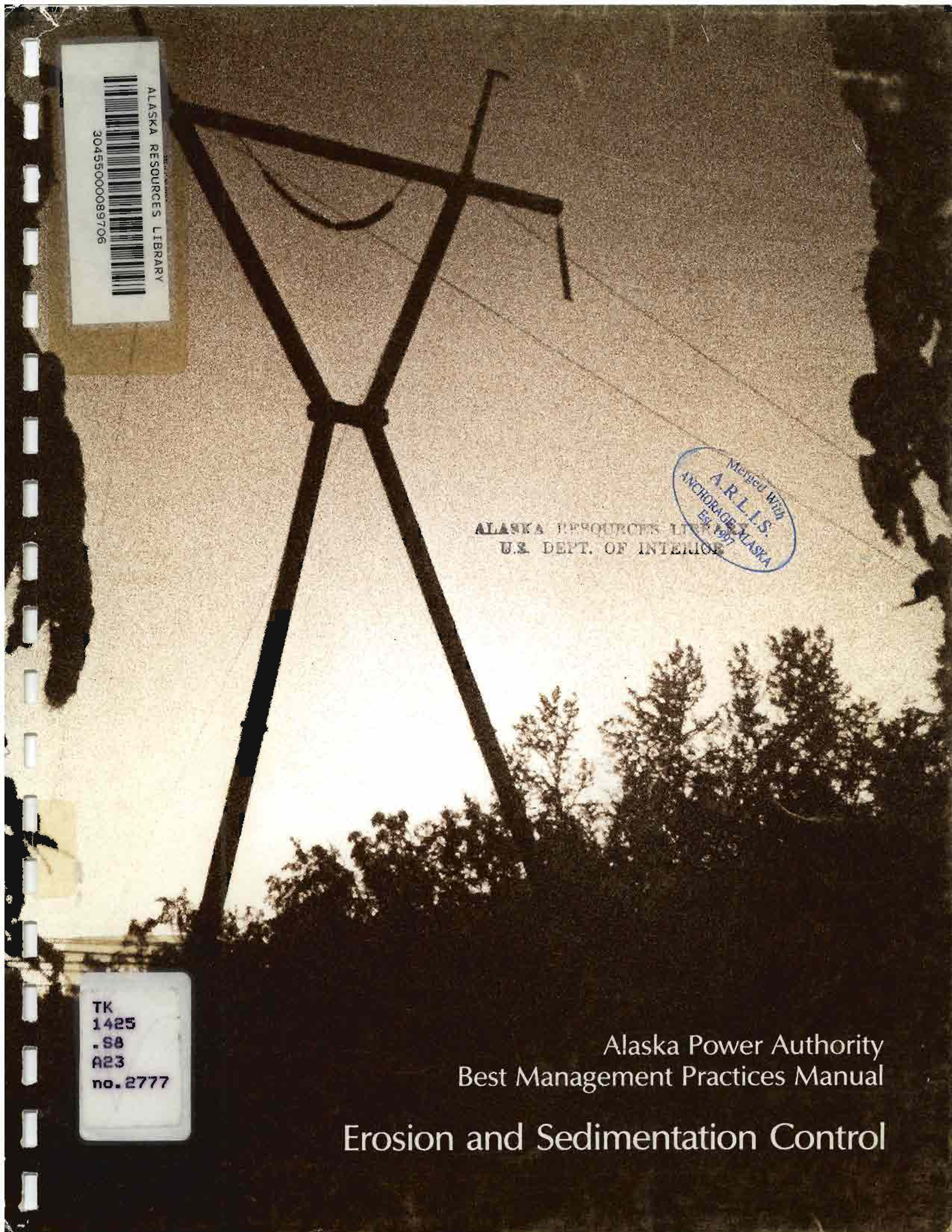

Alaska Power Authority
Best Management Practices Manual

Erosion and Sedimentation Control

ALASKA POWER AUTHORITY

BEST MANAGEMENT PRACTICES MANUAL

EROSION AND SEDIMENTATION CONTROL

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PREFACE

This manual is one of a series of "best management practices" manual to be used in the design, construction, and maintenance of Alaska Power Authority projects. It represents a coordinated effort involving federal, state and local government agencies, and special interest groups.

The Alaska Power Authority intends that applicable guidelines and state-of-the-art techniques contained in the manuals will be incorporated where appropriate into the contractual documents for projects constructed, maintained, or operated by or under the direction of the Alaska Power Authority.

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CHAPTER 1 - INTRODUCTION

This manual has been prepared by the Alaska Power Authority as one of a series of best management practices manuals for projects constructed or operated by the Power Authority in Alaska. The guidelines and techniques presented in this manual for control and prevention of erosion and sedimentation represent a compilation of information contained in numerous published sources and the direct recommendations of public agencies and special interest groups. While the information presented will be used in preparing contractual documents for projects, it is not all inclusive. Rather, it concentrates on commonly accepted practices. Nor are all the techniques appropriate for a particular site. Therefore, this manual should be used only as a guide to select appropriate site-specific procedures. It is intended to create an awareness of the ways and means to minimize effects of construction on the natural environment, to identify potential environmental hazards that must be considered, and to suggest methods that can be employed to avoid or minimize environmental disturbances.

Federal, state, and local law impose specific requirements on particular Power Authority construction projects or activities. This manual is not a substitute for case-by-case identification and compliance with all laws and regulations applicable to the construction and operation of Power Authority projects.

Prior to the start of construction of a project component, the contractor will prepare a detailed plan of operations. This plan will be reviewed by the engineering consultants, who, in turn, will recommend action to the Power Authority. The plan prepared by the contractor will conform with the guidelines presented in this manual and with any appropriate land or water use authorization stipulations or conditions.

Summary guidelines addressing general situations and conditions are contained in Chapter 2 of this manual. Chapter 3 discusses alternative techniques for specific phases of a project to implement the summary guidelines listed in Chapter 2. Regulatory authorities and agencies involved in controlling erosion and sedimentation are listed in Chapter 4.

CHAPTER 2 - SUMMARY GUIDELINES

Any planned action should be conducted with forethought toward minimizing any damage which may result. This chapter summarizes general guidelines for reducing erosion, minimizing sedimentation, and lessening water quality impacts. It is organized according to the phases of project development: planning, design, construction, and maintenance. Alternative techniques to implement these general guidelines are presented in Chapter 3.

2.1 PLANNING

The planning process entails several important elements, including initial site selection, reconnaissance studies, economic evaluations, and review of applicable legal and permitting requirements. This development phase offers the greatest opportunity to explore and anticipate erosion related problems and take initial action to avoid or minimize their occurrence. Following are general guidelines pertaining to the planning phase:

Site Selection

- Utilize a planning team comprised of multidisciplinary specialists experienced in Alaska conditions.

- Fully consider land use management problems and assess impacted resources.

- Maintain an open dialogue among government and private managers, engineers, environmental specialists, and planners, as well as solicit public input.

- Assemble available data concerning water quality, soils, topography, climate and biology to determine erosion potential and other related problems.

- Consolidate related facilities to minimize environmental damage. Utilize existing rights-of-way whenever feasible.

- Identify criteria needed for selection of acceptable sites and routes.

- Avoid, when feasible, siting facilities in areas of unstable permafrost soils, seepage zones, landslide areas, dissected terrain, ponds, natural channels, wetlands, and critical habitat.

- Minimize cut and fill approaches to streams and encroachment on streams.

Reconnaissance

- Minimize surface disturbances when conducting reconnaissance activities.

- Reconnaissance surveys shall include preliminary aerial photography and map studies followed by extensive ground-truthing programs.

- Collect sufficient data on surface and subsurface soils, geology, vegetative type and cover, fish and wildlife, climate and topography not only to be incorporated into conceptual engineering design requirements, but also to estimate erosion potential and risk, and requirements for restoration.

- Areas disturbed by reconnaissance activities shall be treated to prevent degradation.

- Clearing for ground surveys shall be kept to a minimum.

Economic Evaluation

- Erosion protection should be cost justified with alternate sites, routes and configurations.

- Erosion and sedimentation control techniques should be considered as capital costs. Projected maintenance costs of these items should be evaluated.

Review of Project Permit Requirements

- Identify project goals and describe proposed construction and other activities to implement goals.

- Determine project impact on environment.

- Identify statutes, regulations and aencies which regulate either the proposed activity or its impacts. In particular, determine whether existing Power Authority permits control the activities or impacts involved.

- Compare burdens imposed by regulations and/or permits for proposed activities and alternatives (including costs associated with modifying activities to reduce or eliminate requirements).

- Develop and implement permitting strategy to obtain timely issuance of permits.

2.2 DESIGN

Many problems involving erosion during and after construction can be mitigated by proper design. Even with the design, however, some erosion can be expected. Provisions should be made to accommodate unforeseen circumstances and provide for adequate protection. General guidelines pertaining to the design phase are summarized as follows:

Configuration

- When feasible, locate facilities on well drained upland areas and away from stream courses and wetland areas.

- Avoid seepage areas and geologic features which may result in instability.

- Make cuts as steep as possible to minimize surface area. In erodible soils, incorporate slope stabilization measures.

- Fills or embankments should be well compacted and built in lifts. Design slopes flatter than the angle of repose for greater stability.

- Design to reduce the amount of clearing required for cuts and fills.

- Design to prevent accumulation of water on surfaces of temporary or completed work areas.

- Whenever feasible, maintain buffer strips of undisturbed land and vegetation in areas adjacent to streams, lakes over 5 acres in size, critical areas, and borrow sites. Consult resource agency land use plans for suggested buffer widths. Unless agreed to otherwise by the landowner, managing or licensing agency, or when no guidance exists, buffer strips should be 500 feet wide.

Drainage Design

- Maintain natural drainage patterns where possible.

- Design to provide interception and removal of runoff waters. Incorporate temporary measures to protect disturbed areas.

- Give ample consideration to determining the design flood when designing culvert installations. Provide for clean-out or use debris collectors to prevent clogging.

- Provide sufficient cross-drainage to prevent excess accumulation on uphill sides of temporary or permanent work areas.

- On low-use access routes, use water bars and low-water crossings for reduced maintenance. Consider fish passage requirements through the use of such techniques as low-flow channels.

- Provide adequate protection for inlets and outlets of drainage structures.

- Approach stream crossings at right angles, and when feasible leave a buffer strip along the stream bank until actual construction of the structure is ready to begin.

- In permafrost areas or erodible natural soils, avoid concentrated discharges from drainage structures. Attempt to convert to sheet flow to prevent ground erosion.

- Consider bridges where fish passage is critical and where spawning and rearing habitat occurs. Provide clearance for debris and to avoid icing, and stabilize banks.

- In areas where the facility will be endangered, provide a means to remove or control groundwater and seepage waters to prevent "aufeis" buildup.

- Consult applicable federal and state agencies for fish requirements and other habitat features.

Permafrost Design

- Whenever possible, use overlay construction as opposed to cut and fill.

- When practicable, use insulation beneath fills to reduce the amount of fill material.

- When using overlay, avoid stripping of the organic layer.

- Consider winter construction to avoid melting and thermal degradation.

- Provide for stabilization of cut slopes.

- Avoid induced drainage or standing water over permafrost areas which can result in rapid thermal degradation.

Erosion Control Design

- Based on design and construction requirements, incorporate temporary erosion control procedures into design provisions.

- Give special attention to immediate control of surface runoff waters.

- Where feasible, revegetate or otherwise stabilize erodible areas which are to be left uncompleted for the following season.

- Consider work schedules and local climatological events to insure adequate erosion protection is provided.

- Take advantage of natural erosion control features such as vegetative and brush buffer strips.

- Provide for adequate right-of-way to perform erosion-related work.

Design Documentation

- Specifications shall clearly detail measures to prevent erosion.

- Insure correlation between plans, specifications and design documents.

- Insofar as possible, incorporate all temporary and permanent erosion control measures into the final design and bid documents.

- Allow flexibility to resident engineers and contractors to improve upon design or methods.

- Provide contingency to allow for unforeseen circumstances.

- Contract scheduling shall specify the appropriate time to perform all seasonally-effected work, to result in minimal impact.

2.3 CONSTRUCTION

The construction force should follow procedures to prevent erosion. The following guidelines pertain to the construction phase:

General

- A preconstruction conference shall educate and coordinate all involved parties towards the goals of erosion control and protection of water quality, permit requirements and stipulations, and inspections.

- Equipment operators and other personnel shall clearly understand and participate in safe and proper practices.

- The Power Authority's environmental inspector shall be given sufficient authority to be effective.

Clearing and Grubbing

- Protect established monuments and clearly mark work area boundaries on the ground prior to initiating clearing or other ground disturbance operations.

- All trees, snags and other wood material cut in connection with clearing operations shall be felled within the clearing boundaries.

- Avoid destroying the organic mat in permafrost areas. Immediate treatment shall follow any disturbances.

- Keep clearing and grubbing operations closely in line with subsequent activities. Avoid clearing beyond the present season's schedule.

- Dispose of clearing debris in accepted manners. Utilize available materials for brush barriers and ditch checks.

- Whenever feasible, utilize non-mechanical means when clearing in permafrost locations, wetlands and in areas such as along tops of cut banks.

Earthwork

- Dependent upon load-bearing capacity specifications, chipped wood, limbs, and other organic detritus may be mixed with mineral materials in road fill embankments. Compact fills in lifts to reduce infiltration and settling. Avoid placing fill in areas covered by snow or ice.

- Provide temporary protection such as berms to the tops of erodible cut and fill slopes.

- Dispose of waste spoils in approved areas away from water courses. Preferred methods include disposal in any future impoundment area of a reservoir, or retention for rehabilitation of material sites or for solid waste disposal site maintenance.

- Dependent upon material quality and availability, borrow areas should be located in upland areas.

- Provide for perimeter dikes, ditches and sediment removal at borrow sites.

- Apply measures to control surface runoff waters throughout construction areas.

Borrow and Disposal Areas

- Design for phased development whenever feasible.
- Conserve stripped topsoil for respreading over completed areas.
- Provide perimeter dikes, diversions and other techniques to prevent sediment movement from excavated areas into streams and drainages.
- Incorporate sediment removal techniques into disposal site plans.
- Prepare comprehensive operations plans which outline excavation and disposal techniques, applicable erosion procedures, and final restoration measures.
- Stabilize all slopes and embankments. Grade to stable slope angles.

Drainage

- Keep sediment and debris out of all structures. Stabilize at inlets and outlets.
- Consider using low-water crossings for both temporary and permanent cross-drains on low-traffic volume access routes, particularly those that do not cross fish streams.

- Exercise care and comply with permit stipulations when rerouting streams during bridge and culvert installation. Provide a non-erosive temporary channel or sediment removal measure such as silt curtains.

- Avoid sedimentation of water courses when removing temporary structures.

Erosion Control and Revegetation/Reclamation

- Schedule final reclamation activities to closely follow final construction.

- Utilize temporary techniques to protect slopes until final treatment.

- Conserve stripped topsoil for respreading over completed areas.

- Surfaces left exposed for extended periods shall be temporarily revegetated with fast-growing native species in areas subject to erosion or where siltation will be a problem. Encourage reinvasion by native species from surrounding undisturbed areas.

- Establish permanent erosion control items. Give consideration to critical areas and erodible soils. Maintain appropriate erosion control materials on site.

- Abandon, block, and restore unused roads, borrow and disposal sites and other low-use areas. Stabilize cross-drains by either removal or adequate inlet and outlet protection.

- Inspect abandoned facilities periodically to correct any erosion problems.

2.4 MAINTENANCE

Proper maintenance is essential to ensure that some erosion control structures function effectively. General guidelines for maintenance activities are as follows:

General

- Provide a planned, regularly scheduled maintenance program incorporating inspection and expeditious repair.

- Develop dialogue between maintenance and design personnel.

Drainage Systems

- Inspect all drainage structures prior to wet seasons or before winter. Clean out debris and sediment.

- Remove transportable debris upstream and downstream of drainage structures.

- o Clean out ditches, sediment basins and other sediment retention structures periodically. Dispose of sediments according to approved plan design and specifications.

Surface Maintenance

- o Treat washouts and gullies on slopes by filling, mulching and revegetation.

- o Avoid damaging treated areas with mechanized maintenance equipment.

- o Direct special attention to frozen cuts until stabilized.

- o Keep non-paved surfaces crowned or sloped. Avoid windrows along edges to provide lateral drainage.

- o Water and fertilize revegetated areas to promote growth.

- o Dust control chemicals should be used carefully and only with accepted techniques according to local, state and federal regulations.

Winter Maintenance

- o Prior to breakup, remove or level snow berms along road edges to prevent accumulation of meltwaters.

- Use salts and other chemicals prudently, especially near any streams containing aquatic life. Comply with applicable regulations.

- Attempt to divert aufeis-forming flows away from driving surfaces. Where possible, thaw culverts susceptible to erosion from ice-buildup.

CHAPTER 3 - SPECIFIC TECHNIQUES

This chapter presents descriptions of specific techniques to implement the guidelines listed in Chapter 2. In most instances, site-specific conditions will dictate the feasibility of a particular technique or the need to modify it. No attempt has been made to represent all possible techniques, nor should the techniques as described in this manual be considered as design standards or contract specifications.

3.1 EARTHWORK

3.1.1 Clearing and Grubbing

Clearing and grubbing activities involve removal of vegetation and timber.

Any clearing operation must be restricted to areas marked on the ground at the work site prior to beginning construction. All trees, snags and other wood material cut in connection with clearing operations must be felled within the clearing boundaries. To minimize and protect erodible surfaces, clearing should be scheduled to closely precede excavation and construction activities in any given area. All vegetation which does not interfere with construction activities should be left. Whenever feasible, hand clearing, instead of mechanical equipment, shall be used to clear permafrost areas (for summer construction), wetlands, and at the top of cut banks. Buffer strips of existing vegetation at approaches to stream crossings should be maintained until actual construction. Instream equipment operation in anadromous fish streams should be kept to an absolute minimum and as permitted by the Alaska Department of Fish and Game. If felled trees or other debris unavoidably enter a stream, they must be removed within 48 hours.

Clearing and grubbing materials can be buried, burned, chipped or sold as appropriate.

3.1.2 Surface Preparation

A variety of techniques can be used to stabilize disturbed surface areas, promote seed germination, increase soil moisture retention, reduce movement of seed and fertilizer, and increase runoff infiltration.

All disturbed areas, even those which will not be revegetated, should be scarified to a depth of 12 inches to increase aeration and moisture infiltration and to control runoff. "Cat-tracking", which consists of running tracked vehicles up and down slopes to create mini-benches, can be effective on slopes up to 2:1. Dics and harrows can also be used for scarification. Another technique for improving infiltration is to cut or serrate slopes into mini-benches along the contours.

The configuration of a fill area is critical to providing surface drainage and minimizing runoff of eroded soils. For example, in roadbed construction, the final lift of each day's work should be crowned and drum rolled to direct surface runoff to ditches, berms, or other stabilized areas. A surface dressing of aggregate can also minimize surface erosion.

If the surface is to remain unused for extended periods, temporary cover may be required to stabilize soil from wind and winter erosion. This can be achieved by applying aggregate cover or soil binders, or by establishing temporary vegetation.

3.1.3 Borrow and Disposal Practices

Careful site planning of borrow and disposal areas is required to prevent or minimize sedimentation. Each site will impose its own limitations, which should be considered to facilitate economical and effective construction techniques.

3.1.3.1 Operations Plans

A detailed plan of operations will be required for each borrow site. The plan should include:

- Site sketch to scale
- Excavation procedures
- Stockpiling and handling procedures
- Erosion and sedimentation control procedures
- Material properties, quantity, and depth
- Buffer areas
- Excavation dimensions
- Plan modifications
- Time frames
- Traffic routes

- o Dust control procedures
- o Final reclamation measures

3.1.3.2 <u>All Borrow Sources</u>

Whenever possible, borrow sites should be located in upland areas rather than in floodplains where they may degrade water quality and sensitive habitat.

All sites should be surveyed and their boundaries clearly marked. Pre-construction elevation controls will facilitate restoration efforts upon site closure. It is particularly important that sites planned to be open during winter be surveyed during the summer months and that boundary markings be established so they they can be found during heavy snow cover. The limits of the area worked within a site should avoid a straight line configuration and should be shaped to blend with natural physical features.

When possible, borrow sites should be worked in phases to minimize the amount of disturbed areas. As one segment is completed, it may be stabilized while the next segment is developed. Progressive upslope or upstream work will allow use of preceding work sections for settling ponds (see Section 3.5.1).

If operations require washing of heavy equipment, a specially designated area must be provided to facilitate treatment of the wash water. For large operations, treatment may require construction of a catch basin.

3.1.3.3 Upland Sites

Borrow areas should be located away from heavy groundwater seepage pathways. Surface runoff upslope of the pit should be diverted with dikes to ditches. The floor of the pit should be sloped to facilitate drainage and any surface runoff from the pit should pass through settling ponds before entering a waterbody. Small volumes of discharges from settling ponds can be diverted to overland flow if ground conditions allow the water to percolate at a rate which will not cause rills or gullies.

Spoil or waste material removed during site opening should be disposed of in an approved manner or stockpiled.

Borrow area slopes should not adjoin steep slopes except for those slopes composed of rock. Excavated faces of rock quarries may be left vertical, but no face should be more than 30 feet high without an intermediate bench 10 feet wide.

All completed borrow sites should be sloped to stable angles. Further reclamation, such as revegetation, will be performed in accordance with stipulations of the regulatory agency or landowner. Respreading topsoil removed during initial site opening will assist in reclamation efforts.

3.1.3.4 Floodplain Sites

Site Planning

Borrow sites within a floodplain should be developed so that disturbance of the following features is minimized:

- o Fish spawning and overwintering habitats
- o Vegetated banks and associated riparian zones
- o Springs
- o Active channels in small rivers

Projects requiring large borrow quantities (approximately 65,000 cubic yards or more) should consider 1) scraping of unvegetated, mid-channel bars and lateral bars in braided rivers and medium and large split-channel rivers, and 2) pit excavation in terraces or inactive floodplains. Projects requiring less than 65,000 cubic yards should consider 1) scraping unvegetated mid-channel and lateral bars in braided rivers and large and medium split-channel rivers, 2) scraping point bars of large and medium meandering rivers, and 3) scraping in terraces or inactive floodplains. Specific guidelines for borrow operations in rivers of different size[1)] and configuration, and for different deposit locations in each size and configuration are presented in Tables 1 through 3.

Design of specific work area boundaries should incorporate the following factors:

1) Small river - a river with a drainage area less than 40 square miles and a mean annual flow channel top width of less than 50 feet.
Medium river - a river with a drainage area greater than 40 square miles but less than 380 square miles and a mean annual flow channel top width greater than 50 feet but less than 300 feet.
Large rivers - a river with a drainage area greater than 380 square miles and a mean annual channel top width greater than 300 feet.

TABLE 1

GUIDELINES FOR BORROW OPERATIONS IN BRAIDED RIVERS

River size			Site location			Associated channel			Type of deposit								
Small	Medium	Large	Active floodplain	Inactive floodplain	Terrace	Active channel	High-water channel	Abandoned channel	Bed	Point Bar	Lateral Bar	Mid-channel bar	Inside meander	Outside meander	Vegetated island	Vegetated bank	Comments
X	X	X	X			X			X								1. Gravel may be available by scraping or dredging.
X	X	X	X			X					X	X					2. Gravel available by scraping.
X	X	X	X	X			X	X			X	X					3. Gravel available by scraping.
X	X	X	X	X		X	X	X							X		4. Generally should not be mined.
X	X	X	X	X	X	X	X									X	5. Banks should not be mined.
X	X	X	X	X			X	X	X								6. Gravel available by scraping.
X	X	X			X		X		X		X	X			X		7. Gravel available by scraping.
X	X	X		X	X			X	X		X	X			X	X	8. Gravel available by scraping or pit mining.
																	Comments

Comment 1. Generally, the bed of an active channel should not be disturbed. If bed deposits are the only available source, the side channel(s) should be mined rather than the main channel. Select side channel(s) that carry less than approximately one third of the total flow during the mining period; block off upstream ends and mine by scraping operations. If the main channel must be mined, dredging may be an appropriate method.

Comment 2. Gravel is available by scraping gravel deposits to near the low summer flow or no lower than the water level present during the mining operation. Maintain appropriate buffers.

Comment 3. Gravel is available by scraping such that the configuration of the channel is not greatly changed and there is not a high probability of channel diversion through the mined area.

Comment 4. Vegetated islands should generally be excluded. Exposed deposits should be considered before vegetated island deposits. If deposits in feasible alternative locations are not sufficient, and vegetated islands are abundant in the particular reach in question, up to about 10 to 20 percent of this habitat may be removed from about a given 3-mile length of the floodplain.

Comment 5. Vegetated river banks of both active and high-water channels should not be disturbed.

Comment 6. Gravel is available by scraping within the channel; but the general configuration of the channel should be maintained.

Comment 7. Gravel may be available by scraping in these locations, but the general configuration of the channel should be maintained.

Comment 8. Generally, pits should only be considered when more than 65,000 cubic yards are required.

Source: U.S. Fish and Wildlife Service (1980)

TABLE 2

GUIDELINES FOR BORROW OPERATIONS IN SPLIT CHANNEL RIVERS

River size			Site location			Associated channel			Type of deposit								
Small	Medium	Large	Active floodplain	Inactive floodplain	Terrace	Active channel	High-water channel	Abandoned channel	Bed	Point Bar	Lateral Bar	Mid-channel bar	Inside meander	Outside meander	Vegetated island	Vegetated bank	Comments
	X	X	X			X			X								1. Gravel may be available by scraping or dredging.
	X	X	X			X				X	X	X					2. Gravel available by scraping.
	X	X	X	X	X	X	X						X	X			3. Some gravel may be available by scraping or pit.
X	X	X	X	X	X	X	X								X		4. Generally should not be mined.
X	X	X	X	X	X	X	X									X	5. Banks should not be mined.
	X	X	X	X	X		X		X	X	X	X					6. Gravel available by scraping.
X			X			X			X	X	X	X	X	X	X		7. Should not be mined.
X			X	X	X		X		X	X	X	X	X	X			8. Generally avoid, but much available.
X	X	X		X	X			X	X	X	X	X	X	X	X	X	9. Gravel available by scrape or pit.
	X	X			X		X		X	X	X	X	X	X	X		10. Gravel available by scraping.

Comment 1. Generally the bed of the active channel should not be disturbed. If bed deposits are the only available source, the side channel(s) should be mined rather than the main channel. If the site contains a side channel that carries less than approximately one third of the total flow during the mining period this channel can be blocked at its upstream end and mined by scraping. If channels approximately this size are not available then either the side or main channel can be mined using dredging.

Comment 2. Gravel is available by scraping deposits to near the low summer flow, or no lower than the water level present during the mining operation. Maintain appropriate buffers.

Comment 3. Gravel is available if suitable buffers are maintained to protect against channel diversion.

Comment 4. Exposed deposits should be considered before vegetated island deposits. If deposits in feasible alternative locations are not sufficient, and vegetated islands are abundant in the river system in question, about 10 to 20 percent of this habitat may be removed from about a 3-mile reach of floodplain.

Comment 5. Vegetated river banks of both active and high-water channels should not be disturbed.

Comment 6. Gravel is available by scraping in the high-water channel, but precautions must be taken to avoid channel diversion.

Comment 7. Mining is not recommended in or near the active channel of small split channel rivers because there is not must material available.

Comment 8. There generally is not much material available in these deposits and they should be avoided. If only a small amount (13,000 cubic yards) of gravel is needed, these deposits may be considered for scraping.

Comment 9. Pits should be considered when more than 65,000 cubic yards.

Comment 10. Some gravel is available by scraping, but the general configuration of the channel should be maintained.

Source: U.S. Fish and Wildlife Service (1980)

TABLE 3

GUIDELINES FOR BORROW OPERATIONS IN MEANDERING, SINUOUS, AND STRAIGHT RIVERS

River size			Site location			Associated channel			Type of deposit								
Small	Medium	Large	Active floodplain	Inactive floodplain	Terrace	Active channel	High-water channel	Abandoned channel	Bed	Point bar	Lateral bar	Mid-channel bar	Inside meander	Outside meander	Vegetated island	Vegetated bank	Comments
	X	X	X			X			X								1. Some gravel may be available by dredging.
	X	X	X			X				X	X	X					2. Gravel available by scraping.
	X	X	X	X	X	X	X						X	X			3. Some gravel may be available.
X	X	X	X	X	X	X	X								X		4. Not recommended in these systems.
X	X	X	X	X	X	X	X									X	5. Banks should not be mined.
	X	X	X	X	X		X		X	X	X	X					6. Gravel available by scraping.
X			X	X	X	X	X		X	X	X	X	X	X			7. Should not be mined.
X				X				X	X	X	X	X	X	X		X	8. Generally avoid, but much available.
X	X	X		X	X			X	X	X	X	X	X	X	X	X	9. Gravel available by pit or scrape.

Comment 1. Generally the bed of an active channel should not be disturbed. If bed deposits are the only available source, the gravel should be taken by dredging only under strict work plans and stipulations.

Comment 2. Gravel is available by scraping deposits to near the low summer flow or no lower than the water level present during the mining operation. Maintain appropriate buffers.

Comment 3. Gravel is available if suitable buffers are maintained to protect against channel diversion.

Comment 4. Vegetated islands should not be disturbed.

Comment 5. Vegetated river banks of both active and high-water channels should not be disturbed.

Comment 6. Gravel is available by scraping in the high-water channel, but precautions must be taken to avoid channel diversion.

Comment 7. Mining in the active or high-water channels of these small rivers is not recommended because there is not much material available.

Comment 8. There generally is not much gravel available in these deposits and they should be avoided. If only a small amount (13,000 cubic yards) is needed, scraping may be considered.

Comment 9. Pits should be considered when more than 65,000 cubic yards are required.

Source: U.S. Fish and Wildlife Service (1980)

- Site configurations should be shaped to blend with natural physical features
- Slopes and contours resembling those of natural bars should be maintained when scraping point bars of meandering and sinuous systems
- Natural gravel bar shapes should be maintained when scraping mid-channel and lateral bars of braided systems
- Pits should be excavated to provide irregular shorelines with curved configurations, islands, spits, and diverse shoreline depths
- When vegetated areas cannot be avoided, it is usually desirable to locate material sources in large stands of homogeneous mature vegetated areas
- The site should be located on the same side of the floodplain as the material use point to minimize the need for crossing active channels.

Site Preparation

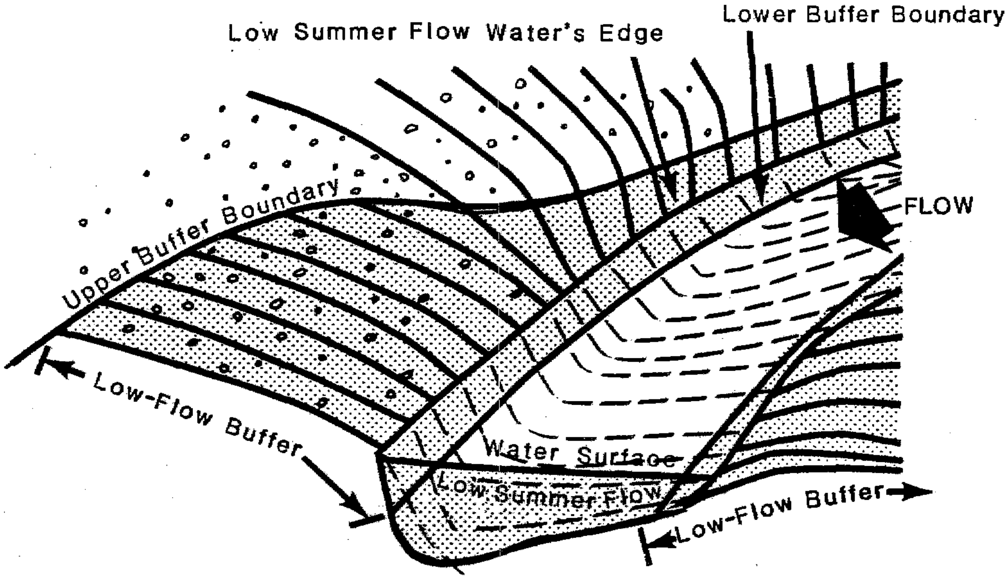
Design of floodplain access should avoid vegetated habitats. If it is necessary to traverse vegetated areas, ice roads should be used for winter operations and gravel should be spread over the organic layer for summer operations. Floodplain access should occur at the inside of a meander to avoid trafficking incised banks at outside meanders. Crossing of other incised floodplain banks should also be avoided. If incised banks must be crossed, a removeable fill ramp should be constructed instead of cutting or notching the bank. If active channels must be crossed, crossing should be via temporary bridges, low-water crossings, or properly culverted access roads.

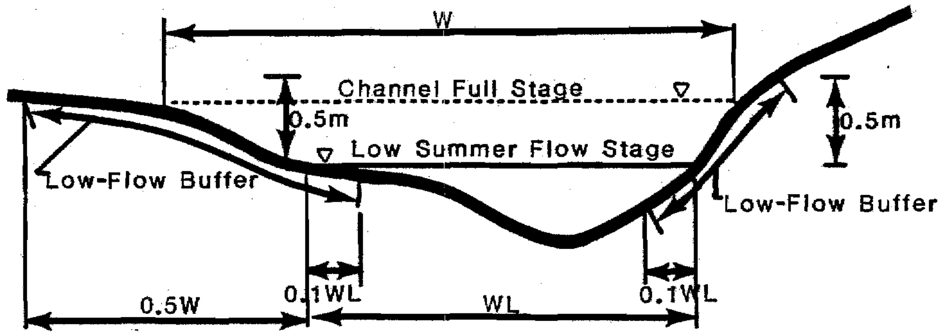
Any vegetation and organic overburden cleared during site preparation should be removed from the active floodplain and either stockpiled for restoration activities or disposed of in an approved manner.

Buffer areas of undisturbed ground surface are required for most floodplain borrow sites to maintain the integrity of active channels. Where natural buffers do not exist or are too low to be effective, man-made buffers in the form of river-training structures and bank protection devices may be necessary.

Low-flow buffers are recommended for scraping operations on unvegetated gravel bars adjacent to active channels. A low-flow buffer is a strip of undisturbed ground surface extending up the bank and beneath the water surface from the water's low summer flow level (Figure 1). The upper limit of a low-flow buffer is that point on the bank that is the lesser of the following: 1) having an elevation that is 0.5 meters (1.6 feet) above the low summer flow surface elevation, or 2) having a horizontal distance to the low summer flow water's edge which is equal to one-half the normal top width at channel-full flow conditions. The lower limit is that point on the bed that has a horizontal distance to the water's edge which is 10 percent of the top width of the low summer flow channel.

Flood-flow buffers should be used for scraping or pit-mining operations that are separated from active channels (Figure 2). The purpose of this





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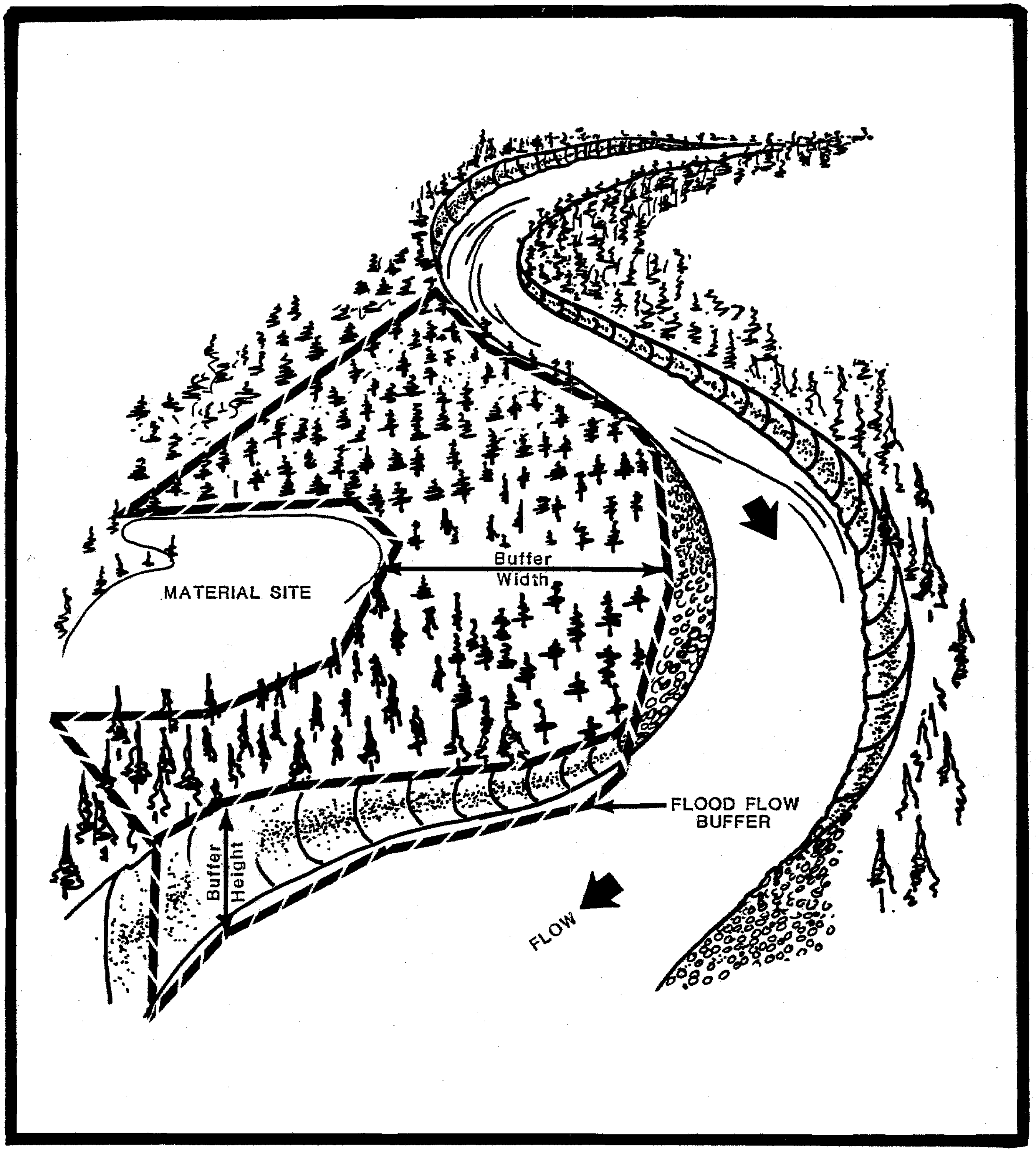
SCHEMATIC DIAGRAM OF A LOW-FLOW BUFFER

FIGURE 1



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SCHEMATIC DIAGRAM OF
A FLOOD-FLOW BUFFER

FIGURE 2

undisturbed, often vegetated, area is to prevent the active channel from diverting through the material site.

In scraping removal operations, the site should be protected by a flood-flow buffer for at least 5 to 8 years to allow re-establishment of vegetation. The height of the buffer should be at least as high as the water level during a 5-year flood. Table 4 lists minimum flood-flow buffer widths for different sites. The width can be reduced to half the recommended minimum at the downstream end of the scraped site.

For pit removal operations, the site should be protected by a flood-flow buffer for at least 20 years to provide long-term protection of this newly created habitat. The elevation of the buffer should be at least as high as the water level during a 20-year flood. Minimum flood-flow buffer widths for pit operations are listed on Table 4. The width can be reduced to 20 percent of the recommended minimum at the downstream end of the pit.

Temporary dikes should be constructed around borrow sites that would be inundated during operation. Dikes should be impermeable, high enough to prevent overtopping, and protected from erosion. They are often constructed of stone and/or earth. Side slopes should be stable and riprapped (generally, a 2:1 slope is recommended). The dikes should be constructed to minimize disturbance to low-flow channels and avoid fish entrapment.

Borrow Operation - Scraped Sites

Gravel bars adjacent to high-water and abandoned channels can be scraped to

TABLE 4

MINIMUM FLOOD-FLOW BUFFER WIDTHS

Scraping Operations

River Size	Minimum Width (ft)
Small	50
Medium	115
Large	165

Pit Operations

River Size	Minimum Width (ft)
Small	250
Medium	500
Large	800

Source: U.S. Fish and Wildlife Service (1980)

a specified level at the edge of the channel and should be sloped toward the channel to provide proper drainage. An average maximum depth (the distance between the average thalweg profile line and the channel-full stage at a point along the channel) should be maintained in the channel to provide for flow containment during periods of high flow within the channel. Approximate values of maximum depth that should be maintained for three ranges of channel-full width are listed on Table 5.

Gravel bars adjacent to active channels can be scraped to a specified minimum level and should be sloped toward the channel to provide proper drainage. The recommended lowest elevation of gravel removal is controlled by the greatest of the following three elevations:

- o The upper elevation of the low-flow buffer
- o The elevation corresponding to 6 inches above the average water level expected during the gravel removal operation
- o The elevation that will maintain a specified average maximum depth in the active channel (approximate values of maximum depth for three ranges of channel-full width are listed on Table 6)

Scraping in high-water and abandoned channels should follow the alignment of the channel. Side slopes should be stabilized for flow conditions during a 2-year recurrence interval (annual) flood. The channel-full top width should not be increased. Longitudinal slope into the material site at the upstream end should not exceed 10 times the average slope of the

TABLE 5

APPROXIMATE MAXIMUM CHANNEL DEPTHS

GRAVEL BARS ADJACENT TO HIGH-WATER AND ABANDONED CHANNELS

Braided Configuration

Channel-full width (ft)	Approximate maximum depth (in) High-water channels	Abandoned channels
0 - 15	12	2
15 - 100	20	6
100 or greater	30	20

Split, Meandering, Sinuous, and Straight Configurations

Channel-full width (ft)	Approximate maximum depth (in) High-water channels	Abandoned channels
0 - 15	15	6
15 - 100	24	12
100 or greater	40	24

Source: U.S. Fish and Wildlife Service (1980)

TABLE 6

APPROXIMATE MAXIMUM CHANNEL DEPTHS

GRAVEL BARS ADJACENT TO ACTIVE CHANNELS

Braided Configuration

Channel-full width (ft)	Approximate maximum depth (in)
0 - 15	12
15 - 100	20
100 or greater	39

Split, Meandering, Sinuous, and Straight Configurations

Channel-full width (ft)	Approximate maximum depth (in)
0 - 15	20
15 - 100	39
100 or greater	51

channel. Longitudinal slope out of the material site at the downstream end should permit channel drainage during a flow recession to prevent against fish entrapment.

Scraping in active side channels that have been diked and dewatered should follow the alignment of the channel and be confined between the low-flow buffers. Slopes of the material site should be stabilized for flows having a 5-year recurrence interval. Existing pool-riffle sequences should be retained. If water is present in an active channel scheduled for winter scraping, the site should not be operated.

Borrow Operation - Excavated Sites

When appropriate, pits should be long and narrow in shape, be aligned parallel to the river, and provide an irregular configuration. At least 30 to 50 percent of the shoreline should have a gradual slope.

Borrow pits connected to a river and those planned for restoration as fish management areas should have a mean depth of at least 8 feet to ensure winter survival of fish. Those pits connected to a river should include an outlet channel for a path of low resistance when the pit is inundated. All outlet channels should be located on the downstream end of the pit and connect to a scour area of an active channel. While outlet channels should be angled downstream, they should not be of straight line configurations. Channels should be deep enough to allow fish passage during low flow conditions. Outlet channels should be constructed at the end of site closure to minimize siltation in the river.

Borrow Operation - Dredged Sites

Active channels scheduled for winter dredging that contain flowing water should not be disturbed as these areas may provide overwintering habitat for fish. Depth of excavation in an active channel during any season should be confined to the width of the summer low flow channel minus the low-flow buffer. The length of excavation in a pool of the active main channel should be confined to the length of the pool. Length of excavation in a riffle should not exceed the average lengths of the pools within 3 miles up and downstream of the site. Slopes of the active channel site should be designed to remain stable during 5-year flood flows.

Borrow Site Restoration

Floodplain borrow sites should be returned, as closely as is possible, to natural conditions immediately following completion of operations. The work area should be sloped and contoured to minimize ponding and to blend with surrounding features. Access roads, culverts, and bridges should be removed. All cut slopes should be stabilized to prevent thermal, fluvial, and wind erosion. Water in the settling ponds should be released by pumping or lowering dikes. Silt from settling ponds may be 1) left in place in inactive floodplains and terrace locations (dikes should be lowered to the level of the impounded silt), 2) used in revegetation activities (see Section 3.8), or 3) removed to an approved disposal area. At side-channel sites which were diked to allow scraping in a dry condition, the downstream dike should be removed and the upstream dike should be lowered to correspond to the river stage of a 1.25-year flood to prevent large quantities of sediment from being washed from the site into the river at low flow conditions. Outlet channels from pits should be constructed during the final phases of site closure.

3.2 DRAINAGE STRUCTURES

The following paragraphs discuss alternative techniques to facilitate drainage and their respective advantages and limitations. Detailed design guidelines, particularly for culverts and bridges, are presented in a report prepared for the Power Authority by the Harza-Ebasco Susitna Joint Venture entitled "Drainage Structure and Waterway Design Guidelines".

3.2.1 Culverts

Culverts are used to provide streamflow and fish passage where continuous access across a stream is required and where flow, gradient and/or length of span do not mandate bridging. Crossings should be 90 degrees to the direction of stream flow. In permafrost areas, culverts should be designed to prevent ponding.

Culvert installation should occur "in the dry" whenever possible. Stream diversion or fluming may be possible in special situations. The use of a temporary dam and pumps to route water around a culvert site often is a practical method for small streams. If culvert installation occurs in flowing water, the upstream end should be sandbagged or backfilled first to immediately direct flow through the culvert. Culvert installation should not occur during frozen conditions unless channel alignment, thalweg slope, and thalweg elevation (inlet and outlet) are properly surveyed and marked before freezeup and snow cover.

3.2.1.1 Non-Fish Streams

The culvert should match the gradient of the natural channel and the depth of headwater at design flow (Q_{50}) should be no greater than 1½ times the culvert diameter. If the grade is steep or the culvert outlet is above the streambed, energy dissipators (see Section 3.2.7) may be required.

3.2.1.2 Fish Streams

Velocity of water within a culvert is one of the primary considerations in ensuring that culvert design is adequate to permit upstream movement of fish. The velocity criteria applied to any installation must generally be adequate to protect the weakest swimming upstream migrant at the time that migration occurs. The culvert velocity through which a fish can successfully swim is dependent on the length of time that the swimming speed must be sustained and, therefore, dependent on culvert length. Where the velocity criteria cannot be met, reducing the width of the road or pad at the crossing to shorten the length of the culvert may achieve compliance.

The slope of the culvert may match the natural river or streambed slope up to a slope of 0.5 percent, provided that the velocity criteria can be attained. Culverts may be installed in a natural streambed having a slope greater than 0.5 percent, provided that the culvert can reasonably be installed to maintain the appropriate velocity without danger of excessive erosion and perching.

The design flow for purposes of fish passage design must be at least the mean annual flood ($Q_{2.33}$). Headwater depth must be less than or equal to culvert diameter at the intake for the design flow ($Q_{2.33}$).

At least one-fifth of the diameter of a round pipe culvert at the outlet end must be set below the lowest elevation of the natural stream bottom. At least 6 inches of all pipe-arch culverts should be similarly set. Depth of burial of the inlet for circular or pipe-arch culverts will depend on the slope of the culvert relative to the streambed slope. The use of oversized, deeply buried culverts should be considered in situations where stream gradients make culvert velocity criteria difficult to meet or where unusually low velocities are required.

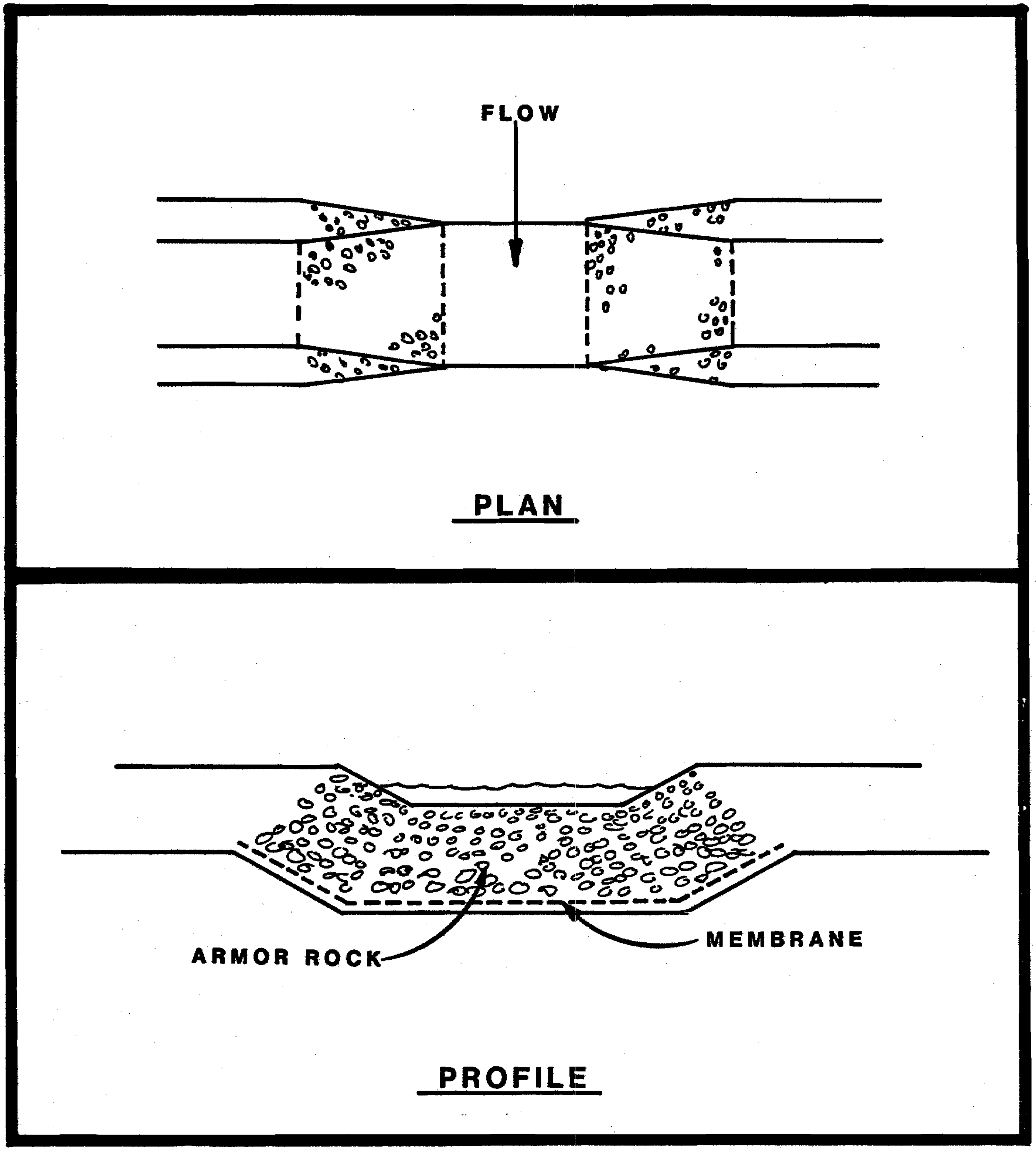
Where alignment and other conditions allow, stream crossings should be located in reaches of lower gradient. Culverts can then be placed as near horizontal as possible, allowing lower in-pipe velocities. All bank cuts, slopes, fills and exposed earth work attributable to culvert installation must be stabilized to prevent erosion during construction and the culvert's operational life. Inlets and outlets must be stabilized with riprap or other appropriate method. Hand labor should be utilized to the greatest practical extent when armoring culvert inlet and outlet areas.

3.2.2 Low-Water Crossings

Low-water crossings (Figure 3) may be used to provide passage of stream flow on roads or workpads having low traffic volumes. They are not suitable for use on high-flow streams, deeply incised streams, and areas of heavy traffic. While low-water crossings are inexpensive to install, they frequently result in more maintenance costs than initial installation costs for temporary bridges. Periodic (perhaps frequent) grading, fish blockage, sedimentation, traffic lane failure, and icing are common problems.

The intent of the low-water crossing is to match the natural geometry as closely as possible. Therefore, they are only applicable where stream banks are low and approach grades are flat. The depth of the crossing should be comparable to that in the stream. Low-water crossings in streams having intermittent or seasonably low flow should be trapezoidal. On fish streams, a minimum water depth of 4 inches must be maintained. Average water velocity within the crossing should not exceed the average velocity in adjoining stream sections. The banks and bed of the excavated crossing should be protected with rock armor sized according to the maximum flow velocity and the anticipated traffic loading. Where applicable, the streambed should be sealed to prevent dewatering through excessive subsurface flow by employing sufficiently fine material or an impervious membrane.

When constructing a low-water crossing, water flow through the disturbed streambed should be minimized. Stream diversion or fluming may be possible. The use of a temporary dam and pumps to route water around the



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LOW-WATER CROSSING

FIGURE 3

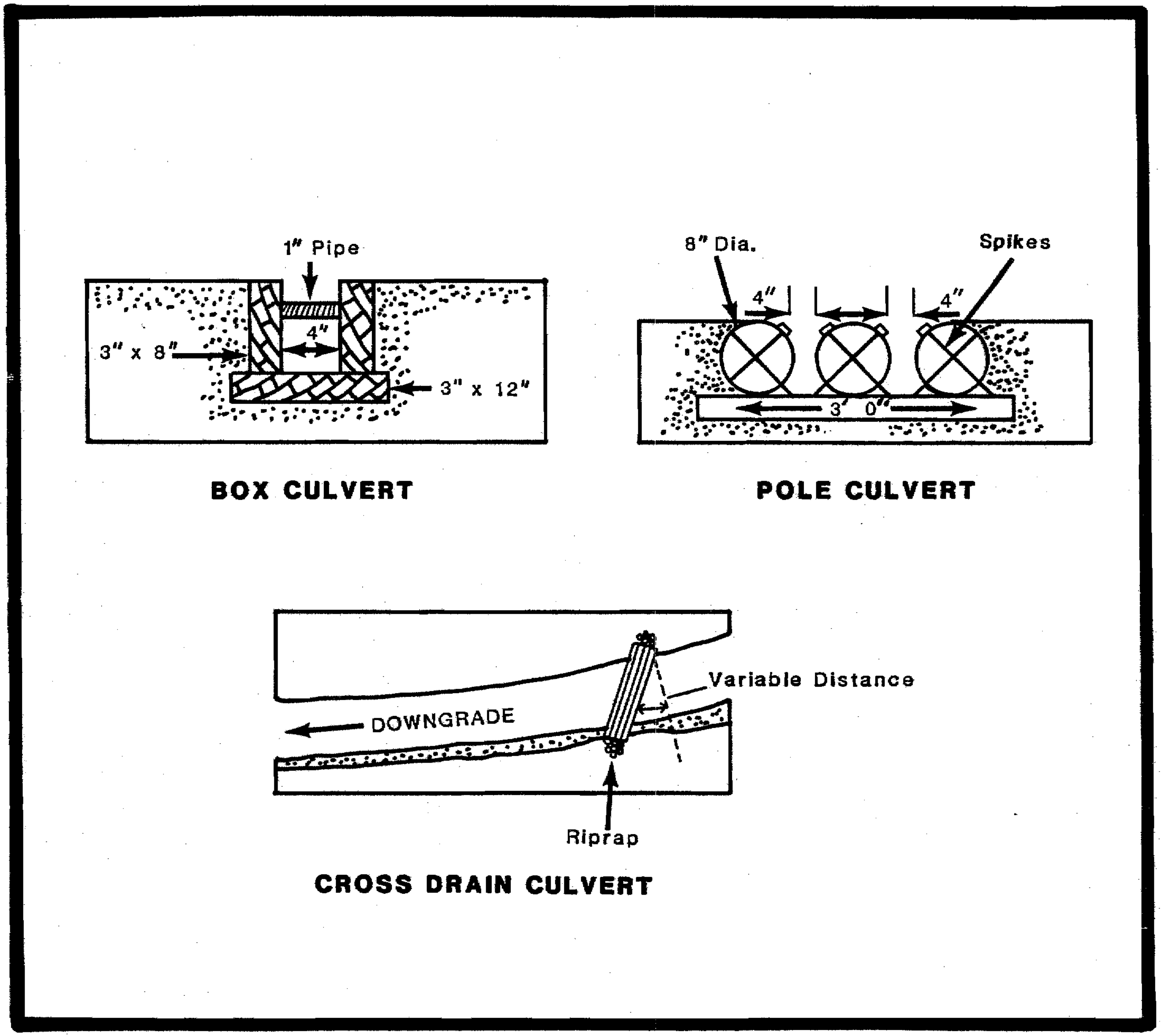
crossing site is a practical method for small streams. Temporary dams should be composed of sandbags, fill contained in visqueen, or other non-erodible materials. Bypass pumps should be adequate to avoid buildup of water behind the dam and to assure sufficient flow downstream. Pump discharge points should be naturally or artifically armored to dissipate energy and prevent erosion.

3.2.3 Grading and Cross Drains

Temporary and other unpaved roads, especially in areas of steep slopes and highly erodible soils, must be provided with adequate drainage to prevent gullying. Careful grading, using dips and pools in the grade, will break up surface flows on or parallel to a road. A cross fall of 3 percent is recommended. Berms and tracks which prevent cross drainage should be graded out. Snow berms should be removed before breakup to permit lateral drainage.

Cross drains, such as box or pole culverts (illustrated on Figure 4), can be installed across the surface of temporary roads to collect surface runoff. Round culverts can be used to intercept flow in ditches upstream of a bridge or culvert crossing, carry it across the road, and discharge it on the downstream side of the crossing to prevent erosion.

The distance between dips or crossdrains should usually be less than 100 feet for slopes over 5 percent. In silt soil areas, intervals should usually be as noted below.



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CROSS DRAINS

FIGURE 4

Slope (%)	Cross Drain Interval (feet)
10	55
8	65
6	70
4	80
2	95

3.2.4 Vegetated Channels

Vegetation can be used to protect man-made or natural channels from erosion where soil conditions, flow velocities, and slope will allow adequate stabilization with grass. While grass lined channels are the least expensive method to carry surface runoff flow, they require careful design and good maintenance to prevent gully erosion.

Generally, grass channels are not suitable for flows greater than 5 to 6 feet per second or gradients more than 10 percent. Nettings (Section 3.2.6), ditch checks (Section 3.2.5), or other techniques can be used in the channels to decrease flows or reduce gradients. Table 7 shows allowable velocities for various species of grass in erodible and erosion resistant soils.

While expensive, sodding may be required where rapid cover and protection are necessary. Overlapping sod strips parallel to the water flow can be used in relatively flat ditches that carry large volumes of water. Shingling, where grass strips are laid perpendicular to the flow, can be used

TABLE 7

SPECIES, VELOCITIES, AND SOILS FOR VEGETATED CHANNELS

Cover Species	Slope (%)	Erosion Resistant Soils (fps)	Easily Eroded Soils (fps)
Kentucky bluegrass	0-5	7	5
Smooth brome	5-10	6	4
Tall fescue	over 10	5	3
Grass mixture	0-10	5	4
Red fescue	0-5	3.5	2.5

on short grades that are steeper than 10 percent. In both methods, staking the overlapped portions will increase effectiveness.

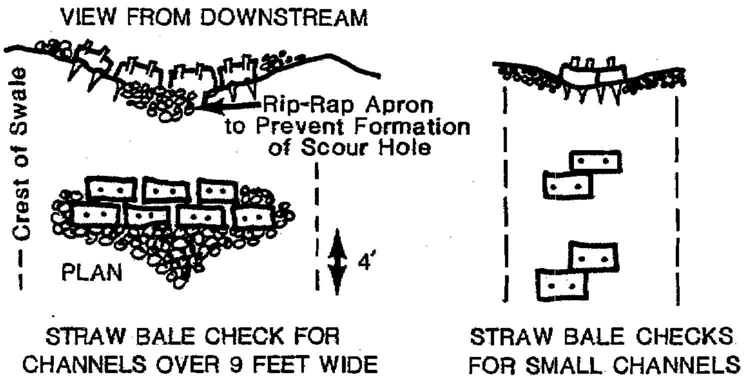
Channel sections may be V-shaped, trapezoidal, or parabolic. Parabolic cross sections have proven to be the most satisfactory. Trapezoidal sections tend to revert to a parabolic shape. Due to flow velocity distribution, V-shaped channels should not be used if channel side slopes would exceed 6:1.

Provision should be made to divert flows during construction of the channel and to avoid excessive compaction of soils. A tile drain placed offset from the center of the channel by at least one-quarter of the channel width will assist in turf maintenance. Regular mowing and a yearly application of fertilizer will increase the effectiveness of the grass channel.

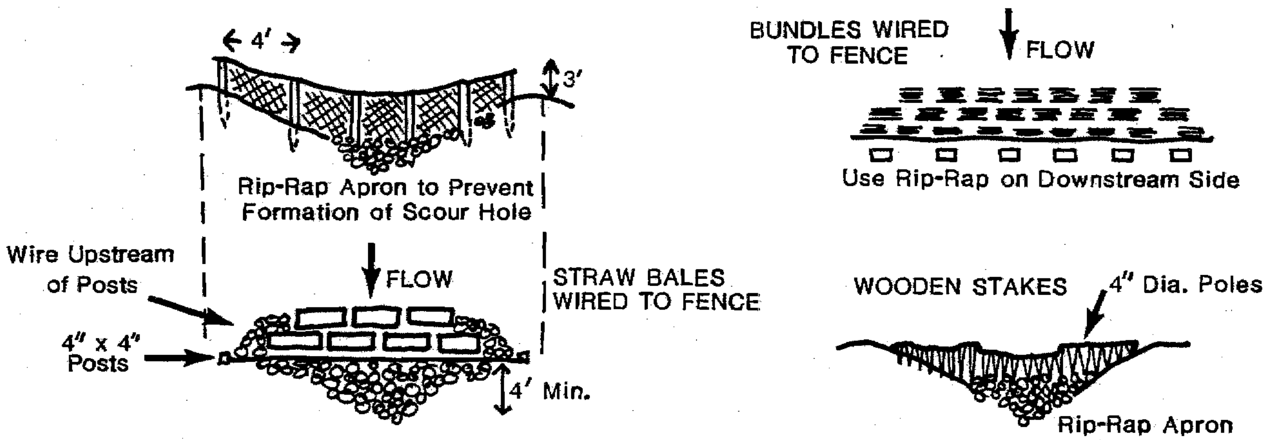
3.2.5 Ditch Checks, Check Dams

Ditch checks and check dams (Figure 5) are temporary structures used during construction to protect natural channels from construction-induced sedimentation, or to protect man-made ditches until permanent liners, such as vegetation, can be established. They are also used in steep channels as a gradient break to reduce slope. These inexpensive structures, which can be built with scrap or native materials, are used to reduce flow velocities, trap eroded sediments, and prevent gullying of the channel. They may require periodic clean-out or replacement due to accumulation of silt which will reduce flow percolation through the structure and may cause water to overtop channel banks.

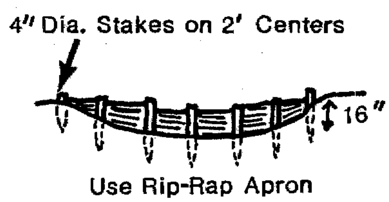
STRAW BALE CHECKS



WIRE FENCE CHECK WITH STRAW OR BRUSH



BRUSH BETWEEN TWO ROWS OF STAKES



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DITCH CHECKS AND CHECK DAMS

FIGURE 5

Straw bale checks in channels over 9 feet wide consist of bales staked with two 2½-foot wooden or metal stakes and tied with nylon cord or wire. A riprap apron is placed downstream of the bales for a minimum of 4 feet and at the edges of the bales to bring the structure to the crest of the channel. On channels less than 9 feet wide, small checks consisting of two bales may be used without riprap. They should be spaced approximately 50 feet apart.

A wire fence/straw bale check consists of a 3-foot cyclone fence nailed to the upstream side of 4-inch diameter wooden stakes which are driven across the width of the channel. Straw bales are wired together and to the upstream side of the fence. A riprap apron is placed downstream for a minimum of 4 feet.

On sites with large quantites of brushwood, bundles approximately 2 feet in diameter can be substituted for straw bales. The bundles should be tied with #9 wire, laid in staggered formation upstream of the fence, and wired together and to the fence.

Two rows of 4-inch diameter stakes with brush packed between them is another inexpensive check. The brush should be secured by criss-crossing #9 wire between the stakes.

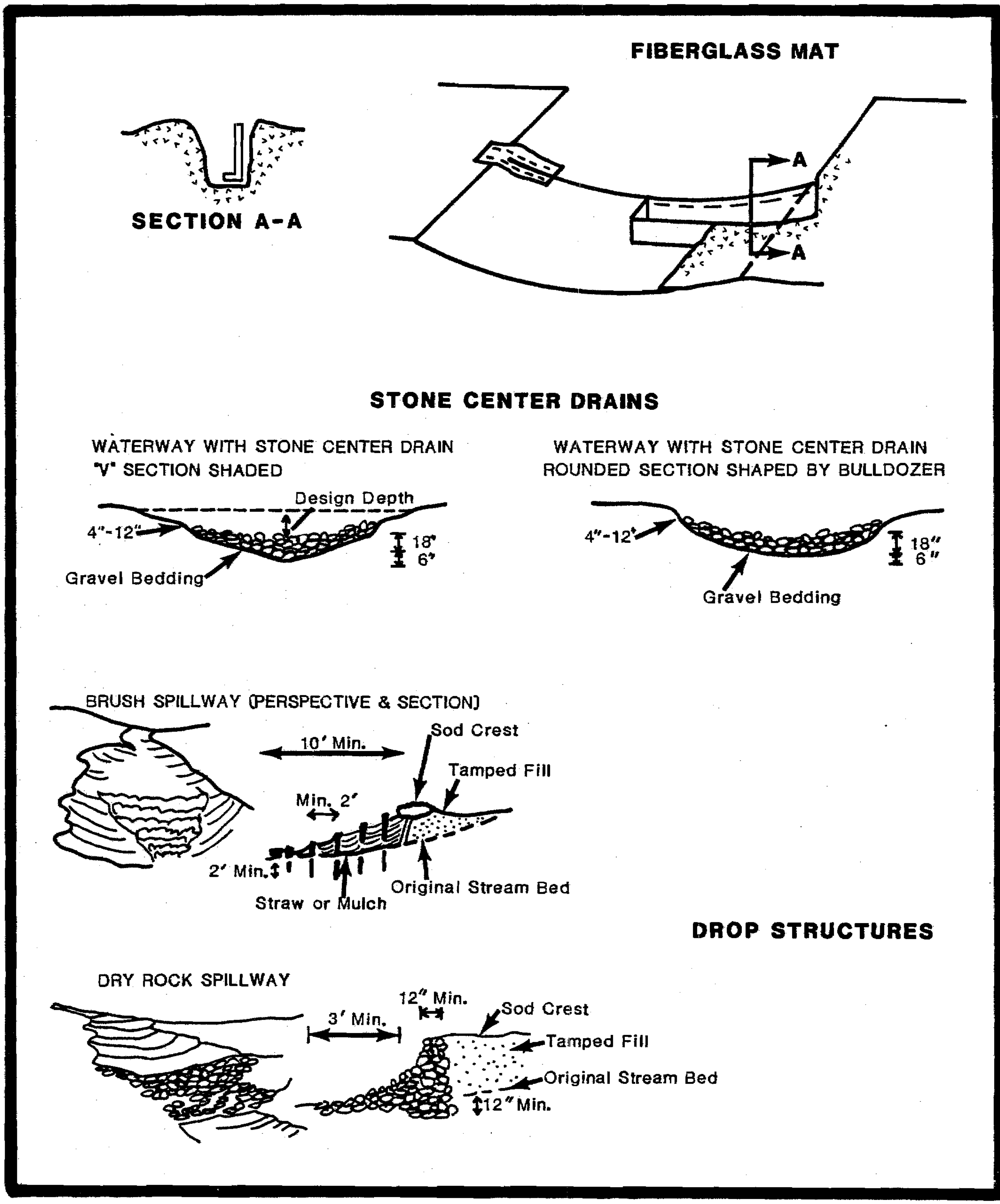
A semi-permeable check may be constructed of rock. Diameters of 9 inches are sufficient for velocities of up to 8 feet per second. One-hundred pound sand bags may be used as a check in areas where rock is not available. A riprap apron should extend at least 4 feet downstream.

3.2.6 Mechanical Channel Liners

Mechanical channel liners are used where runoff quantities, velocities, and soil conditions require greater protection than can be afforded by vegetative means. They may often be used temporarily when vegetative liners are becoming established or permanently in conjunction with vegetative liners to slow velocity and increase infiltration. The initial costs may be higher than vegetative channel liners but, with proper design and construction, mechanical channel liners have long life effectiveness. Some will require maintenance due to scour.

Nettings made of biodegradable materials are often used to stabilize newly vegetated channels. They also offer some protection on their own and are effective for medium velocities up to 6 feet per second. In large channels, where several widths of netting are required, strips of netting should overlap 2 inches at all edges and should be stabilized with hairpin-shaped wire staples. The top end of the netting should be buried in a 4-inch trench. Equipment should roll the channel to assure that the net makes contact with the soil.

A fiberglass mat (Figure 6) embedded in a 1-foot deep trench perpendicular to a drainage swale can function as a spreader to avoid the formation of gullies, allow subsurface flow without migration of sediments, and aid in establishing vegetation. Once the mat is installed in the trench and secured with staples, the trench is backfilled and compacted. Another mat or netting is centered on top of the vertical strip to form a cap extending



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MECHANICAL CHANNEL LINERS

FIGURE 6

½ foot beyond the lateral limit of the design flow. This technique is not appropriate for permafrost soils.

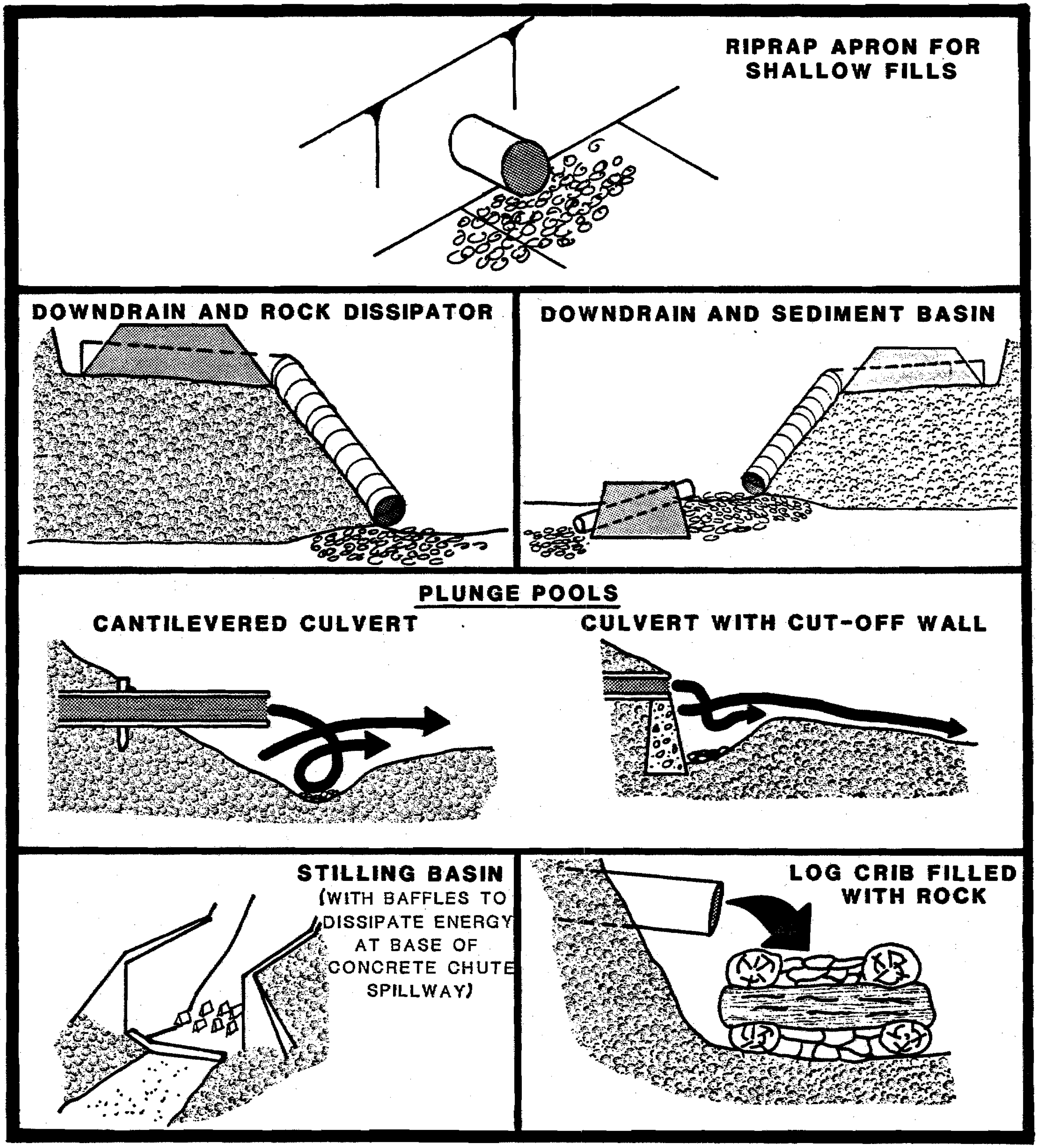
Stone center drains (Figure 6), consisting of a gravel bedding and packed stone in the center of a grassed swale, are used in drainage channels that experience prolonged flow and wetness. Acceptable flow velocities and gradients are determined by standard riprap specifications.

Methods of stabilizing banks in waterways that experience high velocity flows include latticework concrete blocks (gaps in the blocks are back-filled with soil, compacted and seeded with grass), gabions (enclosed wire baskets filled with riprap), paving, sacked sand, and concrete filled mattresses.

Drop structures (Figure 6) and check dams are used to counteract gully erosion by reducing the channel gradient and are preferred over impermeable concrete or asphalt linings when physical conditions are too severe for the establishment of a vegetative cover. Materials can consist of timber, rock, gabions, concrete, brush or sod. Energy dissipators in drop spill-ways will collect silt and debris and require cleaning.

3.2.7 Outlet Protection

A variety of techniques (Figure 7) can be used to slow the velocity of flow at drainage structure outlets. The choice of protection depends on 1) soil and topography, 2) anticipated flows, and 3) height of fill or outlet. None of these techniques discussed below should be used where fish passage



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OUTLET PROTECTION
FIGURE 7

is required. Structures which impound water should not be used in permafrost soils.

Outlet protection for culverts in shallow fills can be accomplished with protective aprons of dumped rock, hand-placed riprap or rock-filled gabions. The width of the apron should be three times as wide as the culvert. Height should be to or above design high water. Depending on soil conditions, filter layers may be required under the apron.

Flows from culverts in high fills can be directed through a downdrain to a rock dissipator or to a sediment basin.

Plunge pools should be used only for free outfall. An armor layer, perhaps underlain by filter layers, is required for the base of the pool to prevent the flow from undermining the toe of the embankment. While aesthetically undesirable, the end section of the culvert can be cantilivered and supported with wood or concrete. A second method is to support the end of the culvert with a cut-off wall that extends into the ground below the anticipated depth of scour.

Stilling basins with energy dissipators can be used at the outlets of chutes, spillways, flumes, or downdrains. The outlet should be shaped to conform to the receiving channel.

Log-rock cribs can be used for free outfalls and at downdrains. If soil conditions permit, the cribs can disperse the discharge to overland flow.

3.2.8 Inlet Protection

Inlet protection consists of a variety of structures located upstream from a culvert. The devices protect the culvert from debris accumulation that may cause flooding and erosion. Regular removal of debris is required to allow full culvert capacity during high flow. These devices should not be used on fish streams.

- Debris Deflectors--usually "V" shaped structures placed upstream from the culvert to prevent the major portion of the debris from entering the culvert. The apex of the "V" is upstream.

- Debris Racks--rails placed across the stream channel to collect debris before it reaches the culvert entrance. Usually vertical and at right angles to the stream flow.

- Debris Risers--closed-type structures, usually of metal piping, placed directly over the culvert inlet in log-cabin fashion to prevent inflow of coarse bed load and light floating debris.

- Debris Crib--open crib-type structures placed vertically over the culvert inlet in log-cabin fashion.

- Debris Fins--walls built upstream of the culvert and aligned with the direction of flow to direct debris through the culvert.

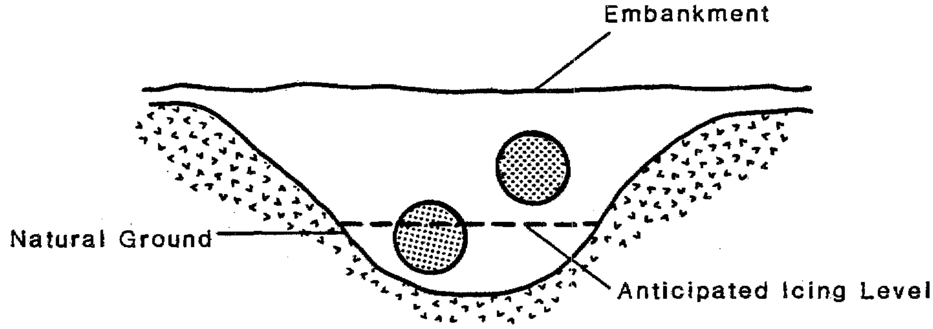
- Debris Dams and Basins--structures placed across well-defined channels to form basins which impede the stream flow and provide storage space for deposition of debris.

3.3 ICING CONTROL

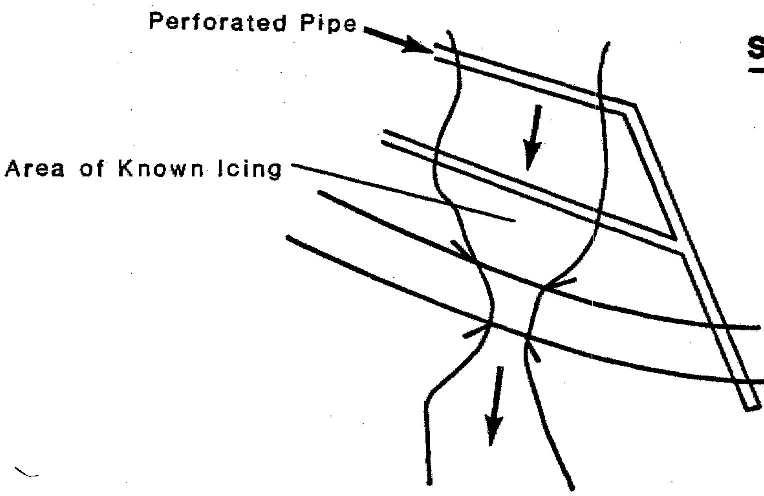
3.3.1 Stacked Culverts and Subsurface Drains

Stacked culverts (Figure 8) provide a relief route for meltwater at an ice-dammed culvert, thus eliminating the need to thaw the culvert at breakup. The drainageway requires a deep fill section and enough storage area for ice accumulation during winter, without plugging the upper culvert. Offsetting the upper culvert reduces the amount of fill required. Offset culverts also provide for fish passage in streams which experience wide fluctuations in flow.

Subsurface drains (Figure 8) are used where topography is steep to allow diversion of subsurface stream flow and exit downstream of the structure to be protected. The subdrain is for low flow only and should not be used to replace the conventional drainage structure. Perforated pipes are placed upstream of the icing area and in a trench across the stream to intercept sub-bed flow and allow filtration of low stream flow. Within the stream channel, the trench should be backfilled with coarse material to allow infiltration. Outside the channel banks, insulation should be placed over the subdrain to prevent freezing. Subdrain outlets must be designed so they will not freeze or so they can be periodically thawed.



STACKED CULVERTS



SUBSURFACE DRAIN

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STACKED CULVERTS AND SUBSURFACE DRAINS

FIGURE 8

Subsurface drains also can be used to reduce artesian head at the roadside beneath seasonal ice. For a subdrain to function effectively, surface flows must be intercepted at the source (since the icing layer is impermeable) and the drain must be buried below maximum freezing depth. Outlets are downslope from the road embankment.

3.3.2 Culvert Thawing

Culvert thawing may be required to maintain winter flow or provide passage of spring meltwater.

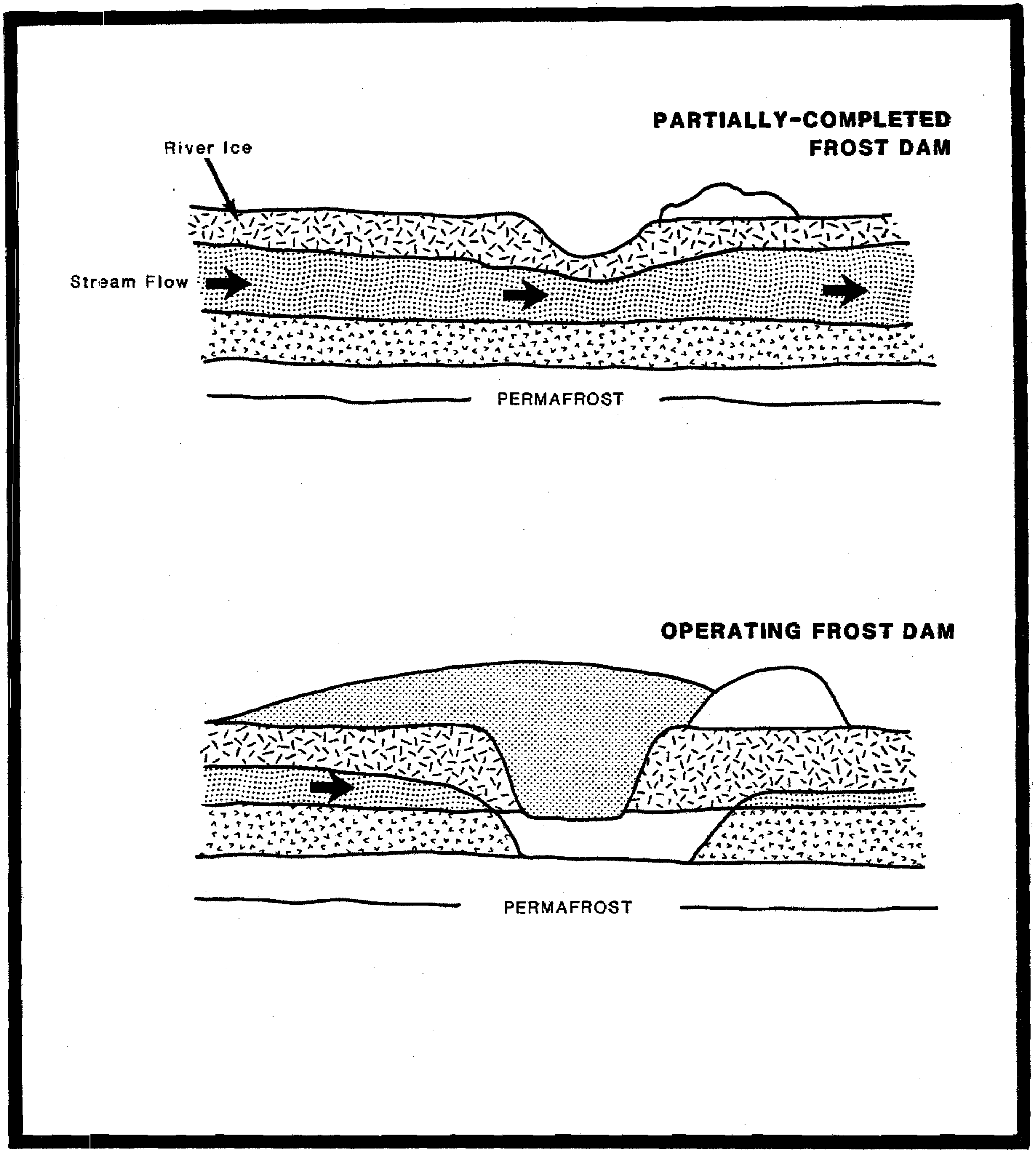
Thaw cables are electrical heat cables used to maintain an open passageway through a culvert. An electrical resistance-type cable is either buried below or suspended inside the culvert.

Steam thawing is suitable for ice-blocked culverts that are accessible to a truck mounted boiler. Thawing can be done by probe or by permanent piping.

3.3.3 Channel Maintenance

Techniques to maintain winter flow through a channel or to induce icing at some location that will not require maintenance include frost belts, air-ice covers, and ice fences.

Frost belts (Figure 9) are constructed by excavating a ditch in the ice 10 to 12 feet wide to the streambed. The ditch progresses downward as the ice



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FROST BELTS

FIGURE 9

below the ditch thickens. A drainage ditch may be required to remove accumulated water downstream. Frost belts must extend well beyond the stream edges. Extension ditches on the banks may be excavated before freeze-up at the selected site, which should be between 600 and 900 feet from the structure. Additional dams should be at least 60 feet apart. Frost belts are best constructed where stream ice usually freezes solid to the bed, as in shallows or near rapids.

Air-ice covers are created by temporarily damming the stream early in the winter and allowing the water to back up through the culvert. The dam is placed a short distance downstream from the culvert and should retain a degree of permeability. After the ice cover freezes to a depth of 5 to 6 inches, the dam is removed. With free flow restored, the water level drops so that an 8 to 15 inch air gap remains. The intervening layer of air usually will insulate the flowing water sufficiently to prevent freezing. Insulation, such as snow, peat, brush or other available materials, may be applied to the ice layer and removed in the spring. Where a broad channel is encountered, additional support for the ice cover may be provided in the form of short wooden or concrete posts acting as columns. Temporary check dams may be required at large icing sites.

A wide variety of materials can be used to form a fence upstream from a culvert or bridge to store ice accumulation. Upstream storage area must be large enough for a winter's accumulation of ice. If avenues open below the fence for water to pass upward through the ice, the fence will be ineffective.

3.4 STREAM PROTECTION

3.4.1 Protection During Crossing and Construction

When construction activity repeatedly crosses active streams, particularly fish streams, or when construction is immediately adjacent to streams, stream protection from erosion and turbidity is required.

Seasonal timing of construction may reduce the impact of construction. Where construction schedules or habitat sensitivity create conflicts, techniques for stream protection should be employed. Periodic inspection for erosion or sedimentation may be required.

Construction dikes and cofferdams can be used to separate the waterbody from the construction area. Construction dikes are placed on the stream side of a construction area. Placement of these structures must not constrict the channel to avoid increasing velocities that could cause channel erosion and obstruct fish passage. Cofferdams completely enclose an instream work area while permitting flow to continue through the channel. While cofferdams cause minimal disturbance to the channel, they are usually expensive to build.

Stream channel diversions should be avoided whenever possible. Temporary diversion channels must be capable of carrying flows anticipated to occur during the construction period. The average water velocity within the channel should not exceed the average velocity in the natural stream. The bed of the diversion channel must be stable at expected flows. During construction and excavation, the channel should be isolated from the stream to be diverted by natural plugs left in place at the upstream and downstream ends. Diversion of water flow into the temporary channel is accomplished by first removing the downstream plug, then removing the upstream plug, then closing the upstream end and then the downstream end of the natural channel of the diverted stream. Abandoned diversion channels must be backfilled or plugged and stabilized.

During ditching operations across small streams, it is often practical to pipe (flume) stream water over the ditch while excavation is in progress. With this procedure, a culvert or other pipe is installed in the stream prior to ditching with all stream flow directed through the flume. The ditch is then excavated underneath the flume and the structure to be placed in the ditch is installed. After installation, the stream channel is restored prior to removing the flume.

Temporary culverts can be installed under temporary roads and work pads to contain stream flow and allow fish passage. Low-water crossings (Section 3.2.2) may be a practical method for small streams.

3.4.2 Bank Stabilization - Revetments

Mechanical streambank stabilization is for the prevention of erosion at critical areas where velocities are too great for vegetative stabilization. Materials consist of riprap, concrete, grouted stone, gabion baskets, and bagged concrete. Generally, most failures occur at the toe, where scour can undermine the lining.

Planning for permanent bank stabilization must consider the following:

- Controlling the grades of the banks either by natural or artificial means, before permanent stabilization is feasible

- Debris or obstructions that may deflect flow toward the bank

- The greatest depth of scour

- Additional stabilization measures, i.e. vegetative cover on the top of slope banks

- The physical and biological impact the modifications will have on the stream

These permanent techniques have high costs. Construction may require hand labor and may be particularly difficult in deep water. Maintenance may become expensive for obstruction inspection and clearing.

The smooth lining of rigid concrete revetments will accelerate the velocity of stream flow that may induce scour downstream. Rigid revetments require good access and dewatering of the streambed for construction. To prevent settling and cracking, they should be used only on well compacted soils. The revetment lining should extend beyond the top of the bank where it is stabilized with vegetative. The toe should be extended to the maximum scour depth anticipated and be protected with riprap. Each concrete joint requires reinforcement to prevent leaking and undermining.

Concrete-filled nylon blankets are revetments consisting of nylon fabric sheets that are stitched together as a quilt, fixed in place, and filled with concrete. These blankets are capable of withstanding small movements and are less susceptible to undercutting than rigid concrete revetments. Installation requires dewatering of the channel. This technique is not recommended for slopes steeper than 1:1.

Dumped stone forms a flexible lining that slumps into scour holes. The rough surface of the stone dissipates the stream's energy, thus minimizing scouring problems at the ends of a revetment or lining. Linings and revetments of hand-placed riprap generally consist of 100-pound stones placed in a single layer. Any shifting of the stone exposes bare soil and is therefore, more subject to damage than dumped stone. Grouted stone revetments are sometimes used when large stones are unavailable to stabilize dumped stone linings. This technique will reduce the roughness of the lining and increase flow velocity which may enlarge any holes or flaws in the grouting and lead to failure.

When large stone for a dumped stone or riprap lining is unavailable, wire baskets or wire mattresses filled with smaller stone may be acceptable. Gabions are easy to install with minimum instream disturbance. Gabion baskets may be placed on steeper streambanks than gabion mattresses. Gabion mattresses may be placed in deep water by sliding them off a raft.

3.4.3 Bank Stabilization - Deflectors and Jetties

Deflectors and jetties are placed on the outside bends of streams to deflect stream flow away from an eroding bank or to prevent meandering and encourage the stream to increase channel capacity by scouring its bed rather than by lateral cutting. Jetties and deflectors should not be used where the stream cannot compensate for restriction in channel width or in fish spawning areas. Because jetties produce excessive eddying, they should not be used in very sinuous channels.

3.4.4 Bank Stabilization - Vegetative

Vegetative bank stabilization is applicable for small streams and low gradient streambanks to prevent or control erosion and sedimentation. Little maintenance is required especially after the first few years when vegetation is well established. If soils and flow dictate, vegetative bank stabilization can be supplemented with mechanical techniques. Vegetation should be incorporated behind revetments, jetties, gabions, etc. on the banks behind the design flow.

3.5 SEDIMENT RETENTION

3.5.1 Settling Ponds

Settling ponds are used in non-permafrost areas for retaining runoff waters to remove sediments generated from construction and borrow activities. They can range from large permanent-type basins to temporary measures such as ditch checks. Generally, a settling pond consists of a dike, a pit, and an outlet for clean water. The effectiveness of a settling pond depends upon:

- o Surface area of the pond
- o Rate of flow through the pond
- o Grain size distribution of the incoming sediment
- o Specific gravity and shape of incoming solids
- o Water temperature
- o Turbulence within the pond as a result of wind or rainfall
- o Entrance and exit effects

To the extent possible, settling ponds should not be located in streambeds or floodplains. The ideal site is on or underlain by a thick layer of fairly impervious soil.

Settling ponds must be sized so that the effluent is in conformance with Alaska Water Quality Standards. Removal of suspended soils particles larger than 0.02 millimeters is usually necessary to consistently meet this limitation. The maximum surface overflow rate (the flow rate through the pond, divided by the surface of the pond) to permit sedimentation of 0.02-millimeter particles is 3,700 gallons per minute per acre (0.011 ft/minute). Ponds should be constructed with a length that is at least twice the width. A length-to-width ratio of 5:1 or greater is desirable. Depth of a pond, while not a factor in settling efficiency, must be considered for sediment storage. Use of flocculants to enhance the settling process to subject to approval from regulatory agencies.

Containment dikes for settling ponds should usually not exceed 10 feet in height. They should have a crest width of at least 12 feet and upstream and downstream slopes of 2:1 or flatter. The core of the dike must be impermeable and should extend through surficial pervious foundation soils into underlying bedrock or other impervious soils.

Outlets should be constructed to limit the level of the water surface to at least 1 foot below the top of the dike. Outlet structures may be constructed as overflow spillways or culvert pipes with risers. At least one overflow or riser should be provided for each 150 feet of pond width to limit nonuniform flow velocities through the pond.

Erosion protection on the downstream slope of the containment dike and at the toe of the overflow should consist of a minimum 2-foot thickness of angular rock, averaging 8 inches in diameter. The crest of the overflow should be protected with at least a 1-foot thickness of 4-inch angular rock. The width of the overflow should be at least 1 foot for each 400 gallons per minute of flow through the pond.

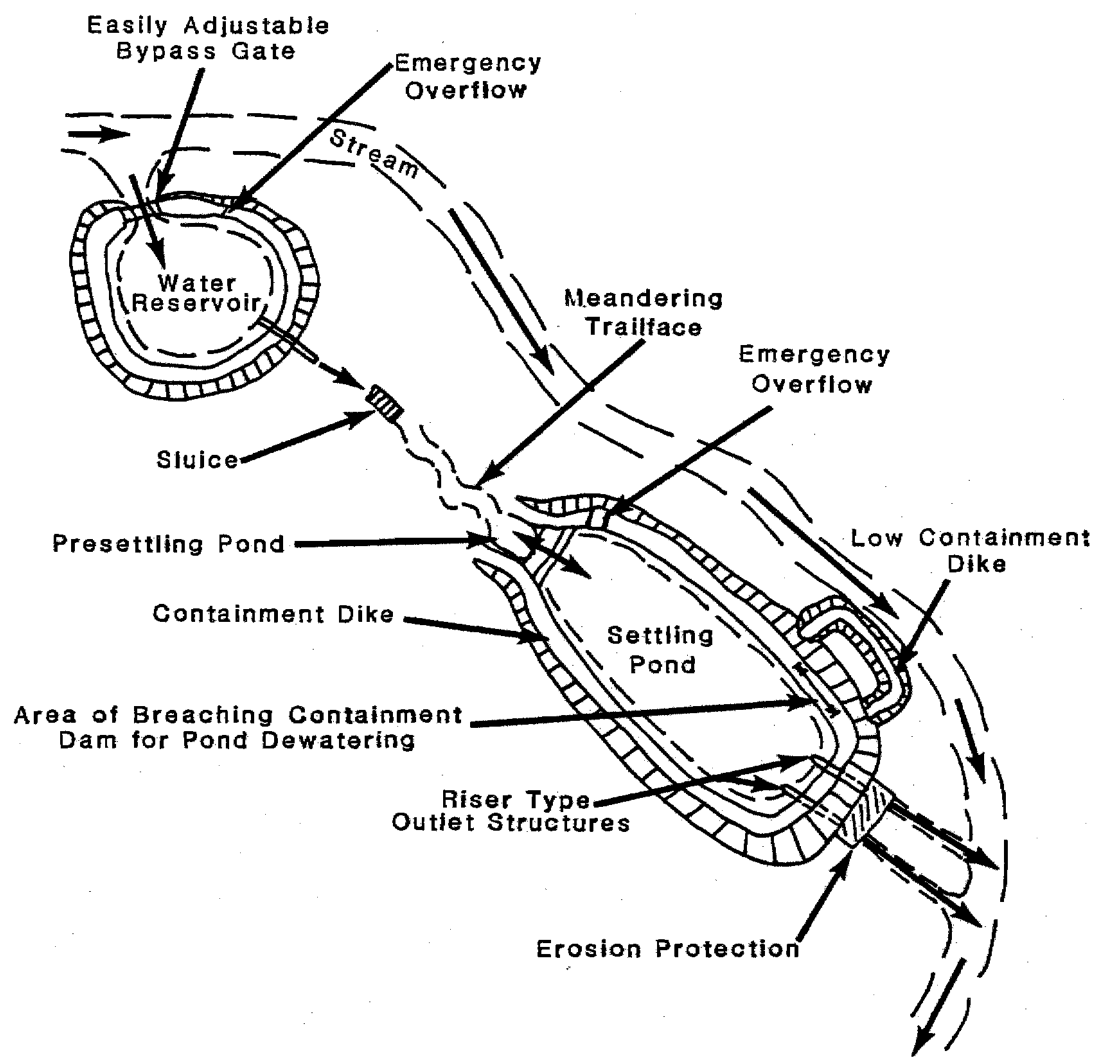
Riser outlet pipes should have a diameter of at least 18 inches. At least 1 inch of pipe diameter should be provided for each 100 gallons per minute of flow through the pond. Several cutoff collars should be installed around the portion of the pipe that passes through the containment dike to prevent erosion of fill materials by seepage along the pipe. Collars may consist of sheet metal, polyethylene sheeting or other impervious materials and should extend at least 2 feet beyond the pipe. An apron of large rock should be placed at the pipe outlet to prevent erosion at the toe of the dike.

Settling ponds used in borrow operations to contain water from gravel washing (Figure 10) may be more effective if sluiced material is discharged to a meandering tailrace that leads to the pond. Construction of a small presettling pond at the pond entrance will reduce inflow velocities and result in additional deposition of coarse sediment before it reaches the pond. The surface area of the presettling pond should be about 1 square foot for each gallon per minute of flow through the pond. Frequent removal of coarse sediments from presettling ponds may be necessary.

Reuse of process water can reduce the quantity of water to be treated. Normally, presettling of the sluice discharge would be desirable to remove coarse sediments before the water is recirculated back to the sluice.

Cleaning of settling ponds should be accomplished when the pond is filled with sufficient sediment to lower the quality of water discharged below acceptable standards. Monitoring pond effluent with an Imhoff cone is the usual method to determine if the pond is becoming ineffective. Cleaning can be performed with a dragline. Removed sediment should be transported to an approved waste area.

If clearing is impractical, or if the pond is to be abandoned, it should be drained and covered with granular material. Draining can be accomplished by breaking the containment dike, provided that a lower containment dike of permeable material is constructed downstream of the pond outlet to prevent accumulated sediments from entering a stream.



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GRAVEL WASHING
SETTLING POND LAYOUT

FIGURE 10

3.5.2 Buffer Strips, Barriers

Buffer zones of undisturbed ground and vegetation, and man-made barriers, are techniques to retard runoff, increase infiltration, and contain sediments eroded from construction areas.

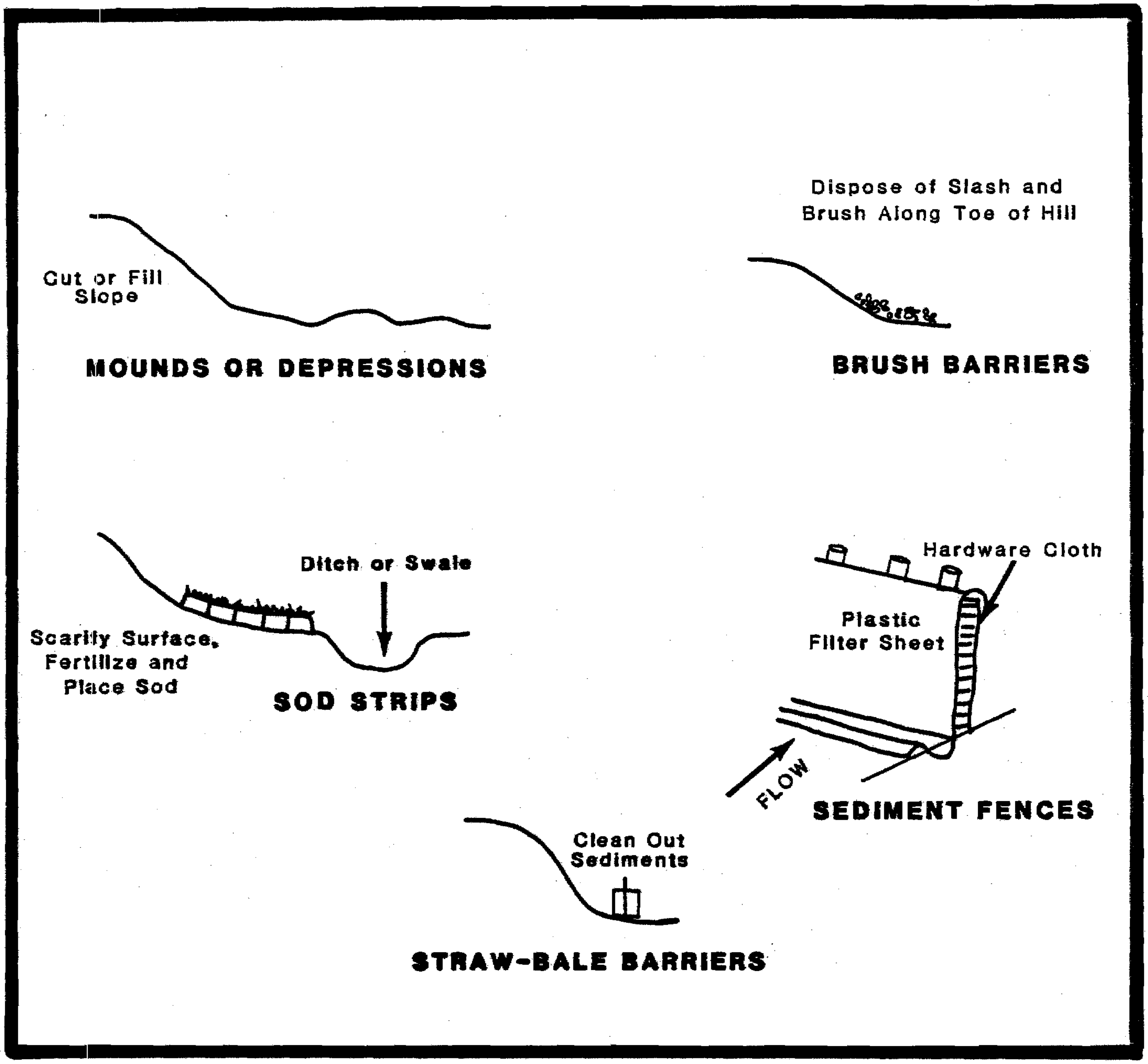
Whenever possible, buffer zones should be left between construction areas and drainages or waterbodies. In most instances, these zones should be 500 feet wide. The use of buffer zones in floodplain borrow sites is discussed in Section 3.1.3.4.

Man-made barriers constructed at the toe of a slope are shown on Figure 11. Some maintenance is required to remove accumulated sediments, especially if these techniques are intended to be permanent.

3.5.3 Traps and Filters for Inlets

Traps and filters are normally applied as temporary measures during construction to prevent eroded sediments and debris from entering natural or constructed drainages. Vegetative or mechanical techniques are used depending on the size of the structure, the anticipated flows and sediment quantities, the maintenance requirements, as well as cost.

Examples of these techniques are discussed in Sections 3.2.5 and 3.2.8.



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SEDIMENT BARRIERS

FIGURE 11

3.5.4 Silt Curtains

Silt curtains are temporary measures used to intercept sediment from construction activities adjacent to waterbodies. They are installed in the waterbody. The intent of the curtain is to prevent muddied water caused by construction activity from spreading over the entire body of water. They are not affective for streams where turbulent flow will prevent settling, deep lakes, or where there is wind induced mixing.

The curtain can be constructed of heavy plastic, canvas, or other suitable material that is of sufficient strength and density to withstand wave action and infiltration of fine-grained material. The curtain is generally fastened to the shore at both ends and fitted with anchors and flotation devices so that is remains in a vertical position.

3.6 SLOPE STABILIZATION

3.6.1 General Techniques for Non-permafrost Areas

Listed below are vegetative and mechanical techniques available to provide temporary or permanent stabilization of slopes. The selection of the appropriate technique is determined by the soils, ground water, and precipitation. In soils where a saturated condition results in liquification or slumping, preferred methods could include paving slopes or ditches and constructing diversion ditches for maximum non-erodible velocities. If soils are not saturated and slumping is not anticipated, methods should be selected to maximize infiltration.

- Serrated Cuts--reduce the velocity of runoff and collect sediment. They are not recommended for saturated slopes where sloughing may occur. Serrated cuts are appropriate in fragmented rock or shale materials.

- Pavement or Riprap--appropriate in high risk slopes of saturated soils where immediate protection is required. Pavement and riprap are expensive and may be difficult to install and maintain.

- Diversion Ditch--appropriate for cut slopes in erodible soils where there is sufficient slope to prevent ponding and saturation. These ditches divert runoff through stable channels and outlets.

- Benches or Fill Berms--reduce the angle of the slope to slow runoff and facilitate seeding and other maintenance programs.

- Slope Drains--prevent gullying erosion by carrying runoff down the slope in a drain. Energy dissipators may be required at the outlet.

- Diversion Berms--made of stable non-erodible material placed temporarily or permanently at a slope crest to divert runoff away from the face of the slope.

- Sodding--immediate, permanent and expensive cover for critical cut or fill slopes.

- o <u>Seeding and Mulch</u>--provide a permanent or a temporary cover on cut or fill slopes (see Section 3.8).

- o <u>Temporary Cover</u>--netting, plastic sheeting, or other material used on steep cut or fill slopes for stabilization until permanent measures can be taken. Plastic sheeting may be difficult to secure.

3.6.2 Temporary Downdrains

Temporary downdrains can be effective methods during construction to safely convey runoff from one elevation to another until permanent stabilization is established. These downdrains can be used on cut or fill slopes or as a channel gradient break to reduce velocities. Temporary downdrains can be extended as construction of the slope progresses, and can serve as an inlet to channels or as a transition from grassed to open waterways.

These structures usually require a diversion and a collection system to intercept and direct runoff to the downdrain. Energy dissipators are usually required at the outlet of the downdrain.

Each structure should be periodically inspected and any damage repaired immediately. Inlets should be examined for undermined slopes. If snow removal equipment is used, care must be taken to prevent damage to the buried structure. When the temporary downdrains are removed, the slopes should be restabilized.

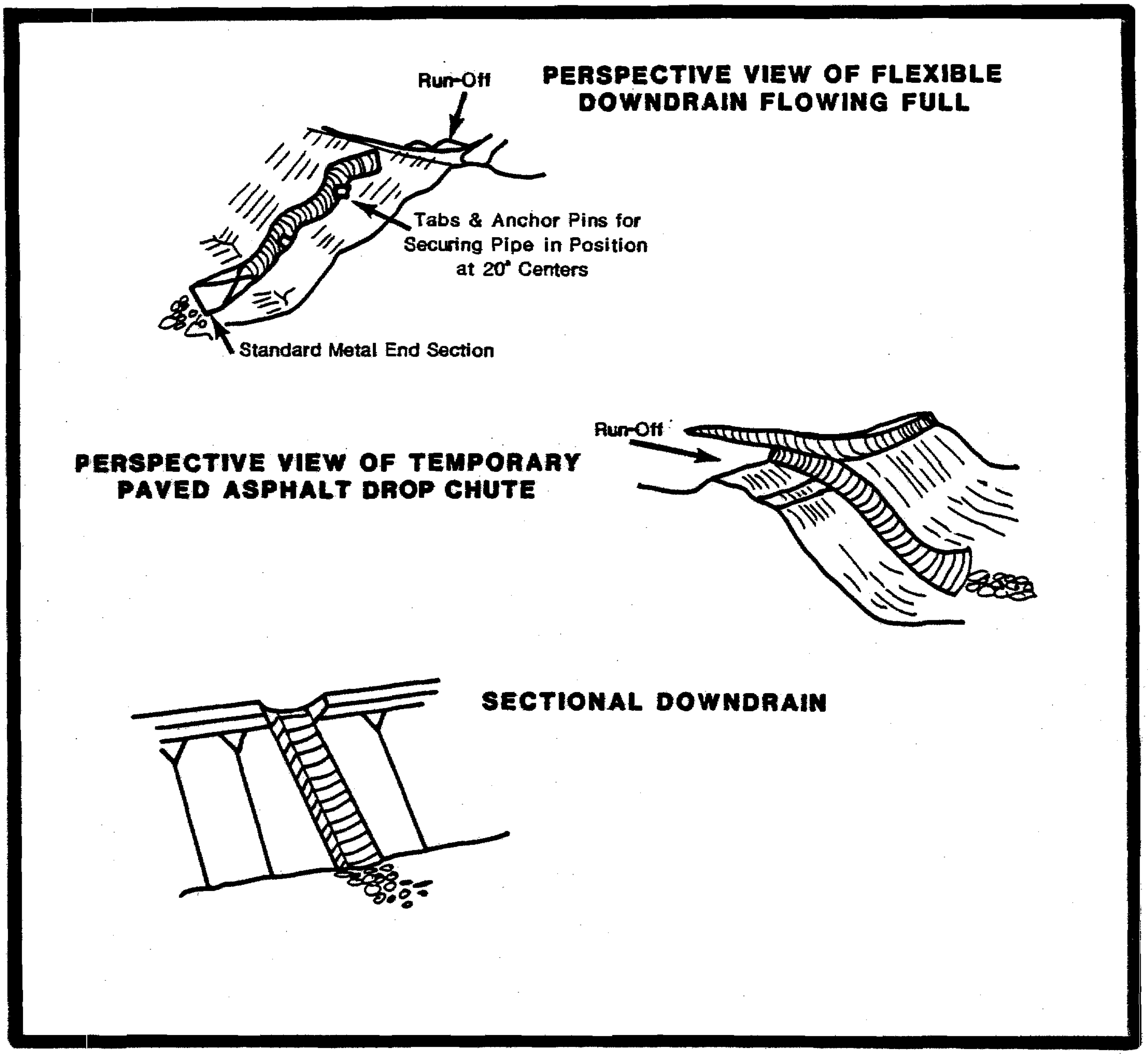
Sectional downdrains (Figure 12) are normally constructed of one-half to one-third of round culvert sections which are secured together and fastened to the slope to prevent leaking and erosion underneath the downdrain. Sectional downdrains can easily be extended as slope construction progresses.

Paved chutes (Figure 12) are generally constructed of asphalt. They are most successful on cut slopes. An asphalt apron should extend at least 3 feet beyond the toe of the slope. The inlet should be designed and constructed to prevent runoff piping underneath the chute.

A flexible downdrain (Figure 12) consists of a flexible conduit (i.e. heavy fabric) that is anchored to prevent movement. They are especially appropriate for benched or terraced slopes. Fabric conduits are not recommended for winter use as freezing could damage the fabric and result in leaking.

3.6.3 Permanent Downdrains

Permanent downdrains (Figure 13) are used to transport runoff down cut and fill slopes, as inlet or transition structures to transport water from a channel at a higher elevation to a lower one, and to provide non-erosive gradient breaks to reduce channel velocities. They are usually used when flows are continuous or runoff quantities dictate a permanent level of protection. Corrugated pipe, bituminous concrete, or cement are often the materials used for permanent downdrains. The cross section can be trapezoidal, parabolic or U-shaped. Energy dissipators are usually required at



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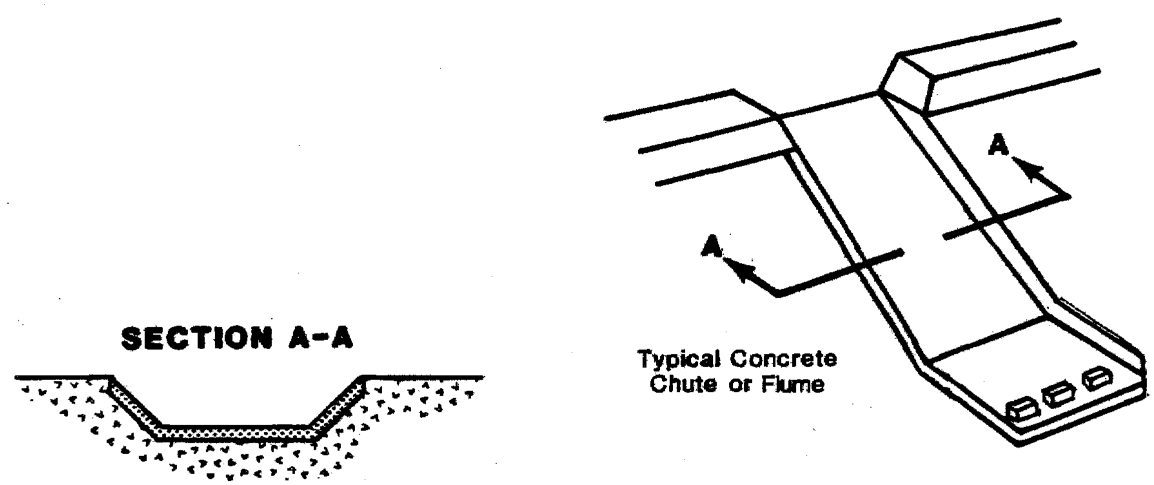
TEMPORARY DOWNDRAINS

FIGURE 12



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PERMANENT DOWNDRAINS

FIGURE 13

the outlets. Inlets and outlets of downdrains should be checked for undermining and erosion. Accumulated debris should be removed.

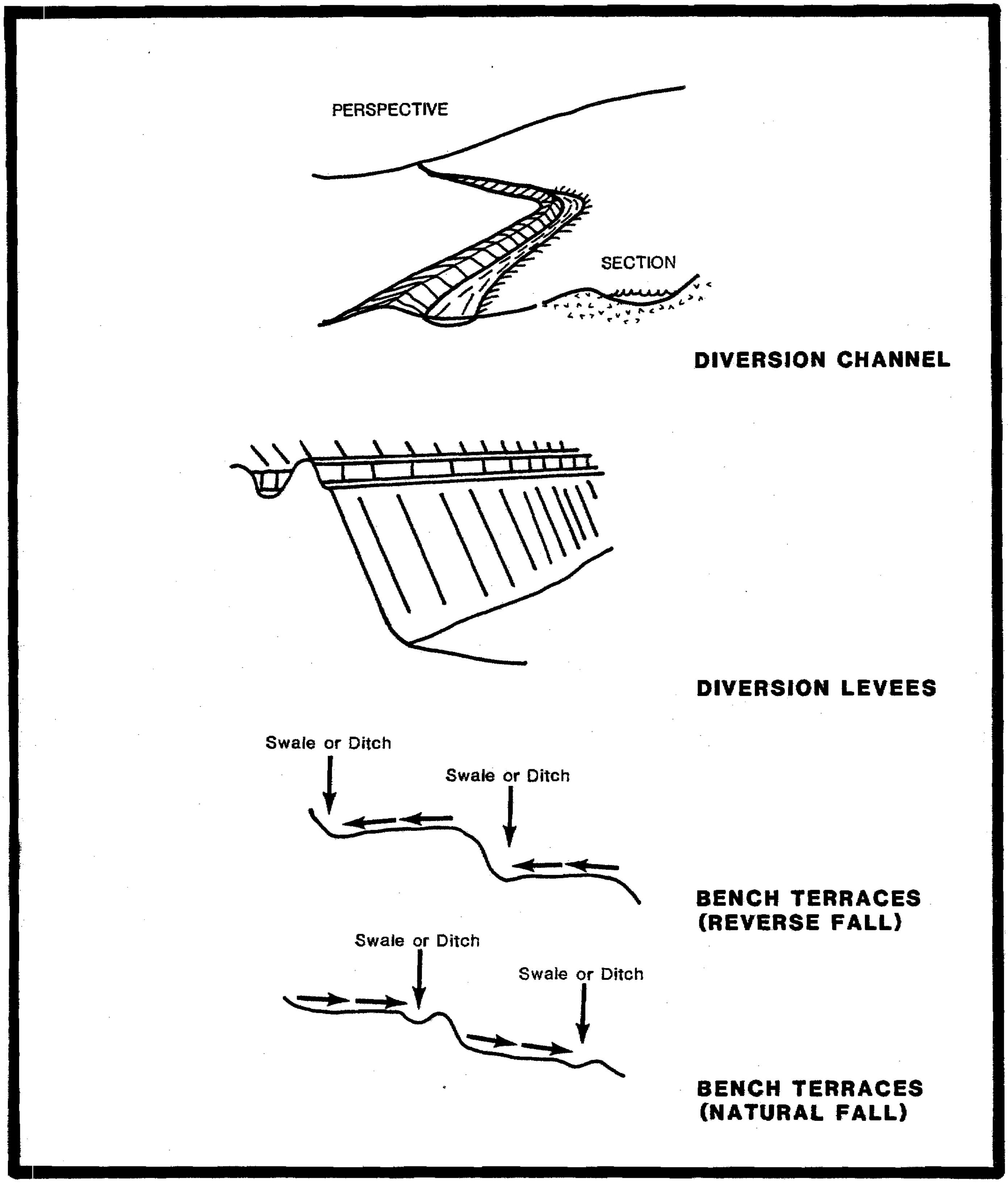
3.6.4 Diversions and Benches

Diversions and benches (Figure 14) are intended to divert runoff water and sediments away from critical areas and convey them to a stable outlet. They may be a temporary measure to protect exposed construction sites or a part of a permanent stabilization plan. Diversions and benches, such as those listed below, can break up concentrations and velocities of water on long, gentle slopes or divert runoff from steep, erodible areas.

- Diversion Channel--a channel with a confining berm downslope constructed laterally across sloping areas. Runoff is conveyed laterally at slow velocity to protected area or outlet channel.

- Diversion Levees--compacted earth ridges placed laterally along the top of steep slopes or cut sections. Often constructed with a diversion ditch upslope to convey runoff to a downdrain or stable outlet.

- Benches--flat areas built along the contours of a slope and parallel to one another. If wide enough, equipment access may be provided. Benches are built with a natural or reverse fall, often with a swale at the lowest point.



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DIVERSIONS AND BENCHES

FIGURE 14

Design is usually based on a 10-year frequency storm. If overflow would be a hazard to water resources or structures, a design frequency of 50 years may be needed. Location and spacing of diversions will depend on slope soils and estimated runoff. Channel gradients are usually 0.5 to 1.0 percent but can be greater in resistant soils. The diversion outlets can be vegetated channels, natural waterways, level spreaders, etc. If flows are carrying sediment eroded from the site, sediment retention techniques (Section 3.5) may be required.

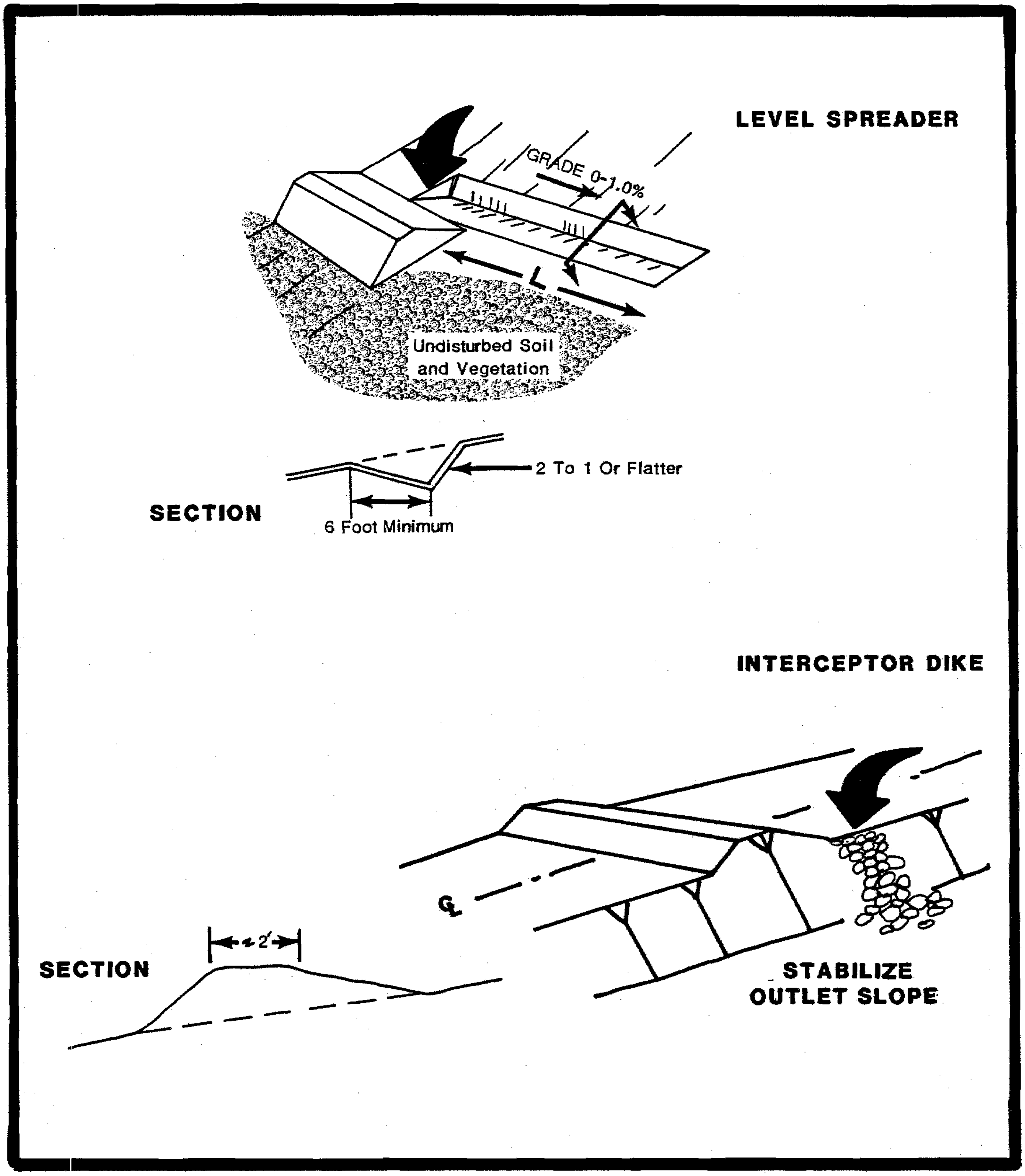
Maintenance requirements include removal of sediment in the channel and the establishment of any vegetation used for stabilization and erosion control.

3.6.5 Level Spreaders and Interceptor Dikes

Level spreaders and interceptor dikes (Figure 15) intercept runoff flow and convert it to sheet flow with non-erodible velocities over stable areas.

Spreaders are used to disperse sheet flow onto undisturbed, vegetated areas where much of the flow will infiltrate the ground. Soils must be well drained and stable; this technique is not appropriate for permafrost areas. Care must be taken to ensure that the outlet lip is level. Length of the spreader can be determined from the inflow (Q) in cubic feet per second (cfs) as shown below.

Design Q (cfs)	Length (ft)
less than 10	15
10-20	20
20-30	26
30-40	36
40-50	44



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LEVEL SPREADERS AND INTERCEPTOR DIKES

FIGURE 15

Interceptor dikes, or water bars, are used to divert flow from roadways or work pads, particularly on long steep grades. The spacing of the dikes is generally as follows:

Grade (%)	Spacing (ft)
less than 5	300
5-10	200
more than 10	150

3.7 THERMAL EROSION CONTROL

3.7.1 Prevention/Treatment of Disturbed Surfaces

Prevention and/or treatment of disturbed surfaces is required in areas of poorly drained permafrost, or wherever disturbances of the active layer could result in melting of underlying ice-rich soils and cause ponding, gully erosion, and other self-aggravating conditions. Disturbed areas should be inspected periodically and treatment of damaged areas should commence immediately after discovery. Treatment also requires periodic inspection until the area is completely stabilized. As access to the disturbed area may be limited and a large amount of hand labor may be required, prevention of damage is a more economical approach in permafrost areas. Prevention measures include:

- o Overlay construction, rather than cut and fill
- o Use of insulation beneath fills

- Maintaining the organic layer; conventional wheeled or tracked vehicles should not be used

- Winter construction

- Avoiding induced drainage or standing water and concentrated discharges from drainage structures

Ditch checks and water bars can be used to convey melt and runoff waters away from a disturbed area or to control the water within the area. Revegetation of a disturbed area, once established, will insulate the underlying soils and help retard melting. Seeding and fertilizing should be done immediately by hand or aerial application to prevent additional disturbance. Sodding and transplanting trees or brush may be favorable in some areas for quick cover and erosion control. In small areas where rapid thawing may be occurring due to removal of the active layer, materials such as straw, excelsior blankets, slash, and styrofoam can be used for insulation.

3.7.2 Cut Slope Stabilization

The general practice for frozen cuts is to make a fairly steep slope (1.5:1 to 1:4) and allow the slope to self-stabilize. While this technique will result in thawing of ice-rich soils, release of melt waters, and some degree of sloughing, the cut will eventually return to a stable condition. In implementing this technique, the vegetated mat should not be damaged and should overhang or drape the cut for insulation. Trees in back of the cut should be cleared by hand to prevent them from tearing the mat as the bank retreats due to melting. Ditch checks or sediment filters should be installed to trap sediment eroded from the cut. If it appears that a cut will not self-stabilize, the slope should be treated with either a filter buttress or insulation (Figure 16).

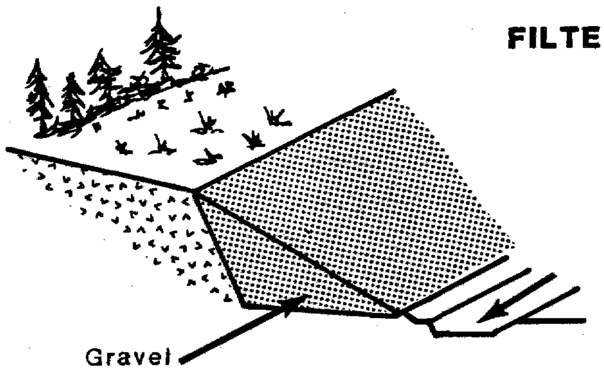
A filter buttress is constructed by re-dressing the slope and placing free-draining gravel filter material. The filter material can be placed at an angle steeper than natural repose to eventually settle to a stable repose. Sediment filters should be placed along the toe to contain silts from melt flows. The buttress can be dressed with topsoil and revegetated.

Insulation is installed by dressing the slope to 2:1, overlaying it with 12 inches of free-draining sand or gravel, and placing urea foam insulation. The insulation can be covered with topsoil and revegetated.

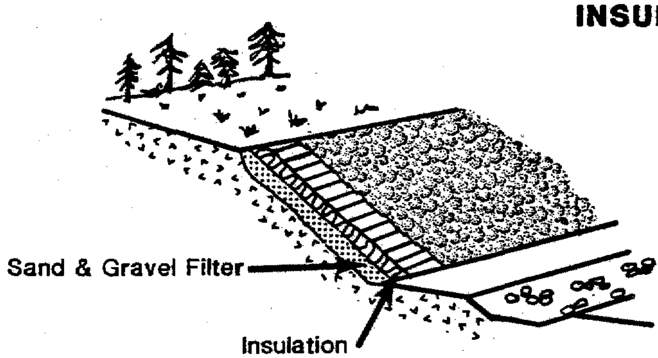
3.8 REVEGETATION

Revegetation of sites disturbed by development activities can provide an effective erosion control mechanism. Whenever possible, reestablishment of native vegetation should be promoted rather than introducing non-native species which may be less hardy and more expensive to maintain. In addition, areas which do not have potential for erosion problems necessitating vegetative cover should be left to revegetate naturally after receiving site preparation.

FILTER BUTTRESS



INSULATION TREATMENT



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TREATMENTS FOR CUT SLOPES

FIGURE 16

3.8.1 Soil Constraints

Soil texture is an extremely important factor in the restablishment of vegetation in disturbed areas. Each of the six soil groups identified in Alaska have unique properties which restrict root development and will influence a revegetation program. Table 8 illustrates the properties in each of the six soil groups and suggests the type of plant species suitable for each soil group. Soil information for specific sites may be available in soil survey reports published by the U.S. Department of Agriculture (USDA), Soil Conservation Service.

3.8.2 Site Preparation

Proper seedbed preparation is essential to encourage revegetation through planting or natural reinvasion. Whenever possible, surface materials removed during construction should be segregated, stockpiled and reapplied.

In arctic and alpine areas, the largest component of soil nutrients is in the surface organic layer. If these nutrients are not retrieved after stripping by replacing the surface materials, large amounts of nutrients are lost which can necessitate use of additional fertilizer.

Restoration grading should avoid creating overly smooth surfaces and surface materials should not be replaced over a "hardpan" of compacted material. All disturbed areas should be scarified to a depth of 12 inches to increase aeration and moisture infiltration and to control runoff.

TABLE 8
SOILS GROUPS IN ALASKA [1]

Group 1 - Soils with Few or No Limitations

Major Soil Limitations	Drainage Class	Depth (inches)	USDA Texture	Available Water Holding Capacity (inches)
None	Well and moderately well drained.	More than 20.	Silt loam, fine sandy loam, sandy loam.	5 to 8 Moderately permeable.
	Substratum	Porous gravel, moderately fine textured sediments, bedrock or rock fill		

A wide range of climatically adapted plant species are suited to these soils if soil nutrients are adequate or fertilized for establishment.

Group 2 - Soils with Moderate Limitations Due to Low Water Holding Capacity -

Major Soil Limitations	Drainage Class	Depth (inches)	USDA Texture	Available Water Holding Capacity (inches)
Droughtiness	Well drained. Up to 20% slope	10 to 20	Silt loam, fine sandy loam, sandy loam.	3 to 5 Moderately permeable.
	Substratum	Very gravelly sand, shattered rock, bedrock		

A wide range of climatically adapted species are suited to Group 2 soils with adequate fertilization and supplemental irrigation. Drought tolerate species may also be selected for this soil group.

Group 3 - Soils with Severe Limitations Due to Very Low Water Holding Capacity or Steep Slopes

Major Soil Limitations	Drainage Class	Depth (inches)	USDA Texture	Available Water Holding Capacity (inches)
Droughtiness or high erosion hazard.	Well and excessively drained.	Less than 10, or steep and deep or shallow.	Silt loam, sandy loam, sand.	Less than 3, or excessive runoff.
		Substratum	Gravel, sand, bedrock.	

Drought tolerant plants that form a dense root mass are optimal for revegetating disturbed sites in Group 3 soils.

Group 4 - Soils with Moderate Limitations Due to Excess Moisture -

Major Soil Limitations	Drainage Class	Depth (inches)	USDA Texture	Available Water Holding Capacity (inches)
Impeded drainage.	Somewhat poorly drained or poorly drained.	More than 20.	Silty clay loam, silt loam, sandy loam, fine sandy loam.	More than 5. May be waterlogged for short periods.

Only plants tolerant of cool, moist conditions are adaptable to these undrained soils. Plants adapted to Group 1 soils can be suitable to Group 4 soils when the surface remains drained.

Group 5 - Soils with Severe Limitations Due to Excess Moisture

Major Soil Limitations	Drainage Class	Depth (inches)	USDA Texture	Available Water Holding Capacity (inches)
Wetness (high water table)	Poorly drained.	More than 20. May have up to 16 of peat on surface.	Very wide range.	Usually waterlogged water table within 2 feet of surface.

Plant choices in this group are limited due to the difficulty of maintaining drained soil conditions. Selected plants should be adapted to cold, wet soils.

Group 6 - Soils Consisting of Wet Peat Materials

Major Soil Limitations	Drainage Class	Depth (inches)	USDA Texture	Water Holding Capacity (inches)
Wetness (water table at surface).	Very poorly drained. drained.	More than 16.	Peat	Waterlogged.
		Substratum	Very wide range	

The choice of plants is limited. Damage to the existing vegetation over these soils should be avoided whenever possible.

[1] Source: Rural Development Council, 1983.

Scarification will result in cooler, looser, more moist soil for seed germination and will increase seed-to-soil contact.

3.8.3 Seeding

3.8.3.1 Timing

Seeding should be done as early in the growing season as possible. Available moisture is the limiting factor necessitating early planting because many areas dry rapidly following spring melting and summer precipitation is low. Early planting also facilitates earlier germination and growth which results in less winterkill than later sowing. Optimum seeding dates for most areas of Alaska are from May 15 to June 15, depending on temperature and soil moisture.

3.8.3.2 Application Methods

There are several seeding methods available depending upon the size, slope, and accessibility of the area to be seeded. On large areas to be planted with grass for erosion control, unseeded strips or areas should be dispersed among the seeded areas to allow for reinvasion and restablishment of native species.

Drill seeding, which results in uniform seed distribution and placement at the proper depth, is the most successful method for achieving a productive density rate. However, it has disadvantages for use in widespread revegetation programs. It is not applicable to rocky areas and must be limited to use on areas having a slope of less than 3:1. It is also expensive and slow.

Broadcast seeding is faster and less expensive than drill seeding, but is less effective and requires more seed. The seed should be covered by harrowing, packing, dragging, or mulching. Aerial broadcasting is advantageous for large or inaccessible areas. Low wind speeds (below 2 mph) and a uniform height are necessary to achieve an even distribution of seed.

Hydroseeding is a good technique, particularly for steep slopes where drilling is not feasible and aerial seeding is not necessary. A water source is necessary for mixing the slurry of 100 to 150 pounds or less of seed with 100 gallons of water. Hydroseeding may be followed by mulching to prevent seed runoff and retain moisture, but the operations should be done separately to ensure sufficient contact between the seed and soil to enable germination.

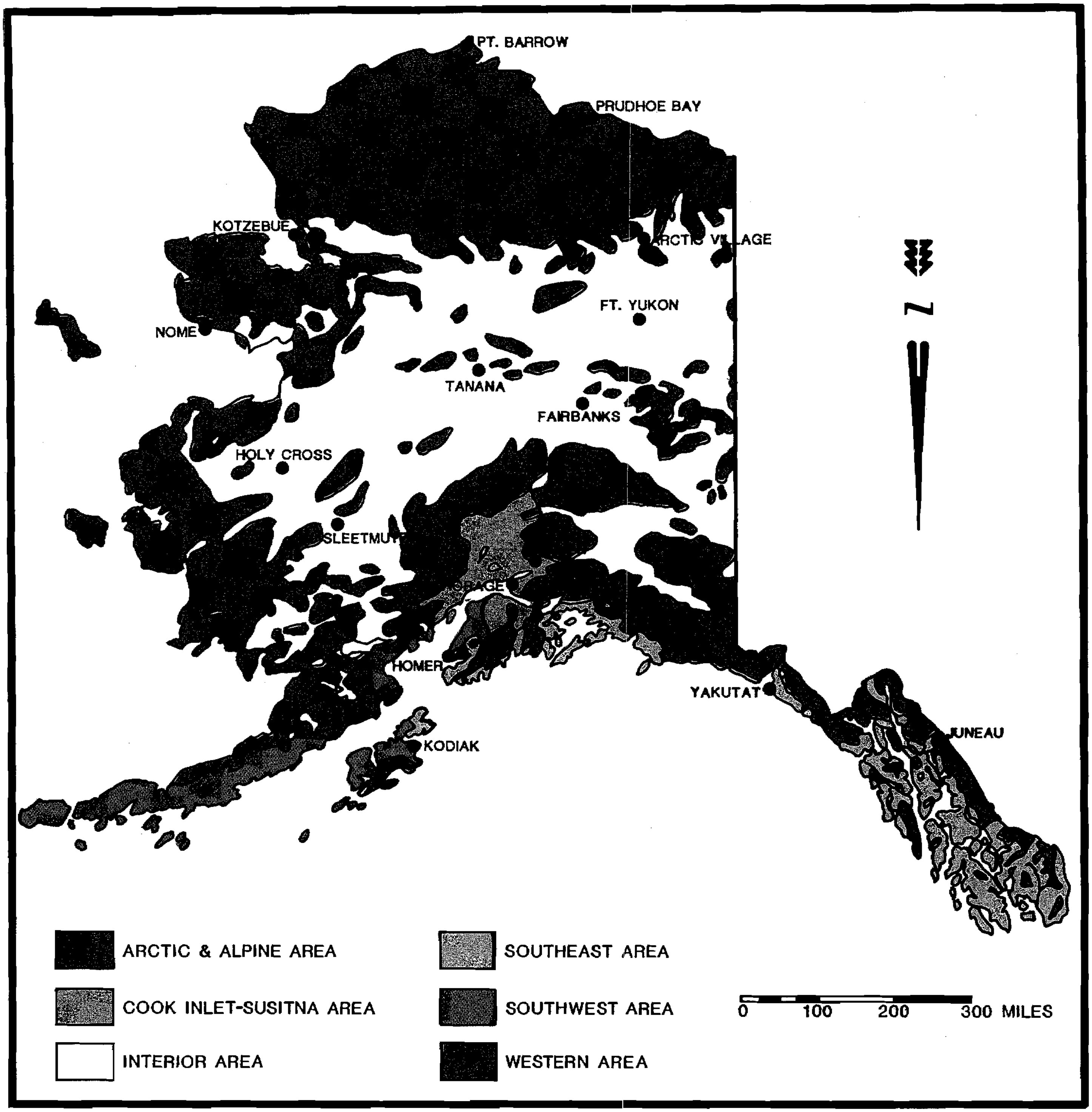
3.8.3.3 Recommended Seeds and Mixtures

The most successful revegetation programs are designed around the use of native grasses, preferably the same species as those adjacent to the site. Barring this, species should be from similar latitudes and, at worst, those adapted to similar weather conditions. One of the greatest advantages of the use of native plants is that once they are established they can grow vigorously and persist without the management and maintenance so necessary for cultivars.

Traditionally, annual ryegrass (Holium multiflorum) has been used as a temporary measure for erosion control. Its very fast growth rate, extensive root system, high seedling vigor, and good acidity tolerance are particularly suited for this purpose. While annual ryegrass may provide a good initial cover for erosion control, it is not a permanent solution to erosion problems. It is an annual plant and will not persist in areas where it is seeded even though abundant seed may be produced. In addition, it discourages the establishment of native species which would provide long-term cover for site stability and requires reseeding and fertilization maintenance treatments to perpetuate its cover. Where annual rye is used, small areas within the site should be left bare to allow for the reinvasion of native plants which can eventually take over the function of erosion control and obviate the need for indefinite maintenance of non-native grasses.

In general, grass seed mixes are preferable to monocultures because they provide different species for microsite differences in soil, moisture, and fertility. However, mixes can result in competition between species which may result in less cover, particularly if high seeding rates are used or if annuals and perennials are mixed.

Using the geographic regions as determined by type of vegetation (depicted on Figure 17) and the soil groups listed in Table 8, alternative seeds and mixtures are presented on Tables 9 through 14. Excluded are recommendations for Soil Group 6 in the Cook Inlet-Susitna, Interior, Southwest, and



ALASKA POWER AUTHORITY

GEOGRAPHIC AREAS BY VEGETATIVE TYPE

FIGURE 17

TABLE 9
COOK INLET - SUSITNA AREA
SEEDING RECOMMENDATIONS

Soil Groups 1 and 2

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Red Fescue	Arctared or	5	10
		Boreal	5	10
	Alsike or White Dutch Cover		1	2
	Annual Ryegrass		2	4
2.	Kentucky Bluegrass	Nugget,	4	15
		Merion or Park	4	15
	Alsike or White Dutch Cover		1	2
	Annual Ryegrass		2	4
3.	Red Fescue	Arctared or	5	10
		Boreal	5	10
4.	Hard Fescue	Durar	5	10
5.	Kentucky Bluegrass	Nugget,	5	10
		Merion or Park	5	10
6.	Smooth Brome	Polar or	10	20
		Manchar	8	16
7.	Polargrass	Alyeska	10	15
8.	Bluejoint Reedgrass	Sourdough	4	8

Soil Group 3

Mixtures and Species in order of Preference*		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Red Fescue	Arctared	5	10
	White Dutch Clover or Sweet Clover		1	2
	Annual Ryegrass		2	4
2.	Hard Fescue	Durar	5	10
	Annual Ryegrass		2	4
3.	Streambank Wheatgrass	Sodar	6	12

* Watering is generally required at least for establishment and preferably for the first 2 years.

Soil Group 4

Mixtures and Species in order of Preference*		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Creeping Foxtail		4	8
2.	Meadow Foxtail		4	8
3.	Red Fescue	Arctared or	5	10
		Boreal	5	10
4.	Reed Canarygrass	Frontier	10	20
5.	Polargrass	Alyeska	10	15
6.	Bluejoint Reedgrass	Sourdough	4	8

NOTE: If land ha- been drained, use recommendations for Group 1.

* Alsike clover at 1 lb./acre drilled or 2 lbs./acre broadcast may be added to any of the following.

Soil Group 5

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Polargrass	Alyeska	10	15
	Alsike Clover		1	2
2.	Bluejoint Reedgrass	Sourdough	4	8
	Alsike Clover		1	2

TABLE 10
INTERIOR AREA
SEEDING RECOMMENDATIONS

Soil Group 1

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Red Fescue	Arctared or	5	10
		Boreal	5	10
2.	Smooth Brome	Polar or	10	20
		Manchar	8	16
3.	Kentucky Bluegrass	Park or	4	15
		Merion	4	15
4.	Polargrass	Alyeska	4	15
5.	Bluejoint Reedgrass	Sourdough	4	8

Soil Group 2

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Smooth Brome	Polar or	5	10
		Manchar	4	8
	Hard Fescue	Durar	2.5	5
2.	Smooth Brome	Polar or	10	20
		Manchar	8	16
3.	Smooth Brome	Polar or	5	10
		Manchar	4	8
	Red Fescue	Arctared or	2.5	5
		Boreal	2.5	5
4.	Bluejoint Reedgrass	Sourdough	4	8

Soil Group 3*

Mixtures and Species in order of Preference**		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Smooth Brome	Polar or	5	10
		Manchar	4	8
	Hard Fescue	Durar	2.5	5
2.	Hard Fescue	Durar	5	10
3.	Red Fescue	Arctared	5	10
4.	Streambank Wheatgrass	Sodar	6	12
5.	Smooth Brome	Polar or	10	20
		Manchar	8	16

NOTE: If the soils of this group are irrigated, use seeding recommendations for Soil Group 1.

* Watering is generally required at least for establishment and preferably for 2 years.

**Yellow or white sweet clover may be added at a rate not to exceed 2 lbs/acre drilled or 4 lbs./acre broadcast.

Soil Group 4

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Creeping Foxtail	Garrison	4	8
2.	Creeping Foxtail	Garrison	4	8
	Kentucky Bluegrass	Park or	1.5	6
		Merion	1.5	6
3.	Red Fescue	Arctared or	5	10
		Boreal	5	10
4.	Timothy	Engmo	1	2
	Red Fescue	Arctared or	2.5	5
		Boreal	2.5	5
5.	Smooth Brome	Polar or	10	20
		Manchar	8	16
6.	Polargrass	Alyeska	10	15
7.	Bluejoint Reedgrass	Sourdough	4	8

Soil Group 5

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Creeping Foxtail	Garrison	4	8
2.	Timothy	Engmo	1	2
	Kentucky Bluegrass	Park or	1.5	6
		Merion	1.5	6
3.	Polargrass	Alyeska	10	15
4.	Bluejoint Reedgrass	Sourdough	4	8

NOTE: The permafrost conditions common to these soils will recede to greater depth after clearing of the native vegetation but usually will return to its original depth if grass is grown continuously for 5 years or more.

TABLE 11
SOUTHEAST AREA
SEEDING RECOMMENDATIONS

Soil Groups 1, 2 and 3

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Broadcast Seeding Rates lb. per acre
1.	Red Fescue	Arctared or	5	10
		Boreal	5	10
	White Dutch or Alsike Clover		1	2
	Annual Ryegrass		2.5	5
2.	Kentucky Bluegrass	Nugget, Park or Merion	4	15
	White Dutch or Alsike Clover		1	2
	Annual Ryegrass		2.5	5
3.	Meadow Foxtail or	Common	4	8
	Creeping Foxtail	Garrison	4	8
4.	Bluejoint Reedgrass	Sourdough	4	8
	White Dutch or Alsike Clover		1	1
	Annual Ryegrass		2.5	5

Soil Group 4

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Broadcast Seeding Rates lb. per acre
1.	Meadow Foxtail or	Common	5	10
	Creeping Foxtail	Garrison	5	10
2.	Red Fescue	Arctared or Boreal	4	15
3.	Reed Canarygrass	Frontier	10	10
4.	Bluejoint Reedgrass	Sourdough	4	8

Soil Groups 5 and 6

When drained refer to Soil Group 1
Undrained refer to Soil Group 4

TABLE 12
SOUTHWEST AREA
SEEDING RECOMMENDATIONS

Soil Groups 1 and 2

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Red Fescue	Arctared or	5	10
		Boreal	5	10
	Alsike Clover		1	2
2.	Creeping Foxtail	Garrison	4	8
	Alsike Clover		1	2
3.	Kentucky Bluegrass	Nugget, Park or Merion	4	15
	Alsike Clover		4	15
4.	Bering Hairgrass	Norcoast	10	15
	Alsike Clover		1	2
5.	Bluejoint Reedgrass	Sourdough	4	8

Soil Group 3

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Hard Fescue	Durar	5	10
	White Dutch Clover		1	2
2.	Red Fescue	Arctared or	5	10
		Boreal	5	10
	White Dutch Clover		1	2

Soil Group 4

Mixtures and Species in order of Preference*		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Meadow Foxtail or	Common	4	8
	Creeping Foxtail	Garrison	4	8
2.	Red Fescue	Arctared or	5	10
		Boreal	5	10
	Alsike Clover		1	2
3.	Kentucky Bluegrass	Nugget, Park	4	15
	Alsike Clover	or Merion	1	2
4.	Timothy	Engmo	4	8
	Alsike Clover		1	2
5.	Bering Hairgrass	Norcoast	10	15
	Alsike Clover		1	2
6.	Bluejoint Reedgrass	Sourdough	4	8
	Alsike Clover		1	2

*NOTE: These recommendations are for undrained soil. For drained soil recommendations refer to Group 1 soils.

Soil Group 5

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Meadow Foxtail or	Common	4	8
	Creeping Foxtail	Garrison	4	8
2.	Bering Hairgrass	Norcoast	10	15
	Alsike Clover		1	2
3.	Bluejoint Reedgrass	Sourdough	4	8
	Alsike Clover		1	2
4.	Reed Canarygrass		10	20
	Alsike Clover		1	2

TABLE 13
WESTERN AREA
SEEDING RECOMMENDATIONS

Soil Groups 1 and 2

Mixtures and Species in order of Preference*		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Red Fescue	Arctared	5	10
2.	Meadow Foxtail	Common	4	8
3.	Creeping Foxtail	Garrison	4	8
4.	Bering Hairgrass	Norcoast	10	15
5.	Polargrass	Alyeska	10	15
6.	Bluejoint Reedgrass	Sourdough	4	8

NOTE: The above recommendations are based on judgement and not on actual trials in the area.

* Alsike clover should be added to any of the following at a rate not to exceed 1 lb/acre drilled or 2 lbs/acre broadcast.

Soil Group 3

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Red Fescue	Arctared or	5	10
		Boreal	5	10
	Alsike Clover		1	2
2.	Hard Fescue	Durar	5	10
	Alsike Clover		1	2
3.	Meadow Foxtail	Common	4	8
	Alsike Clover		1	2

NOTE: The above recommendations are based on judgement and not on actual trials in the area.

Soil Groups 4 and 5

Mixtures and Species in order of Preference		Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1.	Meadow Foxtail	Common	4	8
	Alsike Clover		1	2
2.	Creeping Foxtail	Garrison	4	8
	Alsike Clover		1	2
3.	Bering Hairgrass	Norcoast	10	15
	Alsike Clover		1	2
4.	Polargrass	Alyeska	10	15
	Alsike Clover		1	2
5.	Bluejoint Reedgrass	Sourdough	4	8
	Alsike Clover		1	2

TABLE 14
ARCTIC AND ALPINE AREAS
SEEDING RECOMMENDATIONS

Soil Groups 1 and 2

Mixtures and Species in order of Preference*	Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1. Glaucous Bluegrass*	Tundra	10	15
Polargrass	Alyeska	7	10
Alsike Clover		1	2
2. Red Fescue	Arctared	10	20
Alsike Clover		1	2
3. Bering Hairgrass	Norcoast	10	15
Alsike Clover		1	2
4. Bluejoint Reedgrass*	Sourdough	4	8
Alsike Clover		1	2

NOTE: Disturbed sites may be revegetated by sodding or spreading freshly cut native cottongrass, sedges, or other native tundra from adjacent areas, packing and fertilizing according to soil tests.

* This grass is to be used only in upland sites in the Arctic area.
** This grass is to be used only in the Alpine area.

Soil Group 3

Mixtures and Species in order of Preference*	Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1. Glaucous Bluegrass*	Tundra	10	25
Alsike Clover		1	2
2. Red Fescue	Arctared	10	20
Alsike Clover		1	2

NOTE: Disturbed sites may be revegetated by sodding or spreading freshly cut native cottongrass, sedges, or other native tundra from adjacent areas, packing and fertilizing according to soil tests.

* This grass is to be used only in the Alpine area.

Soil Group 4

Mixtures and Species in order of Preference*	Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1. Bering Hairgrass	Norcoast	10	15
Alsike Clover		1	2
2. Polargrass	Alyeska	10	15
Alsike Clover		1	2
3. Red Fescue	Arctared	10	20
Alsike Clover		1	2
4. Bluejoint Reedgrass*	Sourdough	4	8
Alsike Clover		1	2

NOTE: Disturbed sites may be revegetated by sodding or spreading freshly cut native cottongrass, sedges, or other native tundra from adjacent areas, packing and fertilizing according to soil tests.

* This grass is to be used only in the Alpine area.

Soil Group 5

Mixtures and Species in order of Preference*	Variety Name in order of Preference	Pure Live Seed Drill Seeding Seeding Rates lb. per acre	Pure Live Seed Broadcast Seeding Rates lb. per acre
1. Bering Hairgrass	Norcoast	10	15
Alsike Clover		1	2
2. Polargrass	Alyeska	10	15
Alsike Clover		1	2
4. Bluejoint Reedgrass*	Sourdough	4	8
Alsike Clover		1	2

NOTE: Disturbed sites may be revegetated by sodding or spreading freshly cut native cottongrass, sedges, or other native tundra from adjacent areas, packing and fertilizing according to soil tests.

* This grass is to be used only in the Alpine area.

Western regions where seed recommendations are not yet available. Seed sources for large revegetation programs should be developed several years in advance of project construction.

3.8.4 Fertilization

Fertilizers basically consist of nitrogen, phosphorous, and potassium (N-P-K). While fertilization is normally imperative for plant establishment at disturbed sites, specialized fertilizers with micronutrients are not necessary as part of an Alaska revegetation program. Use of a standard N-P-K fertilizer (e.g. 8-32-16, 14-30-14) is usually sufficient and yields a considerable cost savings to revegetation programs compared to use of fertilizers containing micronutrients.

A standard N-P-K fertilizer should be applied to all disturbed sites. On sites which receive general site preparation but no seeding, application should be at a rate of 300 to 500 lbs/acre. For seeded areas, application rates should be 450 to 600 lbs/acre. Fertilization should include peripheral areas of undisturbed natural vegetation to stimulate seed production and dispersal.

Fertilizer treatments should be applied in the early spring. Maintenance treatments should be applied in the second year after planting.

3.8.5 Mulches

The use of mulches has advantages and disadvantages. Mulches moderate temperature extremes, conserve moisture, protect surface soils from erosion, improve conditions for germination, and can be used to improve soil quality. The use of organic mulch (e.g. straw, woodchips), however, can result in depletion of available nutrients, particularly nitrogen, which becomes tied up in the decomposition process. Mulches may also inhibit germination or result in premature germination after early rains and seedling mortality. In general, the indiscriminant use of mulch is not recommended for environmental conditions where nutrients are limited and decomposition is a slow process.

3.8.6 Woody Plants

While extensive use of woody plants for revegetation is not expected at Power Authority project sites, they may be appropriate in areas of disturbed riparian habitat where annual flooding does not occur. Stem cuttings can be used to propogate many of the deciduous tree and shrub species in Alaska. Willow and poplar are particularly widespread and frequent invaders of disturbed areas.

Cuttings, approximately 8 to 10 inches long, should be collected when plants are dormant, preferably March or early April. They should be stored at freezing temperatures in plastic bags with a wet paper towel wrapped around the bases to prevent drying. Cuttings should be planted as early in the growing season as possible by pushing them into the ground. Approximately 2 to 3 inches of the cutting should be left exposed above ground.

3.9 RECLAMATION

Reclamation of disturbed sites should be undertaken whenever the intended use is complete and for those areas which will remain unused for extended periods.

- o Slopes, borrow areas, and waste areas should be graded to stable conditions and provided with permanent drainage
- o Open culverts and culverts in natural drainages should be removed
- o Fill material in streams should be removed down to the original stream contour
- o Roadways should be shaped to drain by crowning or outsloping and water bars, checks or drainage structures should be installed
- o Abandoned roads should be removed or put to bed (i.e. stabilized, scarified and fertilized in place)
- o Disturbed areas should be treated for revegetation or reinvasion by native species
- o Access blocks such as berms or ditches should be installed to prevent access and damage to stabilized areas.

3.10 INSPECTION AND MONITORING

An environmental inspector will be assigned to Power Authority projects. This individual will be thoroughly familiar with the various portions of the work and with the environmental requirements as they relate to construction operations. Before any activity is begun, the inspector will review the work requirements, make a physical survey of the area, and verify that construction boundaries are clearly marked. The inspector will review the contractor's proposed methods and procedures with special attention to environmental protection. The inspector will then monitor the actual construction activities to ensure that environmental requirements are met. Special attention will be given to equipment movements, excavation, clearing and grubbing, embankments, quarry and borrow operations, ditching, stream diversions, stockpiling, access roads, drainage and revegetation.

Monitoring will be required for some projects to provide documentation that water quality standards are met. The location of upstream and downstream sampling stations will be pre-determined through consultation with the applicable regulatory agency. Considerations include the hydrology of the stream, the allowable mixing zone, and effects of upstream feeder streams.

CHAPTER 4 - AUTHORITIES AND AGENCIES

Any component of a project may require one or more permits from federal, state, or local authorities. The following list of federal and state permits emphasizes those most frequently required from the standpoint of erosion and sedimentation control. Legal requirements applicable to individual projects should be thoroughly examined on a case-by-case basis.

Federal

U.S. Corps of Engineers

Section 404 permit - required for dredge and fill operations in navigable waters and wetlands

Section 10 permit - required for obstructions, alterations or improvements in navigable waters

Bureau of Land Management

Plan of operations for mineral operations and land use leases, permits, easements

U.S. Coast Guard

Section 9 permit - for construction, modification or removal of a bridge or causeway in navigable water

U.S. Environmental Protection Agency

National Pollutant Discharge Elimination System (NPDES permit) - required for point source discharges

U.S. Fish and Wildlife Service

Special use permits for activities on lands under its jurisdiction

U.S. Forest Service

Special use permits for activities on lands under its jurisdiction

State of Alaska

Office of Management and Budget

Coastal zone management consistency determination

Department of Environmental Conservation

Section 401 certification (water guidelines) - required for activities subject to federal permits and licenses

Wastewater discharge permit

Water quality standards

Department of Fish and Game

Anadromous fish protection permit

Habitat protection permits

Department of Natural Resources

Land use permit

Permit to construct or modify a dam

Water rights permit

Material purchase

Right of way

Easements

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