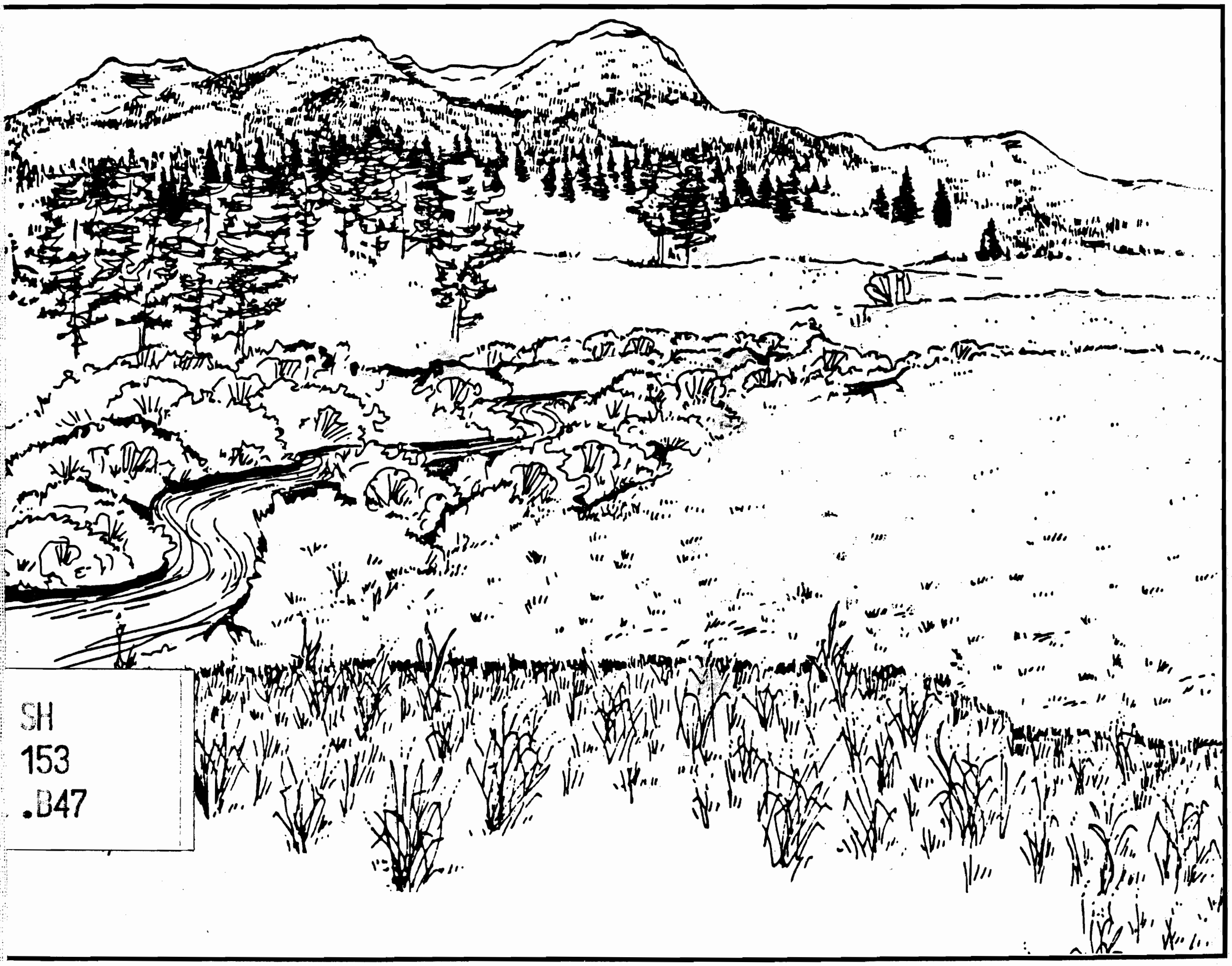
The Best Management Practices for the Management and Protection of Western Riparian Stream Ecosystems

American Fisheries Society
Western Division



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This paper is a product of 2-years' effort on the part of the Riparian Habitat Committee. It is intended to serve as a followup to the Committee's 1980 position paper entitled "Management and Protection of Western Riparian Stream Ecosystems" which presented the WDAFS concerns over issues involving the management, maintenance, and protection of western riparian stream ecosystems. A slide-tape program is being prepared to accompany this report by the Committee's Riparian Concerns/Audio-Visual Subcommittee. It is our goal to provide these management guidelines to public agencies and the private sector to aid in the understanding and management of western state riparian habitats.

The WDAFS hopes that these Best Management Practices will be used as guidance in the future by agencies, landowners, and individuals in the management and protection of our valuable and limited western riparian stream ecosystems.

Donald A. Duff

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Western Division AFS

$5.00

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FOR

THE MANAGEMENT AND PROTECTION OF WESTERN RIPARIAN STREAM ECOSYSTEMS

INTRODUCTION

A national need to address the status and condition of riparian habitat and related resources in the western United States, Alaska, Canada, and Mexico led to the 1980 publication of a Western Division, American Fisheries Society (WDAFS) position paper titled, "Management and Protection of Western Riparian Stream Ecosystems."

This position paper presented the opinion of the WDAFS on the status of impacts on, and concern for, western aquatic-riparian habitats. The paper addressed the following seven primary impacts on riparian resources:

- Livestock Grazing
- Mining
- Water Development and Irrigation
- Road Construction
- Agriculture and Urbanization
- Timber Harvest

In order to provide guidelines applicable to riparian habitat, fisheries, and water quality resources, the WDAFS has developed this present paper listing Best Management Practices (BMP's) for the seven primary impacts defined in the 1980 position paper. This paper addresses the most pertinent BMP's related to these primary impacts. From these BMP's the resource manager can develop additional BMP's to fit specific management situations.

BEST MANAGEMENT PRACTICES

Best Management Practices (BMP's) means a practice or combination of practices that is determined by a state (or designated areawide planning agency) after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality and related aquatic-riparian habitat goals (Federal Register, Vol. 40, No. 230, November 28, 1975). BMP's also refer to a broader process of identifying practices and techniques that may be used to reduce impacts on resources. It is this latter concept that is used in summarizing state-of-the-art techniques and practices.

The major emphasis in identifying BMP's was on technical adequacy of practices to reduce impacts on aquatic-riparian habitat. Limited emphasis was placed on economc and institutional acceptability.

Best Management Practices may involve single practices or combinations of practices which are selected for specific soils, climates, or problem areas. Selection of applicable BMP's should normally be made by the resource manager from appropriate suitable alternatives based on site characteristics, management objectives, and water quality requirements.

Principles used in selecting BMP's are as follows:

1. In many instances there may be several technically adequate alternatives that can be applied to minimize impacts from problem situations.

2. Exclusion of a specific use because of watershed and site conditions may be the BMP in some instances.

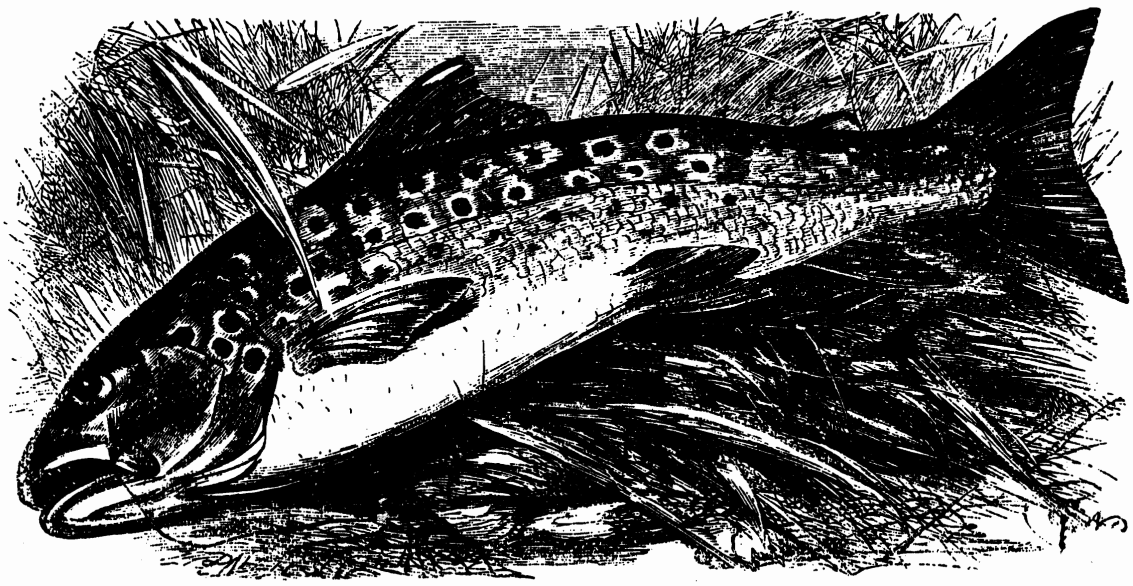
3. Selection of adequate BMP's may require the expertise of interdisciplinary resource specialists.

4. The most effective protection techniques must be based on site-specific conditions such as soils, vegetation, geology, climate, proximity to water bodies, and management objectives.

5. BMP's may prevent as well as mitigate resource problems.

6. BMP's reflect the concept that a system or combination of practices may be needed on a particular site or planning area.

7. The frequency of storm events may have an impact on the ability of BMP's to mitigate impacts. BMP's are more effective in controlling frequent storm events than in controlling the unusual storm climate events. The net effect of BMP's will be some reduction in the total volume of sediment produced, with a large reduction in the concentration during more frequent flows.



Brown Trout

LIVESTOCK GRAZING

Domestic livestock grazing is a major land use activity in the western United States and involves the actions and results of range management planning, range decisions, grazing systems, and range rehabilitation. Throughout the west there are potentials to rehabilitate aquatic-riparian habitats adversely impacted by livestock grazing. The most significant of the adverse impacts are loss of riparian vegetation and increased streambank instability and stream sedimentation.

During recent years, several laws have been passed and Executive Orders signed that address national goals to improve water quality and protect aquatic-riparian habitat. The laws and Executive Orders stress the need to properly manage aquatiac-riparian habitats, water quality, and their related fish and wildlife resources. The Clean Water Act of 1977 (Public Law 95-217) set a national goal for water quality management, to be achieved by July 1, 1983, which provides for the protection and propagation of fish, shellfish, and wildlife, and for water recreation. In order to achieve the national goal of water quality, the Clean Water Act mandates that pollution caused by runoff from agricultural and livestock activities, as well as other nonpoint sources (silviculture, mining hydromodification, etc.), be controlled in addition to the control of point sources.

Executive Orders 11988 and 11990, relating to floodplain and wetland-riparian management, respectively, also stress the need to manage, with integrity, aquatic-riparian habitats, water quality, and their related fish and wildlife resources.

There are widespread differences in the availability of resources, management technology and expertise. The differences influence the attainment of management goals. Published literature concludes that:

- Severe damage to riparian wildlife and fisheries habitat often results from livestock grazing.

- The riparian habitat is critical for the survival of many aquatic and terrestrial species inhabiting a given area.

- Fencing riparian areas from livestock grazing is capable of providing adequate protection.

- It is not economically or sociologically feasible to fence all riparian habitat on livestock grazing lands.

- To protect and enhance riparian habitat, the inventorying of riparian habitat types, and prioritization of specific streams and reaches to be protected must be accelerated.

- Streams and reaches characterized by unstable soils and a fragile but diverse vegetative community should receive urgent consideration for protection.

- Streams should initially receive protection via BMP's with followup monitoring and evaluation.

When developing and implementing livestock grazing practices the following concepts should be blended to determine the best uses of BMP's.

- Livestock graze selectively, and they tend to concentrate their grazing in riparian areas.

- Livestock tend to spend a disproportionate amount of time in and near riparian areas.

- A deteriorated range is difficult to manage for the high production of "all" resources.

- Most wildlife are dependent on aquatic-riparian areas for some or all of their needs.

- The greatest faunal and floral species diversity is associated with aquatic-riparian areas.

- There is no grazing system that will work if the stocking rate is consistently high.

- There is no set formula that will identify the type of grazing system or management that will be best for all livestock operations or allotments.

- Resource management specialists and ranchers have overlapping goals.

- Good range management will work best when users and producers work together to manage range resources.

- Good range management will benefit all users.

- A well-planned riparian management program is essential to the success of obtaining the most efficient use of the range without adversely affecting any resource use.

Allotment Management Planning

Land use plans and allotment management plans will identify the amount of vegetation necessary to provide adequate watershed protection under grazing use to ensure perpetuation of the vegetation, maintain and enhance plant vigor, and assure soil stability.

1. Ecosystem Management. Managers of aquatic-riparian ecosystems must understand the processes that regulate these ecosystems. In addition:

   - Give management priority to riparian dependent resources such as wildlife, fisheries, and vegetation.

   - Recognize that needs of riparian areas may be different than the rest of the allotment.

- Identify high priority riparian habitats for immediate attention.

- Involve fisheries and wildlife biologists and other specialists with the range specialist and the rancher in early stages of the planning process.

- Work directly with ranchers.

- Consider long-term as well as short-term benefits.

- Periodically monitored allotments to evaluate attainment of objectives.

- Maintain history of allotment management.

2. Allotment Unit Design. The allotment unit should be designed so that the design will perpetuate favorable conditions for habitat protection, water flow, and water quality. In addition:

- The allotment should be evaluated to determine the responses of other important resources to livestock grazing.

- Allotment management plans should be designed through an interdisciplinary process.

- New allotment management plans may require an Environmental Analysis Report (EAR).

- Established allotments may not require an EAR; however, allotments should be updated by an interdisciplinary team.

- Allotment management plans should be current with the present permit term.

3. Allotment Maps. The use of maps and aerial photographs in selection and design of allotment areas and grazing systems is beneficial.

- Allotments should be identified on a 1:24,000 scale map and on aerial photos.

- The following features are important and should be designated on the map or on overlays to the base vegetative map.

    a. Location of streams, riparian areas, meadows, lakes, potholes, etc., to be intensively managed.

    b. Areas occupied by any endangered, threatened, or sensitive species.

    c. Structural improvements - whether for grazing, fish, wildlife, or other resources.

    d. Stock driveways, salt licks, and livestock concentration areas.

e. Areas with potential for structural and nonstructural improvements.

Riparian Area Management

Short-term and long-term objectives for aquatic-riparian habitat should be established in all management plans.

1. Management Objectives. Agree upon streamside or lakeside management area where prescriptions will be made to minimize adverse impacts, and:

- Consider factors such as stream class, channel aspect, channel stability, sideslope steepness, slope stability, vegetative class, vegetative condition, habitat type, etc. when determining the constraints of activities and width of streamside management areas.

- Evaluate fisheries and aquatiac-riparian habitat condition and response to grazing activities when determining the need for and width of the streamside management areas.

2. Grazing Management Practices. The following specific practices should be considered for use within grazing systems to manage aquatic-riparian systems. These practices, combined with varying resource management needs, make it difficult to apply uniform guidelines, specific guidelines should be established as the minimum acceptable.

- Place salt blocks at least 1/4 mile away from riparian areas. Salt and supplemental feeding sites should be located away from ephemeral drainages in order to minimize disturbance that could cause sedimentation of adjacent stream areas. These sites can be moved about to avoid excessive trampling and can be a means of encouraging better grazing distribution.

- Develop offsite watering facilities or structures to prevent concentrations of animals along streambanks.

- Developed watersites should be placed on slopes less than eight percent.

- If a riparian area is used for a watering site, select the least sensitive site. Usually rocky sites are least sensitive. Water gaps should be kept small (in length along the stream).

  a. Keep bedding areas and corrals out of riparian areas.

  b. Do not route stock driveways along riparian areas.

  c. Do not establish "feed lots" within riparian areas.

  d. Overgrazing should not be allowed in riparian areas.

  e. Use of herbicides and pesticides in and near riparian areas should be carefully controlled and label directions followed.

3. <u>Grazing Systems</u>. Grazing systems should be established to maintain or enhance fish, wildlife, and vegetative species. Some considerations which would be useful in developing and implementing specific grazing systems based on the resources present are:

- Individual life cycles of riparian-dependent plant and animal species should be identified and livestock managed to maintain these fauna and flora.

- Habitat conversion within riparian areas should be done to meet the needs of riparian dependent resources.

- Riparian areas should not be drained, filled, or partially eliminated.

- Forage for livestock consumption should be available only after plant growth requirements have been met. Timing of grazing use as well as plant phenological needs should be considered.

- The maximum rate of stocking or percent utilization of a key forage species should be low enough to provide a margin of safety during years when forage production is below average.

- Grazing use periods and strategies should be established to meet the needs of all resources. Periodic rest or non-use periods should be implemented when riparian habitats do not show signs of adequate recovery to meet stated resource objectives.

- Habitat conversion activities should be timed to have the least adverse impact on wildlife and fisheries.

- Exposed or raw streambanks or riparian areas should be revegetated immediately.

- Habitat conversion in riparian areas should not take place if wildlife and fisheries will be adversely affected.

- Stock ponds should be adequately designed and constructed to enhance aquatic resources, if appropriate. An interdisciplinary team should design ponds.

- Stock driveways should be located away from riparian areas. In cases where livestock traveling through riparian areas can not be avoided, consideration should be given to minimize traveling impacts on stream environment (i.e., renovation of crossings or constructing stock bridges).

- In cases where the riparian zone has been fenced, water sources for livestock should be developed away from riparian areas rather than installing water gaps along the stream. In cases where water gaps are necessary, revetment of the streambanks with rocks or logs will help to reduce impacts to aquatic resources.

- Riparian pastures should be considered in allotments with perennial streams and grazing intensities designed to maintain all riparian dependent resources.

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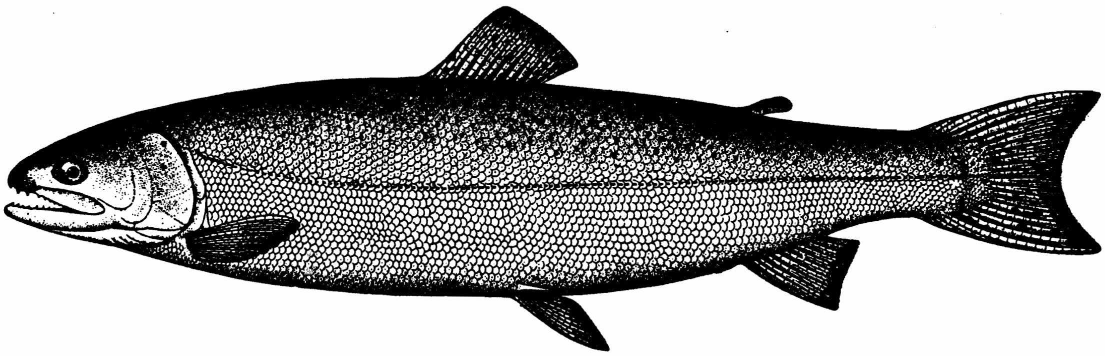

Rainbow Trout

MINING

Mining for important minerals has and will continue to be one of the major economic activities in the western states. Mining operations have often been associated with and responsible for degradation of the aquatic resource. Aquatic biota may be impacted directly through physical injury or indirectly through destruction of vital habitat. Because the elimination or alteration of habitat creates long-term impacts to the aquatic biota, habitat maintenance and restoration must be given primary consideration during mining activities. Of particular concern in this respect is the riparian zone which, in itself is valuable aquatic habitat (e.g., cover for fish, shading etc.). The aquatic ecosystem is also the final line of defense for reducing the impacts of land activities on the aquatic environment.

Although there are many different methods of mining (e.g., strip mining, open pit mining, dredge mining, hydraulic mining, underground mining), mining related impacts on riparian habitat and the aquatic ecosystem can, in general, be divided into physical impacts and chemical impacts. Examples of physical degradation which may occur as a result of mining include the following:

- Removal of riparian vegetation and instream cover associated with stream channelization, road construction, culvert and bridge installation, direct mining activity, and tailing deposition.

- Increased rates of stream sedimentation resulting from vegetation removal, road and mine construction, tailing deposition, stream channelization and dredging, and erosion from overburden.

- Flooding of riparian areas for the construction of tailing pond or water storage reservoir.

- Reduction of stream flows associated with decreases in ground water level or water diversions.

- Entrainment and/or impingement of aquatic organisms due to water diversion facilities and dredge mining activities.

Chemically related impacts associated with mining activity generally affects the aquatic organisms directly without necessarily degrading physical habitat. Examples of chemical degradation to the aquatic environment include the following:

- Introduction of toxic materials utilized in mining operations (e.g., petroleum projects, flocculants, dispersants, frothers, etc).

  a. Thermal shock to aquatic organisms associated with the release of processing water.

  b. Release of acid mine waste into aquatic systems, thereby resulting in precipitation of ferric hydroxide and heavy metals.

  c. Reduction in dissolved oxygen from organic enrichment (e.g., sewage effluent).

d. Increased turbidity and suspended solids due to removal of ground cover.

Chemical impacts can directly affect aquatic biota without necessarily affecting the riparian zone, BMP's are also presented to product guidance for controlling water pollution.

Although every mining operation will to some degree affect terrestrial and aquatic ecosystems, the extent of impact can be minimized through effective mine planning. Proper consideration for and protection of aquatic and riparian habitats can be achieved through utilization of management practices before, during and after mining activity (Martin and Platts 1981). The following Best Management Practices (BMP's) are designed to mitigate and/or eliminate mining related impacts on these important habitats.

Environmental Regulation

Adhere to environmental regulations designed to decrease or eliminate significant mine impacts. In the forefront of regulations is the National Environmental Policy Act (NEPA) of 1969.

Environmental analysis of existing aquatic and riparian areas in proximity to the proposed mine should commence at the earliest possible time in situations where NEPA does not apply (USFS 1977).

Consider use of the Surface Mining Control and Reclamation Act of 1977, the Clean Water Act of 1977, the Federal Water Pollution Control Act of 1972, regulations by the Army Corps of Engineers (e.g., 404 permits), as well as various state regulations which serve to reduce potential mine related impacts before they occur.

Mine Operation Plan

Develop a mine operation plan document by which a mineral operator identifies himself, describes the work he intends to do, where and when he intends to do it, the nature of his proposed disturbance of surface resources, and the steps he will take to protect these resources (USFS 1975).

a. Address potential impacts and offer solutions before the problems occur. Early identification can be cost effective for a mining company.

Buffer Zone

Provide a riparian buffer zone between the stream or lake and the development. A riparian buffer zone is essentially an undisturbed area containing native vegetation which protects the aquatic environment by providing shade to prevent elevated stream temperatures; filtering out sediment and silt before it reaches the system; and providing soil stabilization to prevent bank sloughing.

a. All mining operations should provide some type of buffer zone between overburden deposits, tailings, and other surface disturbance, and streams and lakes.

b. Buffer zones of 75 feet on each side of a stream are recommended (Idaho State Board of Land Commissioners 1976), however, the necessary width to insure protection will vary with the steepness of terrain, the nature of the undercover, the kind of soil and type of mining activity.

c. Sediment and erosion abatement practices (e.g., rip rapping, gabions) should be employed if buffer zones cannot be established along a stream.

d. If streamside disturbance occurs revegetation should begin at the earliest possible time to restore natural streamside protection and prevent erosion.

Tailing Pond Construction

Tailing ponds should be used to settle out the finely-ground rock from which most of the mineral or ore has been removed. In many instances, tailings have excessive amounts of heavy metals and dissolved salts and are void of organic matter. Iron pyrite is one of the major constituents of mine tailings, and oxidation of this material can lower water pH as low as 3.

Tailing ponds should include features to prevent the accidental release of toxic materials which may adversely affect viable aquatic ecosystems. The following design practices for tailing pond construction, restated from Andrews (1976), provides important guidance for the protection of downstream aquatic systems.

a. Cross Section Dam Design. The dam should have a minimum freeboard of five feet below the inside crest. The downstream crest of any dam or embankment should be higher than the upstream crest in order to force all crest drainage to the storage of the dam.

b. Seepage Control. The pond design should provide seepage control features (e.g., cut-off trench in natural soil foundations; an impermeable clay core and/or blanket; chimney drain; and toe drain).

c. Water Level Control Structures. Sufficient water level control structures should be used in the waste storage area behind a dam to maintain a minimum five foot freeboard, and to accommodate the release of storm water resulting from heavy rainfall and/or snowmelt. All structures should be able to accommodate the runoff resulting from the maximum probable runoff event including runoff from heavy primed snowpack conditions. All waste facilities using mechanical or electrical water level control device as the primary system should have as back-up, a non-mechanical system such as a spillway or decant riser or drain.

d. Diversion Structures. Diversion structures should be used upstream of waste storage areas to prevent runoff resulting from the maximum probable storm from entering the waste storage area. Such diversions should be designed to properly release water to natural drainages in order to prevent erosion or failure of their channels and berms. This may necessitate using velocity breakers.

e. Catchment Basin. A catchment pond of sufficient size should be constructed downstream from the tailings pond to collect all seepage water and tailings which have eroded or leaked from the dam (USFS 1977). Such collected water must either be pumped back into the tailing impoundment or recycled through the mill, or discharged in accordance with the limitations of a valid NPDES discharge permit (Soderby and Busch 1977).

f. Fencing of Tailing Ponds. Ponds should be fenced and/or covered to minimize such losses because many tailing ponds contain water sufficiently toxic to cause direct mortality to waterfowl and mammals (Streeter et. al 1979).

Channelization

In some cases, channelization of stream sections may be necessary to reroute a stream away from major mining activities, road construction, culvert installation, water diversion, etc. Dredge mining activity is in essence a type of stream channelization. Channelization of any section of stream generally results in the complete elimination of riparian and aquatic habitat in that section. The deleterious effects on the aquatic environment associated with this loss can, however, be lessened by adopting the following management practices.

- Channelization activity should be conducted during periods of low flow to minimize erosional activity within the stream channel. All channel work should be completed as quickly as possible and finished before spring runoff.

- Channelization design should incorporate means to stabilize stream banks including rip rapping, revegetation and reducing bank slopes. In steep terrain it may be necessary to concrete line or riprap stream banks to prevent erosional activity. In streams containing a viable fishery, habitat improvement structures (e.g., wing deflectors, check dams, boulders, etc.) should be considered for the newly channelized reach (Nelson et. al 1978). Modification which results in the widening of the stream channel, should include provisions for resident fish cover and a low flow channel to facilitate fish movement during periods of baseflow.

Culvert Installation

Culverts may be needed in mining operations to provide for drainage portals across roads and stream crossings (USFS 1980, 1981).

Proper culvert installation, where a viable fishery exists, is needed to minimize downstream impacts and provide for fish migration. A general summary of culvert installation procedures are presented in BMP's discussion for road construction on page 32.

Instream Flows

Mining companies should evaluate the potential impacts of their proposed water withdrawal on the aquatic and riparian ecosystem and provide for the instream flows necessary for these resources for streams which contain viable fisheries. Mining and milling operations typically consumptively use water for their operations. Appropriation of water reduces the instream availability of water and can adversely affect both riparian and aquatic communities.

Overburden Segregation

Segregation or separation of mine overburden may be warranted when a potentially phytotoxic material is present. Such materials can limit revegation of reclaimed areas and should be separated from the overburden materials (Ellison 1976).

- Scrapers are probably the most efficient means for segregating overburden materials.

- Toxic material can be disposed of by placing a layer of clean fill within a strip cut, followed by placement of pollution material and fill material. The depth to which the toxic material should be buried is dependent on its toxicity. Regulations may dictate that materials be buried up to 8 feet deep (Ellison 1976). If ground water contamination by toxic materials is a possibility, a non-permeable layer of material should first be placed into the strip cut.

- The segregation of topsoil from other overburden materials should be done in all strip mining operations to facilitate later revegetation of reclaimed areas.

Mine Wastewater Control

Mine and mill operations often result in the contamination of ground or surface water with toxic materials, heavy metals, etc. To prevent water quality degradation of surface waters, the following management practices, taken from Nelson et. al (1977), should be used where appropriate.

- Discharge Reuse. Water generated during mining operations can be collected in a settling pond or clarifier and returned to the milling operation for reuse. This is essentially a closed circuit system which prevents discharge of toxic mine waters into productive aquatic areas.

- Evaporation Pond. Water generated from a mine can also be collected in evaporation ponds. Thereby, all water is evaporated, eliminating the need to discharge mine waste waters. It may be advantageous to use a clay liner in the collection pond to absorb pollutant-forming chemicals.

- Irrigation. A potentially productive use of excess mine water is for irrigation of mine reclamation areas for the promotion of vegetation.

The water, however, must not be toxic or contain excessive amounts of sodium or soluble salts which may cause long-term soil degradation. Two irrigation methods which lend themselves to reclamation are sprinkler and drip irrigation (DeRemer and Back 1977).

- Underground Injection. Waters which contain highly toxic materials can be injected into underground reservoirs for containment. This is accomplished by boring vertical holes into permeable zones and injecting the waste water by gravity feed or pumping. Detailed studies of the underground geology are warranted to insure that percolation of materials into surface or other ground water does not occur. A permit is required from the Environmental Protection Agency (EPA) to do this.

- Flooding. When underground mines are abandoned, it may be possible to flood them thereby preventing further discharge of toxic materials. Inundation prevents oxidation of pollution-forming minerals. Mine sealing should be done with extreme care, as excessive water pressures can build up, causing seal or outcrop failure. This may result in the sudden release of waste water which can have devastating effects to aquatic and riparian habitats. Detailed geologic and ground water studies are needed.

- Water Infiltration Control. This is a preventative practice designed to reduce the amount of water entering a mine in order to reduce the amount of mine wastewater. Measures include:

  a. Modifying (increasing) surface runoff by eliminating depression areas and grading the area overlying the mine.

  b. Sealing fractures and holes that act as water conduits.

  c. Interception of underground waters by pumps to prevent it from entering the mine.

Mine Wastewater Treatment

Mine wastewater may be sufficiently toxic or degraded to warrant special treatment. The following list, taken from Nelson et. al (1977), presents some of the more commonly used techniques for treating mine wastewater.

- Sludge disposal

- Evaporation processes

- Reverse osmosis

- Electrodialysis

- Ion-exchange process (Lectroclear)

- Freezing and crystallization

- Iron oxidation

Revegetation Practices

Revegetation of mine disturbed areas, including the overburden, tailings deposits and transportation corridors can be one of the most effective pollution control measures to insure the integrity of riparian zones and protection of aquatic resources. Revegetation offers aesthetic improvement and if done properly will return the land to other beneficial uses. A variety of revegetation techniques may be needed to successfully revegetate mine disturbed land. Excellent summary and discussion of these methods are presented in Thames (1977) and Vories (1977) as well as in agency handbooks.

- Topsoil Replacement.

  a. Original topsoil which was removed prior to mining would provide the best chance for revegetation of distured areas with native vegetation. In areas with inadequate topsoil, however, it may be necessary to supplement soil from other areas.

  b. Topsoil stockpiles should be stabilized to prevent erosion (Nelson et. al 1977) and sedimentation of adjacent aquatic systems.

- Soil Preparation. The following soil preparation techniques are designed to increase moisture availability to new vegetation by reducing runoff and increasing infiltration.

  a. Mulching. Mulching with various materials increases soil moisture availability by impeding runoff, lowering soil temperatures, reducing evaporation, and minimizing raindrop splash, surface puddling and sealing.

  b. Deep Chiseling. Deep chiseling of soils loosens compacted soils to a depth of 6-8 inches. The process creates a series of parallel surface furrows along the contour of the reclaimed area which effectively impede water flow and increases infiltration rate. Chiseling forms a cloddy seedbed which creates ideal conditions to receive broadcast native species seed mixes (Hodder 1977).

  c. Off-set Listering. Off-set listering is a surface configuration consisting of alternately arranged elongated depressions approximately 6 inches deep and 4 feet long. The method is especially effective in reducing saltation and impeding runoff.

  d. Gouging. Gouging consists of a series of depressions approximately 10 inches deep, 18 inches wide and 25 inches long. The method is useful in both gradually sloping and flat areas to conserve runoff from moderate intensity storms and in causing differential melting of snow in the winter, thereby retaining moisture longer on the reclamation area.

  e. Dozer Basins. Dozer basins are large depressions, usually 2 feet deep and 15 feet long which increase water retention capacity thereby increasing soil moisture availability for the establishment of new vegetation.

- Soil Moisture Availability. There are many revegetation techniques which increases the amount of moisture available for germination and initial growth state, such as:

  a. Snow Fences. Snow fences properly installed in the reclaimed area can successfully increase moisture accumulation. Snow fencing, however, is expensive and often difficult to remove or relocate from a site.

  b. Sprinkler Irrigation. Sprinkler systems have the advantages of giving full area coverage, and they are durable and are easily portable (DeRemer and Back 1977). Sprinkler irrigation is not well suited on sloping ground since application rates generally exceed infiltration rates. The decision to use supplemental water should depend upon the availability and cost of water and more important, be evaluated with the possibility of failure of establishing adequate plant cover when supplemental watering is discontinued.

  c. Drip Irrigation. Drip irrigation involves delivering water slowly over a long period of time to maintain optimum moisture levels. Generally, drip irrigation is less expensive and requires less water to achieve the same results as sprinkler or furrow irrigation. Fertilizers and/or pesticides can be easily applied by the system. This method has proven very effective in establishing riparian vegetation along the lower Colorado River (Anderson 1979).

  d. Water Harvesting. Water harvesting involves placing a water repellent material around seedlings which serves to increase availability of moisture to the plants. Paraffin, black polyethylene and silicon spray emulsion have all been successfully used in water harvesting (Aldon and Springfield 1977). Paraffin melts into the soil to form a water repellent covering.

- Hydroseeding and Erosion control Chemicals. The following practices can be used for controlling erosion and assisting in the reestablishment of plants (Kay 1977):

  a. Hydroseeding. Hydroseeding involves the application of a slurry of seed and water to reclaimed areas. Fertilizer and wood fiber (hydromulch) can also be applied with the slurry. Wood fiber contained in the hydromulch slurry holds the seed and fertilizer in postion and is a very good technique for applying seed and fertilizers to steep areas. On gentle slopes the fiber also provides protection against erosion until vegetation is established.

  b. Fibers. Fiber mulch covering is very effective in holding seeds in place. For example, one excellent product commercially known as Silvafiber[1] consists of a wood fiber which is applied at 1,000 to 3,000 lbs./acre with the seed and fertilizer in a water slurry. This material will stick in place on near vertical surfaces for extended

[1] The use of specific product names does not imply an endorsement by the American Fisheries Society or any of its divisions or sections.

periods. In addition, Silvafiber contains a green dye to help monitor applications and provide a pleasing appearance.

c. Plastic Emulsions. Plastic emulsions form a crust over exposed areas which is very useful for erosion and dust control. Commercially available products include polyvinyl acetate (PVA) (Aerospray 70, Crust 500 and Soil Bone) or co-polymer (PVA plus acrylics). These products are most effective in intermediate stages of construction or where plant materials are not desired.

d. Straw and Tackifiers. Straw can be used as a mulch for stabilizing soil, encouraging seed germination, and speeding plant growth; however, because it is light in weight, straw should be incorporated into the soil, or held down with a net or by a sprayed chemical tackifier.

- Tailing Reclamation. Tailings are the finely ground rock slurry from which minerals have been extracted. Because of the small size of tailings, they can be easily eroded. Therefore, stabilization and reclamation of tailings is important to prevent sedimentation problems to aquatic systems. The following techniques can be used for the stabilization of tailing slopes:

  a. Preparation of a smooth, loose seedbed for planting accomplished by dragging a "Klodbuster" over the tailing slopes, filling in the smaller erosion crevices and smoothing rills.

  b. Application of barley straw to insulate against heat and cold, to provide organic matter through decomposition and to protect the slope against rainfall impact.

  c. Application of sewage effluent and composted manure for soil conditioner and micronutrient supply.

  d. Use of hydroseeding (as previously described).

- Mine Pond Reclamation. Mine pond reclamation should be considered an important alternative in reclaiming mine disturbed lands. Mining activity often results in the construction of ponds or lakes for water storage. After mining activities are terminated, these lakes offer a potential (depending on water quality) for the establishment of a viable aquatic ecosystem. Ponds left behind by mining operations in the past are, however, generally deep, U-shaped, and have very steep sides with little or no shallow littoral zone.

  a. When converting a mine pond into a viable aquatic ecosystem, consideration should be given to the establishment of a productive littoral zone. According to Joseph (1977), most existing mine ponds can be improved by contouring the shore, thereby reducing the steepness and providing a shallow, productive habitat. In most cases, mine ponds are deep enough to accept the overburden removed from the shore.

b. Once littoral zones are created, emergent aquatic macrophytes (e.g., Scirpus sp., Carex sp.) should be introduced into the new areas. Submergent vegetation will colonize the areas naturally. Ponds should be allowed to stabilize for 1-3 years prior to fish stocking to allow benthic macroinvertebrate colonization. It may be advantageous to artifically fertilize the pond (commercial fertilzer) in situations where mine water contains little organic nutrients for primary productivity. Evaluation of water quality should precede any addition of exogenous material.

c. Many of the above steps (e.g., 1-3 year stabilization period) could be eliminated by incorporating littoral zone design into the original construction of the pond. If this is the case, upon cessation of mining activity, it may only be necessary to stock the ponds with fish to complete the establishment of a new aquatic ecosystem.

Suction Dredging

Placer gold, removed from lode veins by geologic processes, has been transported by runoff into streams, where it eventually settles deep into the substrate. Suction dredging is one technique used to recover such gold from below the wetted perimeter of a stream. Recent increases in gold prices triggered a proliferation of suction dredges, and although a softening in gold prices has resulted in a drop in the current level of activity by hobbyists, large-scale dredges continue to be common in the western United States and Canada.

Aquatic communities may be directly or indirectly impacted in a number of ways by suction dredge operation (Washington Departments of Game and Fisheries 1980), and the magnitude and consequences of such impacts have not been thoroughly evaluated. Because of this, a conservative approach should be taken to the regulation of suction dredging until more extensive studies have been completed. In addition, no dredging should be permitted unless an effective level of monitoring and enforcement can be maintained by regulatory agencies.

- Stream Closures. Studies on trout have shown high mortality of eggs and newly emerged fry after dredge passage (Griffith and Andrews 1981). Areas inhabited by fish should be closed to dredging from the time spawning of each species begins until the time the fry are free swimming. Depending on the species present in the area, the duration of closure may range from a month to the entire year, and such determinations should be made by professional fishery biologists. No preliminary "prospecting" with mechanized equipment should be permitted during closure periods.

- Categories of Dredges. For regulatory purposes, a distinction should be made between small "recreation" dredges used by hobbyists for a few days annually and large machines operated continuously for long periods. This distinction should be made on the basis of intake size, engine horse-power and/or actual dredge performance. Manufacturer's capacity ratings are too inflated to be realistic, but actual performance cannot be easily measured by a regulatory agency. Intake size is the logical criterion, and under no circumstances should 6 inch or larger dredges be classed as "recreational."

Operators of the larger dredges should be required to file an operating plan with the regulatory agency, post a reasonable bond, and pay for the cost of periodic inspection of their operation.

- Zoning to Restrict Dredge Size. Since dredge capacity quadruples as intake diameter doubles, large dredges have the potential to severely alter small streams. Each drainage open to dredging should be zoned to limit dredge size on smaller waters. This should be done on a site-specific basis to take into account biological and physical differences between areas. For example, in basin X no dredges larger than 5 inches might be allowed in forth-order or smaller streams, and none larger than 3 inches might be allowed in second-order or smaller streams.

- Frequency of Dredging. Athough a single pass through an area of stream may not result in high mortality of the aquatic invertebrates entrained through the dredge, recolonization of that area may take at least one month and in some cases considerably longer. To retain productivity, the frequency of dredging of any portion of a stream should be regulated, with a minimum of one year being allowed to elapse before redredging is considered. In order to implement this, blanket area-wide "recreational" permits should not be valid in popular drainages; instead, a limited number of first-come, first served permits should be allocated.

- Dredge Operation.

  a. Streambanks should not be excavated or washed.

  b. Pits created by dredging should be filled in at the conclusion of each day's operation to prevent them from acting as traps for fish.

  c. Materials too large to be moved by hand (boulders, logs, etc.) should not be disturbed.

  d. Fuel or lubricants should not be allowed to enter the stream.

Priority should be placed on developing and using dredges that dispose of fine sediments on the stream bank rather than returning them to the stream. If this is accomplished the impact of suction dredging will be substantially reduced and may, in fact, provide a net benefit in some areas.

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Brook Trout

WATER DEVELOPMENT AND IRRIGATION

A wide range of structural methods have been developed over time to minimize harm to lives and property from flood hazards. Recently non-structural methods directed toward minimizing harm to floodplain resources have received increased attention. The following Best Management Practices (BMP's) emphasize non-structural methods; however, structural methods are also described with a view toward lessening their impacts on aquatic and riparian habitats. Many of these BMP's are also applicable for hydroelectric and water supply projects.

Flood Control (Nonstructural)

Basic non-structural floodplain management strategies for preventing loss of natural floodplain values and reducing the need for costly structural flood control measures are: avoid and/or minimize actions that affect adversely the floodplain, restoration of previously degraded floodplains to serve their natural functions, and preservation of those floodplains whose natural functions are relatively undisturbed (Water Resource Council, 1979).

- Floodplain Regulations. By providing direction to growth and change, regulations are particularly well suited to preventing unwise floodplain occupancy.

    a. Regulations must be equitably applied and should permit reasonable use of the land.

    b. Non-conforming uses can be handled by recognition in an ordinance, by amortization provisions that lead to removal over a predetermined period, or by purchase.

- Land Treatment Measures. Land treatment measures modify floods by temporarily storing runoff and gradually releasing it at a rate that downstream channels can accommodate. These measures include vegetative cover, runoff interceptors, diversions, small detention and erosion control structures, terraces, and street-side swales.

    a. These measures are effective in headwater areas and can help ameliorate flooding in larger watersheds.

    b. These measures are very important in the control of non-point sources of water pollution.

- Floodproofing. Floodproofing involves structural modifications of existing flood plain structures to reduce flood damages and the need for flood control structures (as dams, levees, dikes).

    a. Structural modifications can include elevating buildings, reinforcing foundations, installing small protective dikes and bulkheads, and anchoring buildlings to resist flotation and lateral movement.

b. Floodproofing may, however, undercut attempts to preserve natural floodplain values and can encourage a false sense of technological protection by floodplain owners (New England River Basin Commission, 1976).

- Acquisition and Relocation of Structures. Acquisition and purchase of land rights and open space easements lessen the potential for flood losses and their consequences.

  a. Land can be purchased directly, or land control can be purchased through easement or development rights in order to preclude future uses incompatible with floodplain management programs and to provide open space.

  b. Disaster assistance, urban redevelopment, as well as flood insurance programs should also be used to encourage relocation of structures and facilities away from floodplain areas.

Flood Control (Structural)

Structural means of flood control (dams, dikes, levees, floodwalls, channel alterations and high flow diversions) should be a last resort and used only when it is clearly demonstrated in the public interest to protect human life, health, safety, or welfare. In addition, streams should not be modified to provide for farming of lands that are subject to frequent flooding.

The following guidelines help reduce impacts to aquatic and riparian habitats resulting from structural flood control projects. (Recognize that any alteration of the stream channel or water regime has traumatic consequences upon floodplain ecosystems.)

- High Flow Floodways. Where structural means of flood control is the only alternative, first consideration should be given to the following:

  a. Implementation of high-flow floodways, through non-riparian vegetation, that would bypass only the highest floodflows.

  b. Floodway entrances should be designed to maintain normal and minimum flows in the natural channel.

- Levees. The following structures, if properly planned, can preserve natural floodplain values and provide flood protection at the same time.

  a. Levees should be placed beyond the outer perimeter of the riparian zone and constructed in a manner not to impede ingress and egress of water to wetlands.

  b. Flushing flows should also be provided to obviate channel aggradition and encroachment of vegetation into the low flow channel and also to help maintain a diverse riparian plant community throughout the floodplain.

- Clearing and Snagging. This practice is one of the least damaging techniques for restoring original stream flow capacity. The federal Fish and Wildlife Service, Soil Conservation Service, and various state agencies have established management guidelines to mitigate impacts to aquatic and riparian habitats due to stream alteration. These guidelines include:

  a. Selective removal of log jams.

  b. Removal of hazardous trees (trees leaning over the channnel at an angle greater than 30 degrees).

  c. Removal of major debris accumulations that are obstructing flows to a degree that results in significant ponding or sediment deposition.

  d. Removal of stream blockages, first consideration should be given to the use of hand operated equipment.

  e. Water-based equipment should also be used if appropriate.

  f. In all cases, use the smallest feasible equipment that minimizes disturbance to floodplain vegetation (McConnell, 1980).

- Channel Alteration. Stream alteration should be limited to restoration of original stream flow capacity, in a manner which preserves the existing channel alignment.

  a. Stream alteration should be restricted to channel deepening, but not to widening or straightening. Maintaining the original alignment and width helps to sustain the self-cleaning action of the stream, while at the same time preserving important habitat for fish and wildlife.

  b. Access routes for equipment should be selected to minimize disturbance to riparian vegetation and should be limited to one side of the stream.

  c. Excavated materials should be removed from the floodplain.

  d. Spoil should be placed on the highest practical elevation and no material should be placed in wetlands if floodplain disposal is the only feasible alternative.

  e. Spoil piles should not exceed 50 feet in length or width and a gap of equal or greater length should be left between adjacent spoil piles.

  f. The placement of soil around the bases of mature trees should also be avoided.

  g. All disturbed areas should be reseeded or replanted with plant species which will stabilize soils and benefit wildlife.

- Dams and Reservoirs. Reservoir storage of floodwater or waters for agricultural, industrial, and municipal use can have a broad range of effects on riparian and aquatic ecosystems. In addition to the large areas of land they inundate, reservoirs also modify downstream behavior and habitat. In most cases, dams seriously change streamflow regime by reducing the depth and duration of downstream flooding. Overbank flooding with sediment and nutrient deposition are essential for establishment, maintenance, and regeneration of riparian plant species (WDAFS, 1980). Instream flows also may be reduced below those required to maintain riparian and aquatic habitats. Sediment-free water released from these structures is highly erosive and can cause bank erosion and channel degradation (downcutting) as it acquires a new load of sediment. This, plus impedance of ground-water flows by dam foundations, can result in lowering of the water table and may lead to the replacement of riparian plant species by terrestrial species (McNatt, 1980).

  a. Stage or incremental filling is a management option which can be used when the immediate need for impounded water is less than available storage or initial demands. This practice delays the ultimate loss of stream and riparian habitat, resulting in extended public and wildlife use.

    1. The reservoir sport fishery production will be sustained at a high level over a greater period of time with a gradual inundation of vegetation and nutrients.

  b. The purpose of multi-level intakes is to permit selection of discharge water from various reservoir strata.

    1. Multi-level intakes aid in the control of downstream water quality such as temperature, dissolved gases, and dissolved solids.

    2. Multi-level intakes also can be designed to release sediment and nutrient-enriched water for the preservation and enhancement of downstream riparian and wetland habitats. This, however, should be done with extreme care in order to prevent damage to downstream fishery due to siltation of gravel beds and high stream turbidition.

  c. Reregulating dams, where they are feasible, allow upstream hydroelectric dams to achieve full power production while downstream riparian and aquatic habitats benefit from stabilized flows. The cost of these structures can be a limiting factor as can the location of sites that will not impact important fish and wildlife habitat.

  d. Stilling basins are an accepted feature for dissipating high energy forces of water released from dams. When properly designed stilling basins:

    1. Are an effective means of preventing downstream scouring and erosion, thereby reducing turbidity and silting of spawning gravel.

2. Reduce scouring thus preventing channel degradation and consequent dewatering of downstream water tables that maintain riparian vegetation.

- Instream Flow Regulation. Instream flow regulation is probably the most important prerequisite for the maintenance and preservation of aquatic and riparian habitats. Maintenance flows are designed to maintain a satisfactory combination of spawning, resting, and food-production areas for fish. A number of methods have been developed to determine instream flow requirements for fish and wildlife. For the most up-to-date information on instream flow methodologies contact the Fish and Wildlife Service, Western Energy and Land Use Team, Cooperative Instream Flow Service Group, Fort Collins, Colorado. Other agencies, such as the USDA Forest Service Intermountain and Rocky Mountain Regions, and the United States Department of the Interior, Bureau of Reclamation have adopted specific methodologies to evaluate instream flow conditions to aquatic habitat and hydrological parameters. Although frequently receiving less emphasis, instream flows have a significant effect on groundwater recharge and the riparian plant community. Reduction in both surface water and groundwater will influence riparian vegetation, and can result in the complete destruction of a riparian community.

Western state water laws and administrative regulations frequently place severe limitations on water allocations for aquatic and wildlife resources. In many states, instream flow reservations for maintenance of fish and wildlife values can not be appropriated or reserved. Another major constraint on reserving instream flows for aquatic and riparian preservation is the resulting loss of reservoir storage capacity and yield for irrigation, power production, and water supply. An excellent summary of strategies for achieving minimum instream flows has been developed by Solomon and Horak (1979) and are summarized in Table I.

Table 1 - Evaluation Matrix

Strategies	AZ	CA	CO	ID	MT	NV	NM	ND	OR	SD	UT	WA	WY
APPROPRIATIVE WATER RIGHTS													
State Condemnation/Reallocation of Water Rights	N/A	N/A	N/A	3	3	N/A	N/A	3	3	3	N/A	3	N/A
State appropriation of Instream Flows	3	N/A	1	1	3	N/A	N/A	2	2	2	N/A	1	3
State Moratorium on New Appropriations	N/A	N/A	N/A	3	3	N/A	N/A	3	3	2	3	2	N/A
State Discretionary Water Permit Authority	3	1	N/A	2	2	2	3	3	1	2	3	1	3
LEGISLATIVE/ADMINISTRATIVE CONTROLS													
Federal Reauthorization of Projects	2	2	3	3	3	3	3	3	2	3	3	2	2
State-Federal Wild and Scenic Rivers Systems	3	2	2	1	2	3	3	3	2	2	2	2	2
State Definition of Navigable Waters	N/A	3	N/A	3	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A	N/A
State-Federal Interagency Consultation	3	3	3	3	3	3	3	3	3	3	3	3	3
Federal License and Permit Stipulations	3	1	1	2	2	3	3	2	1	2	3	2	2
State Allocation of Reservoir Space	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
State Purchase and Lease of Water Rights	2	3	1	3	2	3	3	3	2	2	2	2	3
WATER RESOURCE PLANNING													
Federal WRC Planning Programs	3	3	2	2	3	3	2	3	3	2	2	2	3
Federal Aid Funding to Purchase Storage	2	3	1	2	3	3	3	3	2	3	2	3	3
Federal Reservoir Construction/Enlargement	3	3	3	2	3	3	3	3	3	3	3	2	3
WATER RESOURCE MANAGEMENT													
State Water Rights Records Analyzed	2	3	2	3	3	3	2	3	2	2	2	2	3
State-Federal Flow Requests Made Early	2	1	1	1	1	2	2	2	1	2	2	1	1
State-Federal Flow Requests Made Specific	2	2	2	3	2	2	3	3	1	3	3	2	3
State-Federal Combined Storage/Flow Requests	3	3	2	2	3	3	3	2	2	2	2	2	3
ENGINEERING ALTERNATIVES													
Coordinated Multireservoir Operations	3	1	3	2	3	2	3	2	1	2	2	2	3
Reservoir Sediment Storage Releases	3	3	2	3	3	3	3	2	3	3	3	3	3
Stream Channels to Convey Stored Water	2	3	3	3	3	3	2	3	3	3	3	2	2

1 - high utility and/or potential
2 - moderate utility and/or potential
3 - low utility and/or potential
N/A - not applicable to this State

Ref: Solomon and Horak 1979

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ROAD CONSTRUCTION

Roads constructed in or adjacent to riparian zones have high potential for altering the stream channel and disturbing the vegetative complex resulting in long-term negative effects on fish and wildlife populations. The detrimental effects of roads and road construction are; removal of riparian vegetation, increased sediment load to streams, and alteration of the physical stream channel.

Destruction of riparian vegetation eliminates one of the most diverse and productive wildlife habitats known. Vegetation loss on streambanks often results in bank erosion and subsequent channel widening, reduces stream shading which in turn increases stream temperatures, and reduces insect and leaf litter drop, the primary food base for aquatic life.

Sediment load will depress stream productivity by eliminating micro-habitat for fish and aquatic invertebrates, preventing spawning of adult fish by covering and embedding stream gravels, and smothering developing eggs and juveniles.

The alteration of the natural stream channel canals results in the loss of pools, meanders, undercut banks and riffles that provide food, cover, and shelter for fish and other aquatic life.

Roads and road construction impacts on riparian areas can be avoided through careful preconstruction planning, special precautions practiced during road construction, and an adhered-to road maintenance program.

The following is a list of BMP's designed to protect the riparian zone values during; road planning, construction, and maintenance. BMP's have been extracted from a variety of technical reports listed in the reference section.

Road Planning and Design

- The key to reducing negative environmental effects on the riparian zone from road construction activities is long-range planning on the total watershed by an interdisciplinary team of engineers, fish and wildlife biologists, hydrologists, geologists, and soil scientists. Well designed road plans can also reduce total road mileage and construction costs.

- Where possible, locate roads on natural benches, ridges, flat slopes near ridges or valley bottoms, and away from stream channels.

- Roads should be located on well-drained and stable ground, avoiding seeps and other unstable areas.

- Stream crossing approaches should avoid steep pitches and grades in order to prevent sedimentation of stream habitat.

- Stream crossing sites should be selected with particular care, ensuring that bridge structures will have as little influence as possible on the natural stream flow. In streams inhabited by fish, all structures need to provide for fish passage. In addition, structures containing natural stream bottoms are preferred over culverts.

- Culverts and other drainage structures should accommodate at least a 25-year flood frequency, and preferably, a 50-year flood frequency for large structures.

- Downspouts on drainage structures should have appropriate sized energy dissipators, and road fills adjacent to streams should have sufficient fill protection (rip-rap, retaining walls, etc.) to prevent stream undercutting.

- Reduce road dimensions to that which will adequately fulfill anticipated needs and avoid large road cuts and fills.

- Roads should be outsloped and designed with rolling grades to reduce surface water velocities and culvert requirements.

- Roads constructed in valley bottoms should maintain a natural vegetation buffer or filter strip between road and stream.

- Permanent roads should be paved or rocked; temporary roads following completed use or prior to wet weather should be cross-drained, crossings pulled, and natural drains reestablished and revegetated.

- Avoid channel changes or disturbance of stream channels and minimize impacts to riparian vegetation.

Road Construction

- Road construction should be planned so sediment will not reach streams.

- Waste material should be end-hauled and compacted into a stable fill at predesignated locations and not sidecasted in areas where they may enter a stream.

- Minimize excavation with a balanced earth work design; the area of cut slopes should be minimized in order to reduce erosion and slope instability.

- Construction should take place only during the dry season.

- Large cut and fill slopes should be stabilized and revegetated before the next wet season.

- Exposed slopes should be protected with rip-rap, paving or vegetation to reduce erosion and stream turbidity.

- Sediment basins should be constructed to remove silt from run-off before it reaches aquatic areas.

- Drainage ditches should be of adequate depth and size to carry heavy runoff in order to prevent road sloughing.

- Bridges and culverts should be installed in a way that prevents stream sedimentation and channel changes.

- Culverts need to be properly installed to minimize downstream impacts and provide for fish migration (where a viable fishery exists). The following general considerations for culvert installation were taken from Yee and Roelofs (1980):

  a. A single large culvert is better than several small ones because it is less likely to become plugged and carries water at much lower velocity.

  b. The diameter of culverts should be adequate to pass maximum flows. Washing out of culverts and their earth fills may result in road damage and subsequent downstream sedimentation.

  c. Where a stream fishery exists, the entire culvert length should be placed slightly below the normal stream grade to reduce fish passage problems and prevent a lowered streambed. Installation gradient should be at or near zero percent.

  d. In areas where fish passage might be difficult, install open-arch culverts or bridges instead of round culverts.

  e. Avoid creating a culvert outfall barrier where the outlet of a culvert is so far above the tailwater that fish cannot enter the pipe. It may be necessary to provide one or a series of low-head dams, by using gabions or logs, to provide access to the culverts.

  f. Culverts used for drainage down steep slopes should be extended completely down the slope with the exit portal adjacent to and at the same level as the receiving stream. Exit portals placed above the stream may result in bank erosion and instability and subsequent sediment recruitment (BLM 1980).

- Precautions should be taken to prevent chemical toxicants (gasoline, lubricants, heating oils, and pesticides) from entering aquatic areas during construction operations.

- Unless no other source is available, gravel should not be taken from streambeds. At no time should gravel washing operations be conducted in or adjacent to aquatic areas.

- In excavating bridge footings and abutments, limit machine work as much as possible to avoid disturbing the stream.

- Steam crossings approaches should be as near a right angle to the stream as possible to minimize bank disturbance.

Road Maintenance

Road maintenance is an essential prerequisite for safeguarding aquatic and riparian areas from excessive siltation due to road failures and drainage problems.

The following general considerations for road maintenance were taken from the USDA Forest Service, Region I Forest Hydrology Manual:

- Prior to wet weather, roads should be graded so they will drain properly and not become waterways.

- Provide frequent cross-drains on all temporary roads at the end of the use season to prevent erosion of road and fill.

- After the first rain in the fall, check roads to see where drainage problems have developed and take corrective action.

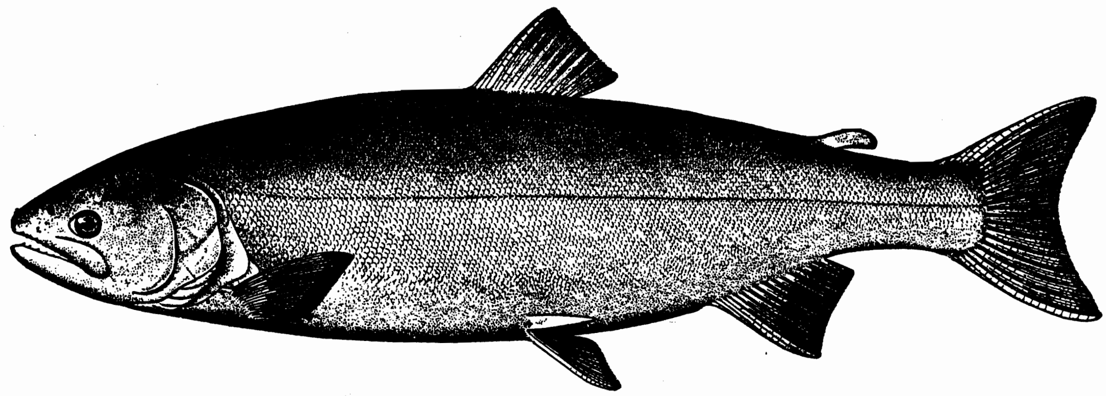
- During heavy run-off periods, road surfaces should be checked to see that drainage systems are functioning.

- Roads should be bladed and ditched before or after the first rain so that there is no interruption to drainage from the center of road to the ditches.

- Debris accumulations at culvert inlets should be cleaned out annually or as necessary.

- Oil or other dust abatement additives should be dispensed in such a manner that they do not enter streams.

- Culverts should be inspected annually to assure that they are functioning satisfactorily for fish passage.



Silver Salmon

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AGRICULTURE AND URBANIZATION

Agriculture use of land, water, and other resources merits high national priority.

The following BMP's are provided to aid land managers in the protection and enhancement of aquatic and riparian environments so as to have the least adverse impact for irrrigated agriculture.

Agriculture

Comprehensive Land Use Planning

a. The goals of land use planning should be the long-term preservation of agricultural productivity and natural resources, including riparian and aquatic habitat.

b. It is important that representatives of all involved interests participate in the planning process.

Water Allocation and Use

a. A comprehensive water allocation plan is essential to balance finite supplies between the needs of agriculture and other water users. If aquatic and riparian resources are to be preserved, agriculture must strive for improved efficiency in water use and reuse.

b. In water deficient areas, less water-intensive forms of agriculture, such as livestock grazing, and dryland farming, should be used instead of construction of reservoirs and groundwater pumping (Sierra Club).

c. Public financed water storage and conveyance projects, whose social and economic costs exceed their benefits, should not be constructed.

Pest Control and Agriculture Chemicals

a. Environmentally damaging pesticides should be phased out in favor of natural management practices and limited pest controls. A rational approach will help maintain species diversity in agricultural and adjacent riparian areas.

b. Artificial fertilizers should be used sparingly, and in accordance to soil test recommendations for the specific crops to be grown.

c. Crop residues and other natural fertilizers should be used in preference to artificial fertilizers.

d. Agriculture pollution control should be improved, focusing on the source and causes of pollution rather than on elaborate downstream treatment facilities (Sierra Club).

Source Control of Soil Erosion

a. The emphasis on soil erosion control should focus on prevention of problems at the source.

b. Special attention should be given to restoration of formerly productive eroded lands, especially riparian areas. The following soil conservation practices are from the U.S. Soil Conservation Service (USSCS 1979). These practices are all essentially the same idea (planting or maintaining riparian vegetation) approached from different solution viewpoints.

1. Vegetative Stream/Lake Buffer Strip. Establish new or use existing adapted grasses, legumes, shrubs, and trees on areas adjacent to streams or lakes, managing these species for adequate vegetative cover. The purpose of the buffer strip is to remove suspended solids carried by water flowing overland toward the stream or lake, improve water quality, provide streambank stabilization, provide wildlife habitat, protect riparian vegetation, and improve natural beauty.

These practices are applicable to irrigated lands adjacent to natural or artificial waterways. Benefits to fishery resources include temperature regulation, sediment filtration, and allochthonous energy input.

2. Streambank Protection. Establish adapted trees and shrubs along streambanks, lakes and excavated channels to protect them against scour and erosion. The purpose of streambank protection is to: 1) prevent erosion, loss of land, or damage to utilities, roads, buildings, or other facilities adjacent to the eroding area, 2) maintain the capacity of a channel, 3) control channel meander which would adversely affect downstream facilities, 4) reduce sediment loads causing damages and pollution, or to improve areas for recreational use or as a habitat for fish and wildlife.

This practice emphasizes the ability of the root structures of riparian vegetation to maintain streambank stability, as a remedy to streambank erosion problems.

3. Tree Planting. Establish adapted trees by planting seedlings or cuttings on riparian areas without trees or on land with a partial stand of trees. The purpose of tree planting is to conserve soil and moisture, beautify an area, protect a watershed, maintain water quality or produce wood crops.

4. Critical Area Planting. Establish vegetation such as trees, shrubs, vines, grasses, or legumes on severely eroding areas. The purpose of critical area planting is to stabilize the soil, reduce damage from sediment and runoff to downstream areas, improve wildlife habitat, and enhance natural beauty (USSCS 1979).

Urbanization

The rapid loss of riparian habitats to urban growth demonstrates an urgent need for better consideration of this resource in urban planning.

The following are several approaches which could be used as BMP's to protect and enhance riparian habitat. A united effort by concerned citizens, developers, and enlightened leadership of elected officials will be necessary to implement these approaches.

Land Use Planning.

a. Establish land use planning at the city, county, and state levels to encourage land uses that are compatible with the preservation of riparian areas for the best interest of the general public, i.e., natural floodways, recreation, open space easements, and wildlife sanctuaries.

Nonstructural Flood Control.

a. Encourage local, State, and federal agencies to utilize or advocate the use of nonstructural instead of structural alternatives of flood control.

b. Adopt subdivision drainage standards that would require developers to implement controls to reduce storm water runoff to a level no greater than the preconstruction rate, thereby eliminating the need for costly flood control projects at a later date and preventing the destruction of valuable riparian habitat.

Watershed Protection.

a. Preserve and protect natural water courses and associated riparian vegetation, thereby ensuring the preservation of natural resource values they provide, i.e., flood control, pollution control, recreation, fish and wildlife habitat.

Building Encroachment.

a. Prevent encroachment of buildings and landfills into the 100-year flood plain.

b. Encourage voluntary relocation of structures out of the 10-year flood plain.

Erosion Control.

a. Implement measures to control erosion and sedimentation from construction sites and exposed areas. The following list is a summary of practices recommended by the U.S. Department of Agriculture, Soil Conservation Service:

1. Disturb only the areas needed for construction.

2. Remove only those trees, shrubs, and grasses that must be removed for construction.

3. The development plan should be designed to conform to the topography and soils so as to minimize erosion hazards.

4. Prior to construction, install sediment basins and diversion dikes to trap and prevent sediment from entering area streams.

5. During construction, temporarily stabilize disturbed areas and sediment-control devices by seeding and mulching. As construction is completed, permanently stabilize disturbed areas with vegetation and, if necessary, install structural measures.

6. After construction, install permanent detention reservoirs so that peak runoff from the development is no greater than that before the development was established.

Perfomance Standards.

a. Implement land use performance standards to protect important riparian and natural resources from unwise development.

Tax Relief.

a. Change tax laws to relieve riparian landowners from heavy tax burdens, thereby providing financial incentives to protect these important resources. Any tax relief law should have features to recover back taxes from landowners who develop their lands. The rollback period should be at least 10 years, preferably the entire period during which tax savings were enjoyed.

Conservation Easements.

a. Purchase conservation easements from riparian landowners to assure a tract of land remains in its natural state. This mechanism would still allow the landowner to use land for prescribed purposes such as grazing, woodcutting, and agriculture.

Enrollment in Federal Programs.

a. Encourage private landowners to participate in the Water Bank Program administered by the USDA Agricultural Stabilization and Conservation Service. This program authorizes the Department of Agriculture to enter into a 10-year lease agreement with landowners to perserve wetland habitat. Recently, the program has been expanded to include riparian and coastal wetlands that provide flood, sediment and pollution control, groundwater rechange, and important wildlife habitat.

Conservation Ethics.

a. A conscientious conservation effort by developers can help to retain much of an area's natural values, as well as making the areas a more desirable place to live.

b. Elements that could be incorporated into the design of such environmentally-oriented new subdivision are open space corridors, restriction of development in flood plains, and control of runoff by retention ponds.

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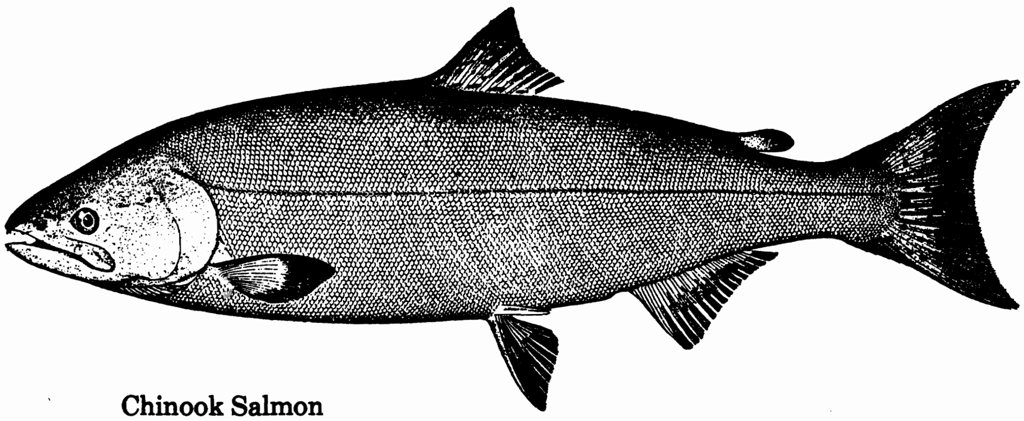

Chinook Salmon

TIMBER HARVEST

The maintenance of riparian vegetation is necessary to provide shade, bank stability, and a healthy aquatic ecosystem. Protection of riparian vegetation also reduces sedimentation and other pollutants from entering the stream. Harvest of trees from the riparian zone should be done only if it can be accomplished without adverse impact upon streamcourses, wetlands and associated vegetation. The streamside zone, including associated riparian vegetation should be given an intense level of protection, sufficient to maintain natural stream temperatures and the aquatic ecosystem.

The following best management practice's (BMP's) are designed to mitigate and/or eliminate impacts from timber harvesting that can directly affect aquatic biota and water pollution:

- Timber Harvest Unit Design. The preparation of an integrated and comprehensive timber harvest design is essential for the protection of aquatic and riparian resources and sound timber management. In addition, the approved design should ensure that favorable water flow and quality will be maintained after the proposed harvesting activities are completed.

  a. Proposed timber harvest units should have a preliminary field examination by an interdisciplinary team in order to predict watershed response to timber harvesting.

  b. The final design of timber harvest units should incorporate hydrologic and ecological recommendations made by qualified specialists to minimize impacts of timber harvestng activities. These recommendations should become a formal part of the final plan for timber harvesting.

- Sale Area Maps. A final map should be required for each planned timber harvest unit indicating important features of harvest activities and areas to be protected. This serves as a guide to buyer and seller and ensures proper recognition of important features to be protected within the timber harvest units. The map also becomes a formal part of any plan or contract and should include the following elements:

  a. Location of stream courses to be protected

  b. Wetlands (meadows, lakes, pot holes, etc.) to be protected

  c. Boundaries of harvest units

  d. Specified roads

  e. Roads where log hauling is prohibited or restricted

  f. Structural improvements

  g. Crossings (temporary or permanent) of all water courses

  h. Areas for different skidding and yarding methods

i. Sources of rock for road work riprapping, etc.

j. Water sources available for contractor's use

k. Other unit features as developed during the design of a timber harvest sale

- Streamside Management Zone Designation. Management zones along water courses and wetlands should be designated and prescriptions recommended to minimize the effects of nearby logging and related land disturbance activities.

  a. As a preventative measure, roads, skid trails, landings, and other timber harvesting facilities should be kept at a prescribed distance from streams. Factors such as stream class, channel aspect, channel stability, sideslope steepness, and slope stability should be considered in determining the constraints of activities and width of streamside management zones. Fisheries habitat condition and its estimated response to the proposed timber sale also need to be evaluated in determining the required width of the streamside management zone.

  b. Timber harvesting within the management zone should only be allowed as long as shade, bank stability, cover, habitat and visual amenities can be maintained. Disturbance to vegetation and to soils within the zone should be kept to an absolute minimum.

- Streamcourse Protection. Generally, during timber harvesting specific practices are employed to prevent adverse environmental changes to stream resources. In the course of operations it may, however, be possible to restore or improve some stream reaches which have suffered damage from previous logging or land use activities. The following points refer to protecting streamcourses from past and proposed logging practices.

  a. Location and method of streamcourse crossings should be coordinated with the buyer and agreed to prior to construction.

  b. Material used for temporary road and skid trail streamcourse crossings should be removed and streambanks restored.

  c. The purchaser, to whatever extent practicable, should repair all damage resulting from his and past timber operations, including damage to banks and channel.

  d. All project debris should be removed from streams in an agreed upon manner that will cause the least disturbance.

  e. At a minimum, equipment should not operate within 100 feet slope distance of the apparent high water mark in streamcourses, except as necessary for fire suppression activities. Equipment exclusion zone boundaries may be modified by agreement to meet unforseen operation conditions or to provide additional streamcourse protection.

f. Logs should be end-lined out of streamside areas.

g. Water bars and other erosion control structures should be located so as to prevent water and sediment from being channeled into streamcourses, and to dissipate concentrated overland runoff.

h. Trees cut within fifty (50) feet of the stream and lake, as measured along the surface of the ground, should be felled as nearly as possible at right angles away from the stream or lake, or in such a manner as to minimize erosion, damage to other vegetation, and water quality problems.

i. Cable logging operations within the streamside management zone should keep logs fully airborne at all times.

j. Water sources for timber sale use should be identified and provisions made to guarantee flow for all downstream aquatic resource needs.

- Tractor Skidding Design. Water can be controlled in a manner that will minimize erosion and sedimentation by designing skidding patterns to best fit the terrain, the volume, velocity, concentration, and direction of run-off. Watershed factors to be considered include slope, soil stability, exposure, streamside management zones (SMZ), meadows, and other factors that may affect the flood- and sediment-yield potential of the land.

  a. The traversing of perennial or intermittent streams by skid trails should be avoided wherever possible. Unavoidable stream crossings should not be undertaken unless individually and specifically approved in a timber harvesting contract. Such approval should be based on the adequacy of the bridging technique proposed at each crossing and on the measures to be taken to prevent sedimentation of the stream. In no event should log culverts, or any like method requiring the placing of rock and earthen material into the stream or streambed, be considered adequate bridging techniques. This does not, however, preclude the installation of adequate, properly installed metal culverts.

  b. Two complementary methods of protecting water quality from tractor skid trail are:

    1. End Lining. This method involves winching the log directly out of a sensitive area (such as riparian areas, stream management zones, and meadows) with a long cable operated from outside the area, thereby avoiding damage by heavy equipment within the sensitive area.

    2. Felling to the Lead. This method involves felling trees toward a predetermined skid pattern. This procedure facilitates an uncomplicated approach of the tractor operating between the log and the skid trail. Soil disturbance and compaction are consequently lessened, and residual stand and site damage is minimized.

- Log Landing Location. Landings should be located in such a way as to avoid creation of hazardous watershed conditions and resulting water quality degradation.

  The following criteria will assist in evaluating landings:

  a. The size of the area cleared or excavated for a landing should not exceed that needed for safe and efficient skidding and loading operations.

  b. Where a choice exists, landing locations should be selected where the least amount of excavation is required and erosion potential is lowest.

  c. Where possible, landings should be located near the points of ridges so that felled timber lying between drainages can be skidded to the landing without crossing stream channels, or violating the streamside management zone.

  d. Landings should be located where the least number of skid roads are required, and where sidecast materials will neither enter streams nor damage other sensitive areas.

  e. If practical, landings should be positioned such that the skid road approach will be nearly level.

  f. The number of tractor roads entering a landing should be minimized.

  g. If practical, landings should be designed and constructed as part of specified roads.

- Meadow Protection. The following practices are recommended in order to avoid damage to the ground cover, soil, and aquatic areas of meadows.

  a. Vehicles and skidding equipment should avoid all meadows, especially wet meadows. Unless otherwise agreed, trees felled into meadows should be removed by end-lining and resulting logging slash removed. Meadows should not be used for debris disposal or slash burning, and water sources of wet meadows should not be developed for timber harvest activities.

  b. Special management zones, similar to those for streamcourses, should also be employed around meadows, especially wet meadows.

- Slash Treatment. Sensitive tributary areas should be protected from degradation resulting from using mechanized equipment for slash disposal.

  a. Special slash treatment to facilitate slash disposal by other means than mechanized equipment should be prescribed for streamside and meadow management zones. Slash treatment methods should be incorporated into each cutting unit and indicated in the Sale Area Map.

b. Areas below a stream and lake transition line should be kept free of slash, debris, side cast, and other material from logging operations. Accidental deposits should be removed as soon as possible.

c. The timber operator should prevent the discharge of soil, silt, bark, slash, or other organic and earthen material from any logging, construction, or associated activity into any stream or lake.

- Suspended Log Yarding. Suspended log yarding includes all yarding systems which suspend logs either partially or wholly off of the ground. These systems include skyline, helicopter, and balloon yarders. All of the systems result in less soil disturbance since heavy machinery is not used over the sale area. In most cases these systems require fewer roads, thereby, less soil disturbance will result and impact to water resources is reduced.

  a. Areas where suspended log yarding is to be used should be determined during the pre-sale planning process and designated in an assessment of environmental impacts of the proposed harvest. The specific systems should also be included in the contract and designated on the Sale Area Map.

  b. Trees should not be cut or yarded within one hundred (100) feet slope distance from the edge of a stream channel or a perennial or intermittent stream, except where selected cutting is allowed for the purpose of sanitation.

  c. No yarding equipment should be allowed in meadow areas.

  d. Trees should not be felled into perennial or intermittent streams, or into a meadow or lake.

  e. Trees should be felled in such direction as to avoid destruction of streamside vegetation.

- Modification of Timber Sale Contract. At times, it may be necessary to modify a Timber Sale Contract because of new concerns arising over the affects of land on water resource disturbance. If this is the case, qualified specialists in hydrology, fisheries, forestry or other disciplines should be assigned to reassess the contract and provide management with recommendations to reduce resource impacts.

  Recommendations should address whether or not the timber sale as currently planned will:

  a. Irreversibly damage soil, water, or watershed conditions.

  b. Inadequately protect streams, streambanks, shorelines, lakes, wetlands, and other bodies of water from detrimental changes in water temperatures, blockages of watercourses, and deposits of sediment. The timber sale should then be amended to reflect any new findings.

- Timber Sale Contract Agreement. The concerns and constraints mentioned above should be set forth in the Timber Sale Contract Agreement. The contract also should specify that a buyer is subject to a damages charge each time equipment enters a designated special management zone. Damage to streamcourses, meadows or streamside management zones caused by unauthorized operations should be repaired by the buyer in a timely and agreed upon manner and to the extent practicable to restore and prevent further damage to these resources.