products of the Economic Efficiency Analysis

2.7a Present Value of Costs and Benefits. The present value of the costs (PVC) is the sum of all project costs discounted to the present time. The present value of the benefits (PVB) is the sum of all dollar benefits discounted to the present time.

2.7b Net Present Value. Net present value (NPV) is the difference between PVB and PVC (PVB-PVC=NPV). If the NPV is greater than zero, the benefits of the project outweigh the costs; if the NPV is less than zero, the benefits are less than the costs; if the NPV equals zero, the benefits equal the costs. NPV provides a suitable index for comparing project alternatives, but may not be suitable for comparing projects of significantly different size.

2.7c Benefit/Cost Ratio. The benefit/cost ratio (B/C) is the ratio of PVB to PVC (PVB/PVC = B/C). If the B/C is greater than one, the benefits are greater than the costs; if the B/C is less than one, the benefits are less than the costs; and if the B/C equals one, the benefits equal the costs. Benefit/cost ratios identify the amount of benefits for each dollar of costs. For example, the B/C ratio of 1.67:1 means a return of $1.67 per $1 of costs, or $.67 net benefits. The B/C ratio is the measure that is carried forward into the project effectiveness index (PEI). See sections 5 and 6 for a description of PEI.

Benefit/cost ratios may also be misleading when comparing projects that are significantly different in size or cost. Both NPV and B/C should be examined to obtain a better view of how alternatives and projects compare.

3. Environmental Quality

3.1 Effects on Environmental Quality. The effects on environmental quality are often nonmarket and nonmonetary. Beneficial effects ar contributions resulting from the proposed projects that maintain, r or enhance one or more of the characteristics of the natural enviro Such contributions generally enhance the quality of life; however, could be adverse impacts on environmental quality. For example, a that significantly modifies a vegetation type may adversely affect wildlife species while benefiting others.

3.2 Assessing Nonmarket Values. Document the projected environmen effects, both with and without the project, in relevant physical te Each factor is rated relative to the significance it has to the pro area. This information is recorded on Form EBNFFR CRM I, Environmemtal Quality Benefit Rating (pg. 79-c). The numerical environmental qua ratio indicates the relative change in the quality of the environment the project compared to "without" the project.

Rate all watershed improvement projects on the basis of specific cr It is possible to use additional environmental quality factors, uni region. Lands include such diverse ecosystems that it is difficult prescribe specific standards and guidelines relative to the project in environmental quality over the expected project life. Therefore following guidelines relate more to the change in condition than th condition itself.

3.2a Erosion (Onsite). When analyzing the environmental impact of proposed watershed improvement project, document the expected benef reduced erosion. For large projects, one may convert the benefits reduced soil loss to dollars and use them as part of the economic e analysis. For most watershed improvement projects, it is difficult a dollar value on reduced soil loss because this is difficult to pi-measure at the planning area level. Therefore, erosion is more prc evaluated under environmental quality. For example, because of dec plant cover, the rate of erosion and sedimentation is increasing. project is implemented, the expectation is that this trend would re The potential benefit would be the difference over the life of the

3.2b Sedimentation (Offsite/Downstream). In addition to assessing economic costs of downstream sedimentation and reservoir siltation, the impact of sedimentation on environmental quality. Consider als intangible costs of sediment on fishery habitat, recreation, esthet water quality standards and goals, and water use.
To help indicate the relative benefit, consider the following factc

1. Gully erosion.
2. Streambank disturbance.
3. Sediment deposition in channel affecting channel cap fishery habitat.
4. Sediment deposition in reservoirs resulting in loss storage capacity.
5. Potential flood damages downstream.

6. State and local water quality standards and goals.

3.2c Water Quality. Uses and quality determines the value of water. To determine water quality values, assess its physical characteristics, which include--but are not limited to--clarity, color, temperature, turbidity, sediment, litter, and dissolved chemicals. Then determine its uses such as domestic, irrigation, recreation, power generation, fisheries, etc.

3.2d Improved Productivity. Good watershed condition is the key to ensuring renewable multiple uses of the resource and sustained resource values. Factors to examine are expected long-term change in condition and increased production over the life of the project.

3.2e Visual Quality. The proposed watershed improvement project may enhance the visual scene of the range or forest landscape. For forage improvement practices, design the project whenever possible to enhance scenic values. This design may result in establishing a mix of vegetative covers with a natural diversity of clearings and untreated areas. The benefit is expected to occur over the total life of the watershed improvement practice even though the first few years may have a negative impact because of debris and the time necessary for establishing the desired vegetative cover. Some structural improvement practices may not enhance the landscape, but with proper design they should not detract from the existing visual quality. The amount of benefit shall relate to the specific area (acres of land benefited) and the extent of human use and enjoyment.

3.2f Wildlife Habitat. Watershed improvement projects stabilize soils, increase vegetative cover, and enhance water quality. Many of these projects also enhance the wildlife habitat for both game and nongame species. For example, good condition rangeland may also provide food and cover for wildlife. One can quantify and calculate in the economic efficiency analysis the increased hunter-day use that may result from improved wildlife habitat. In this analysis, determine the magnitude of the effect on the total supply of the specific wildlife population within the area.

Watershed improvement projects that increase water yield may increase water available for livestock watering sites and also provide drinking water for certain wildlife species. Vegetative type conversion projects may increase the variety of bird species or enhance the habitat for deer or other mammals. Some watershed improvement practices significantly modify wildlife habitat, which may adversely affect wildlife populations. The benefit is based on the expected size of wildlife populations over the length of the project life. Consider all wildlife--game and nongame--and give special attention to threatened and endangered species.

3.3 Guidelines for Rating Environmental Quality Benefits. Exhibit 2 (pg. 79-A) provides guidelines for rating the environmental quality benefits. Determining the relative significance of the various environmental quality criteria is a subjective evaluation and requires considerable professional judgment. Use the guidelines for rating environmental quality for preparing the environmental quality benefit ratio.

3.4 Rating Environmental Quality Condition Changes. Environmental. changes over time both with and without the project. There is a ne indicate the significance of the change and whether it is positive negative. Form EBNFFR CRM I, (pg. 79-C) Environmental Quality Bern Rating is designed to show the projected change for each environmental quality criteria both with and without the action alternative in tl influenced by the project over the life of the project. To arrive numerical rating, the significance is scored as follows:

1. Highly significant 4
2. Significant 3
3. Moderate 2
4. None or minor 1

When the change over the life of the project is positive, the scor project is greater than without project. Conversely, if the proje-change is negative, the score with project is lower than without p This technique eliminates the use of negative numbers yet recognize positive and negative changes.

3.5 Environmental Quality Benefit Index Ratio. The environmental benefit ratio is a numerical rating for indicating the expected ch the environmental condition of the area affected, both onsite and with the watershed improvement project compared to without the pro amount of change or improvement in condition indicates the relativ significance of environmental quality benefits with the project. greater than 1.0 indicates a positive change in condition; 1.0 ind change; and less than 1.0 indicates a negative change. One can ca negative values.

Use a relative weight because the environmental quality criteria t usually do not have equal value and vary on different watersheds. weight of 3 for the criteria of highest importance and I for the I important criteria. In situations in which you consider all of the environmental quality criteria equally important, use a relative w 1. Enter the relative weight for each criteria in column B of For CRM 2 (pg. 79-D).

To compute the ratio, rate the change in environmental condition f criteria without the project in column C and with the project in c G, I, and K using a score of:

a. Highly significant 4
b. Significant 3
c. Moderate 2
d. Minor 1

Calculate the weighted value for each criterion by multiplying the weight in column B by the relative significance in columns C, E, E and enter in the results in columns D, F, H, J, and in L. Total t weighted values for without project (column D) and with project ir F, H, J, and L for the various alternatives being considered. Rec total on line 8.

Compute the environmental quality index ratio by dividing the total weighted value for with project (line 8, column F, H, J, and L) by the total weighted value for without project (line 8, column D) and enter on line 9.

The ranking of the ratio determining environmental quality benefits is:

Highly favorable	3.0 or greater
Favorable	1.5- - 2.9
Marginal	1.1 - - 1.4
Unfavorable	1.0 or less

Identify the ranking of the environmental quality benefit index ratio by marking the appropriate box on line 10 for each alternative.

4. Social Well-Being

4.1 Identification of Social Well-Being Effects. Watershed improvement projects have varying effects on the social well-being of people and communities. People relate the beneficial effects of social well-being to security of life, health and safety, reduced property damage, cultural values, employment, local business activity, vital community services, protection for special sites, minority participation, technology transfer, and other social variables that may be identifiable for a specific project. Effects on social well-being are related to the basic values and goals of society and usually are not subject to monetary evaluation.

4.2 Assessing Social Well-Being. Use the guidelines in sec. 4.4, and exhibit 3 to analyze the following seven example primary variables.

4.2a Security of Life, Health, and Safety. The beneficial effects of watershed improvement projects include reducing risk of floods that affect the security of life, health, and safety and reducing exposure to water pollution. An example of a benefit is the protection of a domestic water supply or a waste treatment plant from floods. Estimate the potential of the project to prevent loss of life or other health hazards to the population of the areas affected by the project.

4.2b Property Protection. Estimate the potential of the project to prevent structural damage to homes and businesses. Also consider the potential of the project for preventing damage to nonstructural facilities such as roads and campgrounds. If claiming dollar benefits in the environmental quality analysis, do not claim these same benefits again in the social well being analyses, as this would be double counting.

4.2c Employment. Some types of watershed improvement projects can provide employment. Do not include as a benefit people who are already working who transfer to this work from some other planned activity.

4.2d Vital Community Services. Consider the types of community services that could be protected by the project, such as hospitals, water supplies, and utilities.

4.2e Special Sites. This benefit relates to the social value of preserving cultural, historical, and scientific sites for society. List the number and type of affected sites and indicate the significance of the site where appropriate. Consider as significant, effects on sites that have s designation.

4.2f Minority Participation. Estimate the opportunity for minority participation in the area affected by the project.

4.2g Demonstration Opportunity/Technology Transfer. Projects can demonstrate and promote new management practices and restoration techniques. Express this intangible value on a subjective basis. social value relates to the size of the area the project affects, *i* land-ownerships, cooperative efforts with other organizations and c and the involvement of Research.

4.3 Other Social Effects. Other factors unique to the area may ex Thus, project planners should develop and use other variables appropriate portray the most important social changes likely to occur under each alternative.

4.4 Rating Social Well-Being Effects. Use the guidelines displayed in exhibit 3, Guidelines for Rating Social Benefits, to calculate a social well-being ratio for the proposed watershed improvement project. The relative importance of social concern related to watershed improvement projects is variable. Therefore, these guidelines may be modified where there are unique local situations.

4.5 Calculation of Social Well-Being Ratio. Compute the social well-being ratio from a total numerical score based on a subjective evaluation of each social well-being variable. Use the following guidelines to determine the social well-being ratio for each proposed project alternative.

4.5a Rate the relative significance of each variable as displayed on form EBNFFR CRM 2, (Exhibit 5) Rating of Social Well-Being, on a scale of 1 to 4. Compare the without project to the with project. For each alternative, enter the following score in the column designated "Relative Significance."

Expected level of relative significance	Score
High	4
Moderately high	3
Moderately low	2
Low	1

4.5b Where all the social well-being criteria are not likely to have equal value on the project under consideration you may weight them. Using relative weight factors of 1, 2, or 3, with 3 having the highest importance and 1 the least. In situations where all the criteria are of equal importance, use a weight factor of 1 in column B.

4.5c Multiply the rating of relative significance for each alternative by the relative weight for each alternative you are considering. The social well-being ratio is equal to the sum of the weighted values for the alternative divided by the sum of the relative weights, column B.

4.5d Interpret the social well-being ratio as follows:

Highly favorable	3.0 or more
Favorable	1.5 to 2.9
Marginally favorable	1.1 to 1.4
Unfavorable	1.0 or less

5. Project Effectiveness

Project effectiveness considers the environment's quality, social well-being effects, and economic efficiency through a screening analysis. Economic analysis is the initial screen. Projects that have positive economic benefits, that is favorable economic efficiency ratings, have high potential for implementation. Improvement projects that do not have positive economic benefits, that is a rating of marginal or unfavorable economic efficiency, receive further screening to determine whether net environmental quality or social well-being benefits justify the project. On the other hand, a project that is economically feasible may be socially unacceptable. Therefore, consider social well-being analysis in all projects.

6. Rating Improvement Projects

Rate proposed improvement projects individually for effectiveness u following criteria,

Rating Elements	Rating Indices	Rating Criteria
Economic Efficiency Incremental B/C	1.5 or greater 1.1 or higher 1.1 to .9 less than .9	Highly Favorable Marginal Unfavorable
Environmental Quality Index Ratio	3.0 or greater 1.5 to 2.9 1.1 to .4 1.0 or less	Highly Favorable Marginal Unfavorable
Social Well-Being Significance Index	3.0 or greater 1.5 to - 2.9 1.1 to - 2.9 1.0 or less	Highly Favorable Marginal Unfavorable

7. Summary of Protect Effectiveness and Decision Guidance

Document the project effectiveness analysis by completing the following summary.

For example, a project may exhibit the following:

Analysis Criteria	Rating Indices	Criteria Rating:
Economic	1.4:1 B/C	Favorable
Environmental	1.8	Favorable
Social	2.3	Favorable

Comparisons of project summaries aid the project planners in ranking projects.

EXHIBIT 2 GUIDELINES FOR RATING ENVIRONMENTAL QUALITY BENEFITS

RELATIVE SIGNIFICANCE OF PROJECTED CHANGES (COLUMNS C, E, G, I. and K on Form EBNFFR CRM 1)

ENVIRONMENTAL QUALITY CRITERIA	HIGHLY SIGNIFICANT (4)	SIGNIFICANT (3)	MODERATE (2)	MINOR (1)	REDUCTION (-1)
EROSION	Accelerated soil erosion is expected to Increase without project. "With" project Is expected to reduce soil erosion by 75% or more.	"With" project Is expected to reduce soil erosion by 50% - 74%.	"With" project Is expected to reduce soil erosion by 25% – 49%.	Soil erosion Is not a problem, "with" project will maintain or improve existing soil and vegetation	"With" project will cause a 1-5% increase in erosion and a similar decrease in vegetation cover.
SEDIMENTATION	Accelerated downstream sedimentation is expected to Increase without project. "With" project is expected to reduce sedimentation by 75%.	"With" project is expected to reduce soil erosion by 50% - 74%.	"With" project Is expected to reduce soil erosion by 23% - 49%.	Downstream sedimentation is not a problem but "with" project will further reduce sedimentation.	"With" project will cause a 1-5% increase in sedimentation.
WATER QUALITY	"With" project will Improve water quality (critical parameters) by 50% or more compared to "without" project	"With" project will improve water quality (critical parameters) by 30 to 49%.	"With" project is expected to improve water quality (critical parameters) by 10 to 29%.	"With" project will have minor or no effect on water quality, but existing water quality will be maintained.	"With" project will have a slight, but measurable decrease In water quality.
SITE PRODUCTIVITY	Watershed productivity "with" project will be stabilized and maintained on 85X or more of the unstable area and production will begin to increase toward site potential.	"With" project will stabilize or maintain WS productivity on 60 to 84% of unstable area.	"With" project will stabilize or maintain WS productivity on 30 to 59% of unstable area.	"With" project will stabilize or maintain WS productivity on less than 30% of unstable area.	"With" project will cause a slight decrease in productivity potential.
VISUAL QUALITY	"With" project will enhance and meet visual quality objectives on 50% or more of the WS project area.	"With" project will enhance and meet visual quality objectives on 30% to 49% of the WS project area.	"With" project will enhance and meet visual quality objectives on 20% to 29% of the WS project area.	"With" project will have little or no effect on visual quality objectives for the WS project area.	"With" project will impair visual quality on 1 to 10 % of the WS project
WILDLIFE HABITAT	"With" project will enhance or maintain habitat necessary for one or more threatened or endangered species.	"With" project will enhance wildlife habitat for several "indicator" species	"With" project will enhance wildlife habitat for at least one indicator species.	"With" project will have little or no effect on wildlife habitat.	"With" project will cause a slight deterioration of wildlife habitat for current occupants.

RELATIVE SIGNIFICANCE OF PROJECTED CHANGES (Form EBNFFR 2)

SOCIAL WELL-BEING VARIABLES	HIGH (4)	MODERATELY HIGH (3)	MODERATELY LOW (2)	LOW (1)	REDUCTION (-1)
SECURITY OF LIFE HEALTH & SAFETY	Project will prevent loss of life.	Project will prevent serious Injury.	Project will mitigate a threat to health.	Project will do little to mitigate a threat to health and safety.	Project may create situations hazardous to health and safety.
PROPERTY DAMAGE	Project will prevent structural damage to 10 or more houses or businesses.	Project will prevent structural damage to 1 to 9 houses or businesses.	Project will prevent structural damage to 1 to 4 houses	Project will prevent little to no structural damage.	Project may actually create hazard to I to 3 downstream structures.
EMPLOYMENT	Project will create potential jobs greater than or equal to 3. 1I% of present employment In the county.	Project will create potential jobs equal to 2.1% to 3.O% of the present employment in the county.	Project will create potential jobs equal to 1.1% to 2.O% of the present employment in the county.	Project will create potential jobs less than or equal to 1.O% of the present employment in the county.	Project will cause a 1.O% drop in employment in the county.
DISRUPTION OF VITAL COMMUNITY SERVICES	Project protects critical public services such as fire stations, hospital, or water supplies.	Project protects public utilities, electricity, gas, and sanitation.	Project prevents disruption of communication and transportation facilities (roads and bridges).	Project maintains school or municipal/ county building accessibility.	Project may create hazard to school or municipal county building accessibility.
IMPACT ON SPECIAL SITES	Project preserves more than one site on State or national register of historic places.	Project preserves at least one site on state or national register of historic sites	Project preserves one site which is a significant local historic site	Project does not preserve historic sites, but does preserve records which are relocatable.	Project may cause minor damage to historic sites.
MINORITY PARTICIPATION	Opportunity for minority participation in the project area is 50% or greater	Opportunity for minority participation In the project area is 35% to 49%	Opportunity for minority participation in the project area is 20%to 30%.	Opportunity for minority participation in the project area is less than 20%.	Opportunity for minority participation In the project area decreases to 0 %
DEMONSTRATION OPPORTUNITY/ TECHNOLOGY TRANSFER	Project is applicable to the majority of the prevailing ecosystem.	Project is applicable to 30% to 50% of the prevailing ecosystem	Project is applicable to 1O% to 29% of the prevailing ecosystem.	Project is applicable to less than 1O% of the prevailing ecosystem.	N/A

WATERSHED IMPROVEMENT ENVIRONMENTAL QUALITY BENEFIT RATING	1. WTSD Number		2. Watershed name				3. Land Owner/Manager				
	4. Watershed Project				5. Prepared By (Print Name)			6. Date			
ENVIRONMENTAL QUALITY CRITERIA (A)	Relative Weight	Without Project		Project Alternative A		Project Alternative B		Project Alternative C		Project Alternative D	
	1/(B)	Relative Significance 2/(C)	Weighted Value (B)x(C) (D)	Relative Significance (E)	Weighted Value (B)x(E) (F)	Relative Significance (G)	Weighted Value (B)x(C) (H)	Relative Significance (I)	Weighted Value (B)x(I) (J)	Relative Significance (K)	Weighted Value (B)x(K) (L)
1. Erosion											
2. Sedimentation											
3. Water Quality											
4. Site Productivity											
5. Visual Quality											
6. Wildlife Habitat											
7. Other(optional)											
8. Total →	XXXXX	XXXXXXXX		XXXXXXX		XXXXXXX		XXXXXXX		XXXXXXX	
9. Enviromental Quality Benefit = $\frac{TotalWeigh\ tedValueOf\ Alternativ\ e}{TotalWeigt\ edValueWit\ hout\ \mathrm{Pr}\ oject}$ →				$\frac{F}{D}$ Total		$\frac{H}{D}$ Total		$\frac{I}{D}$ Total		$\frac{L}{D}$ Total	
10. Ranking of Item		a. Highly Favorable (3.0 or >)									
		b. Favorable (1.5 – 2.9)									
		c. Marginal (1.1- 1.4)									
		d. Unfavorable (1.1 or <)									

1/ Use a relative weight factor of 1, 2, or 3, with 3 being the most important. See Section 3.5
2/ Enter relative significance ratings of 1 to 4. See Section 3.5

SOCIAL WELL-BEING VARIABLES (A)	Relative Weight 1/(B)	Without Project		Project Alternative A		Project Alternative B		Project Alternative C		Project Alternative D	
		Relative Significance 2/(C)	Weighted Value (B)x(C) (D)	Relative Significance (E)	Weighted Value (B)x(E) (F)	Relative Significance (G)	Weighted Value (B)x(C) (H)	Relative Significance (I)	Weighted Value (B)x(I) (J)	Relative Significance (K)	Weighted Value (B)x(K) (L)
1. Security of Life Health & Safety											
2. Property Damage											
3. Employment											
4. Disruption of Vital Community Services											
5. Impact on Special Sites											
6. Minority Participation											
7. Admin Opportunity/ Technology Transfer											
8. Other(optional)											
9. Other(optional)											
10. Total →	XXXXX	XXXXXXXX		XXXXXXX		XXXXXXX		XXXXXXX		XXXXXXX	
11. Social Well-Being = $\frac{\text{Total Weighted Value Of Alternative}}{\text{Sum Of Relative Weights Column B}}$ → Ratio				$\frac{F}{B}$ Total		$\frac{H}{B}$ Total		$\frac{J}{B}$ Total		$\frac{L}{B}$ Total	
12. Social Well-Being Ranking of Ratio		a. Highly Favorable (3.0 or >)									
		b. Favorable (1.5 – 2.9)									
		c. Marginal (1.1- 1.4)									
		d. Unfavorable (1.1 or <)									

1/ Enter relative significance ratings of 1 to 4 : high (4), Moderate high (3), Moderate low (2), and low (1)

2/ Use relative importance weight factor of 1, 2, or 3, with 3 being highest and 1 being the least important. See Section 4.5

APPENDIX F

Treatment Costs

APPENDIX F

TREATMENT COSTS
Costs Estimates Associated With Restoration Work In The EBNFFR Watershed

Fencing Costs

Fencing: Fencing will be necessary where restoration work is done in livestock grazing allotments. These costs are an estimate. True cost per mile can vary according to the accessibility of the site, contour of the fence line, number of corners, soil and vegetation type, and even weather can alter materials and labor costs. A one mile length of stream will require approximately 2.2-2.5 miles of fence.

Materials ---		$2300
Labor--		$2500.
	Total	$4800.

A one mile length of stream will require approx. 2.2-2.5 miles of fence.

Materials ---		$2000.
Labor--		$ 2500
	Total	$4500.

Engineering Costs: The following estimates of per mile geomorphic channel reconstruction costs cannot address all site specific variables. However, two variables can be identified as significantly affecting per mile cost and can be considered common to all projects. The first is the transportation distance (cost) to transport construction materials to the site. The greater the distance the higher the cost. The second is the degree of risk accepted for a given design. Design and construction costs go up as risk of failure goes down.

This cost estimate looks at three different treatment costs based on stream type and degree of channel degradation. The first cost estimate deals with total reconstruction of A-type and B-type channels that have degraded to a G-type channel. A G-type channel is a confined gully. Healthy A-type channels are steep, landform confined channels with gradients of 4% or greater. These channels are characterized as pool/drop systems that dissipate accumulated energy as turbulence in and between pools. The same is true for B-type channels with some exceptions. Healthy B-type channels are less steep and somewhat less confined with gradients of 2-4%. In addition to the pool/drop sequence a pool/riffle system is also at work to dissipate energy. In both stream types gullying is common when grade control is lost. Nick points form in the channel and advance upstream. Controlling this type of channel impairment requires the replacement of grade control features. The placement of vortex rock weirs have been demonstrated to provide the energy dissipation and grade control function of a resistant material while allowing normal sediment transport through the weir and pool depth maintenance.

The complete conversion of one mile of confined gully to a functioning A-type and/or B-type pool/drop channel system includes; channel shaping, weir materials, weir construction, and construction supervision.

Pool/drop Reconstruction Costs for A and B-Type Streams (one mile reach)
Cost in 1994 Dollars
Costs include material acquisition, construction and supervision.

Channel shaping --- 14 days with dozer --- $800.00 per day	$11,200
Weir materials --- 1125 cu. yds. of 3' boulders --- $20.00 per yrd .	$22,500
Weir installation --- 14 days with excavator --- $960.00 per day	$13,440
--- 14 days with loader --- $800.00 per day	$11,200
Construction supervision --- 173 hrs --- $25.55 per hour	$4,420
Per Mile Total	$62,760

Per mile employment opportunities on pool/drop channels.

Material Acquisition

Blasting: ---------------------	2 jobs for 3 days	$4,620
Excavator w/operator----------	1 job for 6 days	$4,800
Transport 4 trucks w/operator	4 jobs for 6 days	$11,040
Contracts/Supervision- --------	1 job for 10 days	$2,040

Channel Construction

Dozer w/operator	1 job for 14 days	$11,200
Loader w/operator	1 job for 14 days	$11,200
Excavator /operator	1 job for 14 days	$13,440
Contracts/Construction supervision	1 job for 21 days	$4.420
		$62,760

C-type channels are moderate to low gradient, moderately confined, high sinuosity channel systems that dissipate energy by meander pool turbulence a the lateral spreading of flows onto flood plains. Typically, healthy C-type channels degrade to F-type and D-type channels. F-type channels are generally confined within gully walls created as the C-type channel downcut to steepen its grade and increase it's velocity in order to transport an increased sediment load. Over time confinement of the channel within the gully may lessen as the banks erode during lateral channel migration. As the gully widens a new flood plain begins to form in the bottom of the gully. C-type channels that become D-type channels have undergone a similar occurrence as F-type channels the main difference being that D-type (or braided) channels have a slightly higher gradient and an increased discharge.

Meander (pool/riffle) Reconstruction Costs for C, D, and F-Type Streams Cost per one mile reach in 1994 dollars.

Channel and
Flood plain shaping --- 45 days with dozer ---------------------------- $800.00 per day --- $36,000.
…………………………15 days with loader ------------------------ $800.00 per day --- $12,000.

Materials
500 root wads --------- $40.00 each -------------------------------- $20,000.

1500 logs -------------------- $5.00 per log ---7,500.
4,000 yds rock for bank and weir --- $20.00 per yd. ---------------------- $80,000.

Construction
Excavator --- 45 days --- $960.00 per day -- $43,200
Loader --- 30 days ---- $800.00 per day -- $24,000.
Construction supervision --- 600 hrs --- $25.55 per hr.------------------------------ $15,220.
Per Mile Total $238,030.
Per mile employment opportunities on pool/riffle channels.

Material Acquisition
Rock:
Blasting-----------------------------------3 jobs for 6 days-----------------------------$13,860
Excavator w/operator-------------------1 job for 24 days-----------------------------$19,200
Transport 4 trucks w/operator--------4 jobs for 24 days-----------------------------$44,160
Contracts/Supervision------------------1 job for 10 days-------------------------------$2,040

Logs/Root wads:
Timber fallers---------------------------2 jobs for 2 days-------------------------------$2,800
Skidder-----------------------------------2 jobs for 6 days-------------------------------$7,000
Loader-----------------------------------1 job for 6 days---------------------------------$3,600
Transport--------------------------------4 jobs for 6 days-------------------------------$11,040
Contracts/Supervision----------------1 job for 10 days---------------------------------$2,040

Channel Construction:
Excavator w/operator-----------------------1 job for 45 days--------------------------$43,200
Loader w/operator---------------------------1 job for 45 days--------------------------$36,000
Dozer w/operator----------------------------1 job for 45 days--------------------------$36,000
Contracts/Construction Supervision------1 job for 45 days--------------------------$11,220
$232,360

Not all impaired streams will require a total conversion as reflected in the above costs. Most channels will require work on portions of any given one mile reach. Impairment may be occurring on short sections of an otherwise stable channel. In these cases, enhancement of the existing stream type will require less construction per mile of impaired channel.

Coefficients for applying Geomorphic cost estimates where stream type conversion is not necessary.

Stream type	Coefficient	Estimated cost per mile
A-type channel	0.25	$15,690
B-type channel	0.50	$31,380
C - type channel	0.50	$119,015

Problem Roads

Road closures can be accomplished by restoring the road surface to near natural soil and vegetation conditions. This is done by ripping the compacted surface draining, revegetation and permanent closure. This is best accomplished using a D4 or D5 Caterpillar tractor fitted with modified ripping teeth known as winged rippers. This modified attachment will rip the road surface well bellow the compacted layer, usually from a 10 to 16 inch depth. The cost is dependent on type of equipment used, subsurface soil condition, amount of compaction, length of stay on site. Costs may vary from $1500 to $7500 a mile.

		Estimated cost per mile
Road closures		
	Ripping, Draining and Seeding the road.--------	$7500.
	Placement of earth or rock barriers.---------------	$150.
	Total	$7650.
Road reconstruction (upgrade)		
	Reconstruction of existing road to higher standard (improve existing road).--------------	$1600.
Road construction		
	High standard Forest access road.- ------------	$30,000.
	Low standard forest access road.--------------	$15,000.

Problem Stream Crossings

No costs estimates have been developed at this time.

Bio-technical Stream Rehabilitation Costs

The following costs represent a "typical" treatment for a degraded channel where bio-technical bank stabilization and other associated revegetation techniques are utilized. This estimate is based on a generic downcut channel. with eight foot banks, sloped at 2:1 or less which have isolated clumps of existing vegetation in limited areas. Cost is for treatment of both banks ii one mile reach.

A diversity of bio-technical stabilization and planting techniques are incli for overall rehabilitation of a one mile stream reach. The cost estimate is based on $14.00 per person hour which includes basic wages, payroll taxes, workers compensation, and project administration.

Treatment Type	% of Bank Treated	Unit Cost Per Linear Foot	Treatment cost Per one mile reach
			Brush Matting 15
			Brush Wattles 30
Brush layering	<10 [1]	$15.00	$23,760
Trench Packing	<10 [2]	$3.00	$28,512
Plant Rolls	<10 [3]	$2.50	$3,960.
		$2.10	$2,218.
		$4.50	$19,008.

Live Staking	<10[4]	$0.50	$2,640.
Planting-seeding	<25[5]	$0.25	$2.640.
		Total per mile cost	$82,738.

Note:
\l. Assume treatment of a small 5 '.wide rill-gully requiring 3-5' wide layers (15 total linear feet) spaced at a 2' vertical interval through the gully.

\2. Assume 10 linear feet of trench packing per 100 feet of bank.

\3. Assume 40 linear feet of plant rolls per 100' of bank to be used in channel and/or for toe stabilization in combination with matting or wattle treatment.

\4. Assume 50 live stakes per 100' of bank requiring 2 person hrs. to collect-cut-install.

\5. Assume 10 "super cell" container plants per 100' of bank, with fertilizer tabs, and native perennial seed. Plant, fertilizer and seed acquisition and installation is estimated at $25 per 100' of bank.

Because of variable microsite conditions including existing vegetation, slope character, aspect, soils, moisture, elevation, and degree of channel impairment few channels will need 100% treatment of the degraded reach.

Streamtype	Coefficient	Est. Cost per mile
A-type channel	0.10	$8,275
B-type channel	0.40	$33,100
C-type channel	0.50	$41,370

Table 1

COSTS ASSOCIATED WITH TREATMENT OF ROADS WITH LOCATION/ALIGNMENT PROBLEMS
Note: All treatment miles and costs are estimates and subject to revision
For The Five Top Ranked Subwatersheds In The EBNFFR Watershed

SUB-WTSD NUMBER	SUB-WTSD NAME	MILES ERODING ROAD	MILES LOCATION /ALIGNMENT PROBLEM ROAD	MILES OF ROAD OBLITERATION	MILES ROAD UPGRADE/ RECONSTRUC	TOTAL COST IN MILLIONS
24	U. SPANISH	99	46	27	19 / 10*	0.54
15	WOLF-R. VALLEY	39	18	11	7 / 5*	0.25
22	L. SPANISH	40	18	11	7 / 5*	0.35
23	GREENHORN	81	37	22	15 / 11*	0.53
14	LIT.-GRIZZLY	74	33	20	13 / 10*	0.48
TOTALS		333	152	91	61 / 41*	2.15

* ROADS THAT ARE OBLITERATED AND RELOCATED - NEW ROAD CONSTRUCTION AT $ 30,000 PER MILE.
NOTE: OBLITERATION COSTS APROX $7500 PER MILE. UPGRADE COSTS APROX $2000 PER MI.
TOTAL COST - $ 2.15 MILLION + 15% ADMIN AND PLANNING + 20% OPPERATION AND MAINTAINCE -$3.0 MILLION

Table 2

CHANNEL ENHANCEMENT - ENGINEERING COSTS
Note: All treatment miles and costs are estimates and subject to revision
For The Five Top Ranked Subwatersheds In The EBNFFR Watershed

SUB-WTSD NUMBER	SUB-WTSD NAME	MILES A-TYPE CHANNE	MILES B-TYPE CHANNE	MILES C-TYPE CHANNE	COST A-TYPE IN MIL	COST B-TYPE IN MIL	COST C-TYPE IN MIL	TOTAL COST IN MILLIONS
24	U. SPANISH	58	54	19	0.9	1.7	2.3	4.9
15	WOLF-R. VALLEY	42	39	14	0.7	1.2	1.8	3.7
22	L. SPANISH	15	14	5	0.2	0.5	0.6	1.3
23	GREENHORN	32	30	10	0.5	0.9	1.2	2.6
14	LIT.-GRIZZLY	87	80	29	1.4	2.5	3.5	7.4
TOTALS		234	217	77	3.7	6.8	9.4	19.6

TOTAL CHANNEL MILES=528
TOTAL COST = 19.6 MILLION + 15% ADMIN AND PLANNING + 20% OPERATION AND MAINTENANCE = $26.5 MILLION

For The Five Top Ranked Subwatersheds in the EBNFFR Watershed

SUB-NUMBER	SUB-WTSD NAME	MILES A-TYPE CHANNE	MILES B-TYPE CHANNE	MILES C-TYPE CHANNE	RE-VEG COST A-TYPE IN MIL	RE-VEG COST B-TYPE IN MIL	RE-VEG COST C-TYPE IN MIL	TOTAL RE-VEG. COST IN MILLIONS
24	U. SPANISH	58	5-4	19	0.5	1.8	0.8	3.1
15	WOLF-R. VALLEY	42	3-9	14	0.3	1.3	0.6	2.2
22	L. SPANISH	15	14	5	0.1	0.5	0.2	0.8
23	GREENHORN	32	30	10	0.3	1.0	0.4	1.7
14	LIT. -GRIZZLY	87	80	29	0.7	2.6	1.2	4.5
TOTALS		234	217	77	1.9	7.2	3.2	12.3

TOTAL CHANNEL MILES – 528

TOTAL COST - 12.3 MILLION + 15% ADMIN AND PLANNING + 20% OPERATOIN AN MAINTAINCE= $16.6 MILLION

TOTAL CHANNEL CONSTRUCTION COSTS----------------------------$26.5 MIL
TOTAL REVEGETATION AND BIOTECHNICAL COSTS-------------$16.6 MIL
TOTAL ROAD COSTS---$3.0 MIL
TOTAL $46.2 MIL

TABLE 4

COSTS ASSOCIATED WITH TREATMENT OF ROADS WITH LOCATION/ALIGNMENT PROBLEMS

Note: All treatment miles and costs are estimates and subject to revision

SUB-WTSD NUMBER	SUB-WTSD NAME	MILES ERODING ROAD	MILES LOCATION /ALIGNMENT PROBLEM ROAD	MILES OF ROAD OBLITERATION	MILES ROAD UPGRADE/ RECONSTRUC	TOTAL COST IN MILLIONS
13	RUSH-MILL	44	20	12	8	0.11
14	LIT.-GRIZZLY	74	33	20	13	0.18
15	WOLF-R. VALLEY	39	18	11	7	0.10
16	LIGHTS-COOKS	72	32	19	13	0.17
17	MID.-INDIAN	35	18	11	7	0.10
18	ANTELOPE LK	53	27	16	11	0.14
19	SQUAW QUEEN	26	13	8	5	0.07
20	RED CLOVER	57	29	17	12	0.15
21	LAST CHANCE	130	66	40	26	0.35
22	L. SPANISH	40	18	11	7	0.10
23	GREENHORN	81	37	22	15	0.20
24	U. SPANISH	99	46	27	19	0.24
TOTALS		750	357	214	143	1.91

NOTE: OBLITERATION COSTS APROX $7500 PER MILE. UPGRADE/RECONSTRUCTION COSTS APROX $200 PER MI
TOTAL COST = $1.91 MILLION + 15% ADMIN AND PLANNING + 20% OPERATION AND MAINTAINCE= $2.6 MILLION

NOTE: NO COSTS WERE DEVELOPED FOR NEW ROAD CONSTRUCTION FOR THIS TABLE, SEE TABLE 1.
New road construction costs is approximately $30,000 per mile. At this stage in the analysis an estimate of new road construction needs over the entire EBNFFR Watershed still needs to be identified.

TABLE 5

SUB-WTSD NUMBER	SUB-WTSD NAME	MILES A-TYPE CHANNEL	MILES B-TYPE CHANNEL	MILES C-TYPE CHANNEL	COST A-TYPE IN MIL	COST B-TYPE IN MIL	COST C-TYPE IN MIL	TOTAL COST IN MILLIONS
13	RUSH-MILL	47	43	15	0.7	1.3	1.8	3.8
14	LIT. -GRIZZLY	87	80	29	1.4	2.5	3.5	7.4
15	WOLF-R. VALLEY	42	39	14	0.7	1.2	1.8	3.7
16	LIGHTS-COOKS	57	53	18	0.9	1.7	2.1	4.7
17	MID .-INDIAN	26	16	8	0.4	0.6	1.0	2.0
18	ANTELOPE LK	34	38	56	0.5	1.2	6.6	8.3
19	SQUAW QUEEN	11	22	39	0.2	0.4	4.6	5.2
20	RED CLOVER	33	43	126	0.5	2.7	15.0	18.2
21	LAST CHANCE	53	69	196	0.8	4.3	23.0	28.1
22	L. SPANISH	15	14	5	0.2	0.5	0.6	1.3
23	GREENHORN	32	30	10	0.5	0.9	1.2	2.6
24	U. SPANISH	58	54	19	0.9	1.7	2.3	4.9
TOTALS		495	501	535	7.7	19.0	63.5	90.2

TOTAL CHANNEL MILES = 1531
TOTAL COST = $90 MILLION + 15% ADMIN AND PLANNING + 20% OPERATION AND MAINTAINCE= $122 MILLION

TABLE 6

REVEGETATION AND BIO-TECHNICAL ENHANCEMENT COSTS

Note: All treatment miles and costs are estimates and subject to revision

SUB-WTSD NUMBER	SUB-WTSD NAME	MILES A-TYPE CHANNEL	MILES B-TYPE CHANNEL	MILES C-TYPE CHANNEL	RE-VEG COST A-TYPE IN MIL	RE-VEG COST B-TYPE IN MIL	RE-VEG COST C-TYPE IN MIL	TOTAL RE-VEG. COST IN MILLIONS
13	RUSH-MILL	47	43	15	0.4	1.4	0.6	2.4
14	LIT. -GRIZZLY	87	80	29	0.7	2.6	1.2	4.5
15	WOLF-R. VALLEY	42	39	14	0.3	1.3	0.6	2.2
16	LIGHTS-COOKS	57	53	18	0.5	1.8	0.7	3.0
17	MID .-INDIAN	26	16	8	0.2	0.5	0.3	1.0
18	ANTELOPE LK	34	38	56	0.3	1.3	2.3	3.9
19	SQUAW QUEEN	11	22	39	0.1	0.7	1.6	2.4
20	RED CLOVER	33	43	126	0.3	1.4	5.2	6.9
21	LAST CHANCE	53	69	196	0.4	2.3	8.1	10.8
22	L. SPANISH	15	14	5	0.1	0.5	0.2	0.8
23	GREENHORN	32	30	10	0.3	1.0	0.4	1.7
24	U. SPANISH	58	54	19	0.5	1.8	0.8	3.1
TOTALS		495	501	535	4.1	16.6	22.0	42.7

TOTAL CHANNEL MILES = 1531
TOTAL COST = $43 MILLION + 15% ADMIN AND PLANNING + 20% OPERATION AND MAINTAINCE= $58 MILLION

TOTAL CHANNEL CONSTRUCTION COSTS--------------------------------$122 MIL
TOTAL REVEGETATION AND BIOTECHNICAL COSTS-------------------$58 MIL
TOTAL ROAD COSTS---$3MIL
TOTAL $183 MIL

Table 7

SUB-WTSD NUMBER	SUB-WTSD NAME	SIZE IN ACRES	IN THE LAST 20 YEARS
13	RUSH-MILL	49,024	912
14	LIT.-GRIZZLY	94,272	1,578
15	WOLF-R. VALLEY	46,016	2,513
16	LIGHTS-COOKS	75,136	0
17	MID .-INDIAN	26,368	1,400
18	ANTELOPE LK	44,352	10
19	SQUAW QUEEN	26,112	129
20	RED CLOVER	74,752	122
21	LAST CHANCE	99,072	30,122
22	L. SPANISH	21,109	3,820
23	GREENHORN	44,695	525
24	U. SPANISH	60,976	35
TOTALS		661,884	41,166

* Note fire information in this table does not include fires under 5 acres and does not included controlled burns.