(ditches and culverts), sedimentation basins, and handbuilt structures for small and remote projects.

The last step in a remediation project is revegetation. The guidelines provide a step-by-step outline for the revegetation of a site including topsoil replacement, fertilization and seedbed preparation, seeding and transplanting, and mulching. Most parks will have considerable local experience in revegetation, and this experience should prevail when developing a revegetation plan. Even where a park has considerable experience, the guidelines may be of help in special problems unique to AML sites such as treatment of acidic soils.

Mitigation plans must be consistent with park and regional requirements. Where there are conflicts between this handbook, and local park and regional requirements, final decisions regarding remediation lie with park management. The guidance given here is not mandatory, it is offered as a starting point and reference on methods that have been successful in mitigating AML sites. The following space is provided to write in references to local and regional guidance that must be consulted in completing a remediation plan.

PARK AND REGIONAL REQUIREMENTS DOCUMENTS

All of the remediation measures described below have been used successfully in State AML programs, some NPS parks, and the reclamation of modern mines. Many states have very efficient and mature programs with sites that have now been restored for a number of years.

METHOD SELECTION

This section provides guidance on how to select appropriate measures for the remediation of a particular site. Charts, tables, and matrices provide selection criteria. In some categories, the remediation measures are self-evident or a step-by-step procedure, and not a question of choice. It is assumed that the decision has already been made whether a site will be temporarily or permanently closed, or preserved for its historic values.

TABLE I

SITE CHARACTERIZATION DECISION MATRIX

	Recommended Studies				
Impacts	Soil	Water	Vegetation	Wild Life	History
More Than 2 Acres	X	X	X	X	X
Acidic/Alkaline/ Heavy Metals	X	X	X		
Barren Vegetation	X	X	X		
Extreme Erosion		X			
Requires Topsoil Borrow	X				
Threatened/Endangered Species			X	X	
Mine Fires (Requires special studies)	X	X	X	X	
Structures/Artifacts					X

Site Characterization and Monitoring

The initial site inventory and reconnaissance provides the information necessary to choose relevant baseline studies. The decision matrix of Table I can assist in selecting the appropriate baseline studies. Possible AML impacts are listed in the left hand column, and the top row lists the baseline studies. A tick appears at the intersection of row and column when a particular baseline study is recommended for the opposite impact.

The matrix recommends all baseline studies where the site disturbance exceeds a maximum acreage. This maximum may be adjusted to suit local park conditions. In addition, if a park has numerous similar AML sites, individual baseline studies may become redundant, and it will be more efficient to prepare a programmatic environmental impact study.

The matrix recommends mine drainage studies whenever there is a hint of toxic effluents. The chemistry of mine drainage is unique to each AML site, and the remediation generally must be site specific.

The mitigation of mine fires requires highly specialized technology. The baseline studies, engineering, and mitigation should be contracted to experts.

If there is a possibility that the site may be preserved in some form, a detailed historical survey should be conducted. If not, information collected in the site reconnaissance (Tab VII) is generally adequate for historical inventories.

Mine Closure

Mine closure methods are specific to the type of disturbance:

* Surface openings of underground mines.
* Area disturbances of surface mines, quarries, pits, and roads.
* Surface subsidence from collapse of underground mines.
* Mine drainage.
* Waste dumps including overburden, spoil, development muck (waste rock from underground mines), stockpiles, tailings ponds, impoundments, and processing wastes.
* Abandoned structures and equipment.

For all but underground openings, simply look up the disturbance in the Table of Contents for applicable remediation measures. To choose a closure method for underground openings, first answer the following questions:

* Will the site be preserved for its historical value?
* Is the opening vertical (shaft) or horizontal (adit)?
* Is the wall rock competent or incompetent ?
* Will the closure be temporary or permanent?
* Is the site remote or accessible to construction equipment?
* Is the opening a habitat for threatened or endangered species?
* Is there a nearby source of building rock (12 in. to 18 in.) for bulkheads?

Once these questions are answered, enter the tree diagram Table II, and follow the indicated path to the bottom level. The bottom level recommends the appropriate closure method for the given circumstances.

TABLE II

DECISION TREE FOR UNDERGROUND CLOSURES

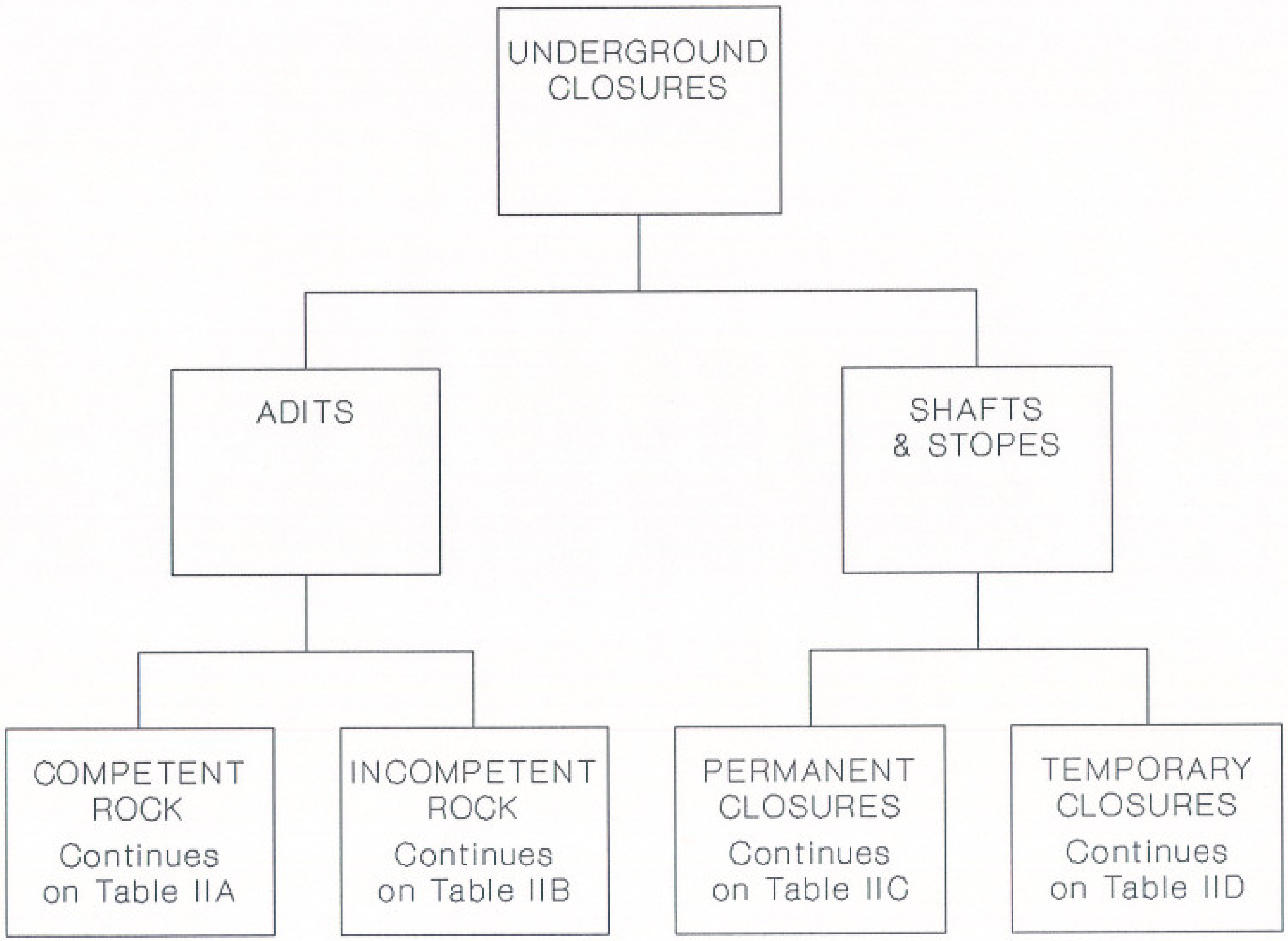


TABLE IIA

DECISION TREE - ADITS IN COMPETENT ROCK

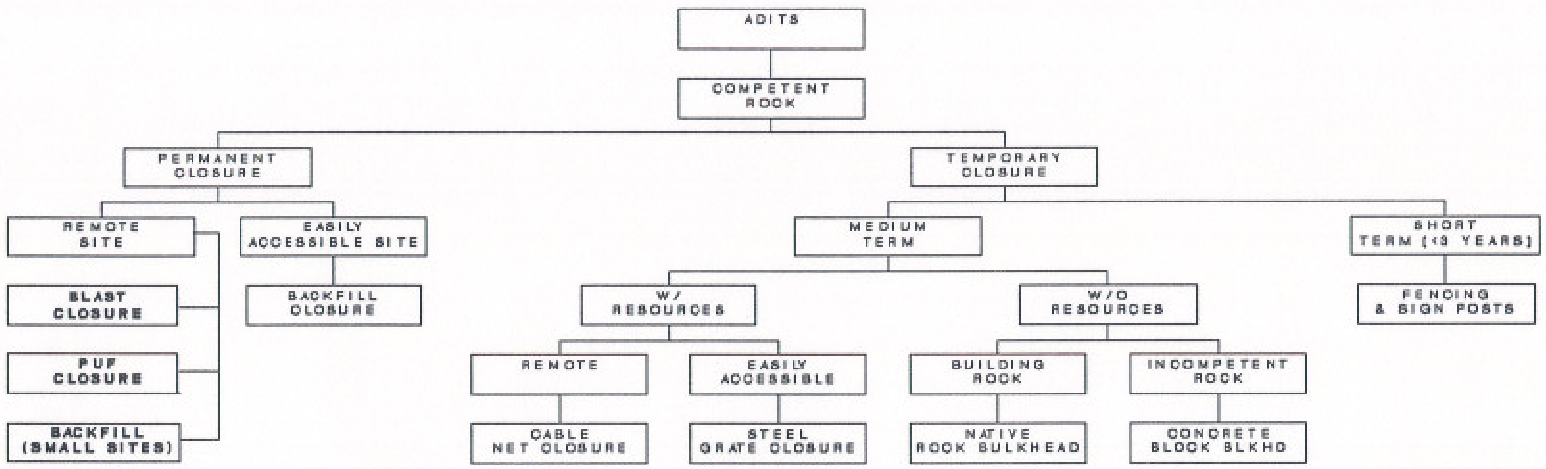


TABLE IIB

DECISION TREE - ADITS, INCOMPETENT ROCK

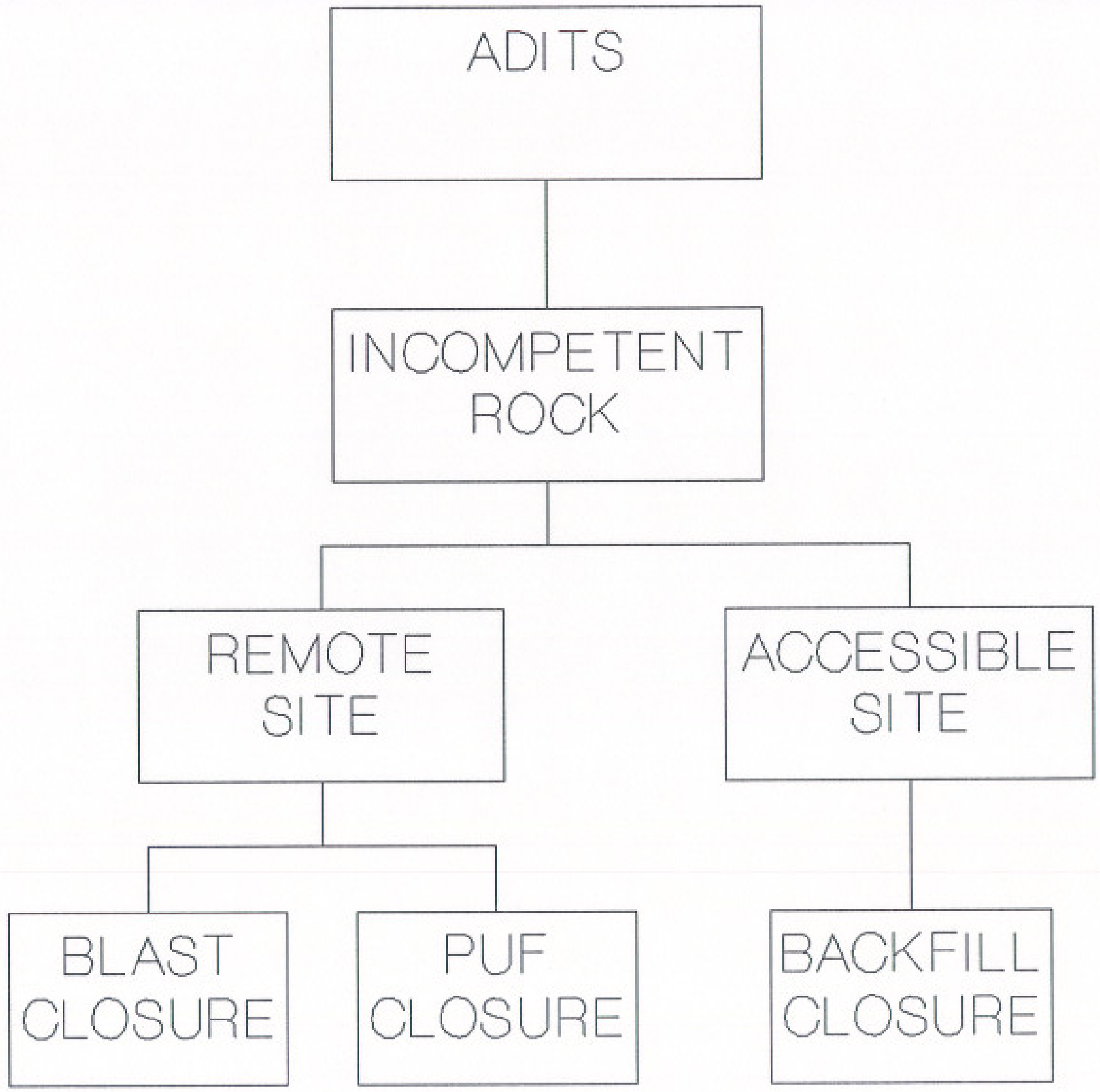


TABLE IIC

DECISION TREE - SHAFTS, RESTORE SITE

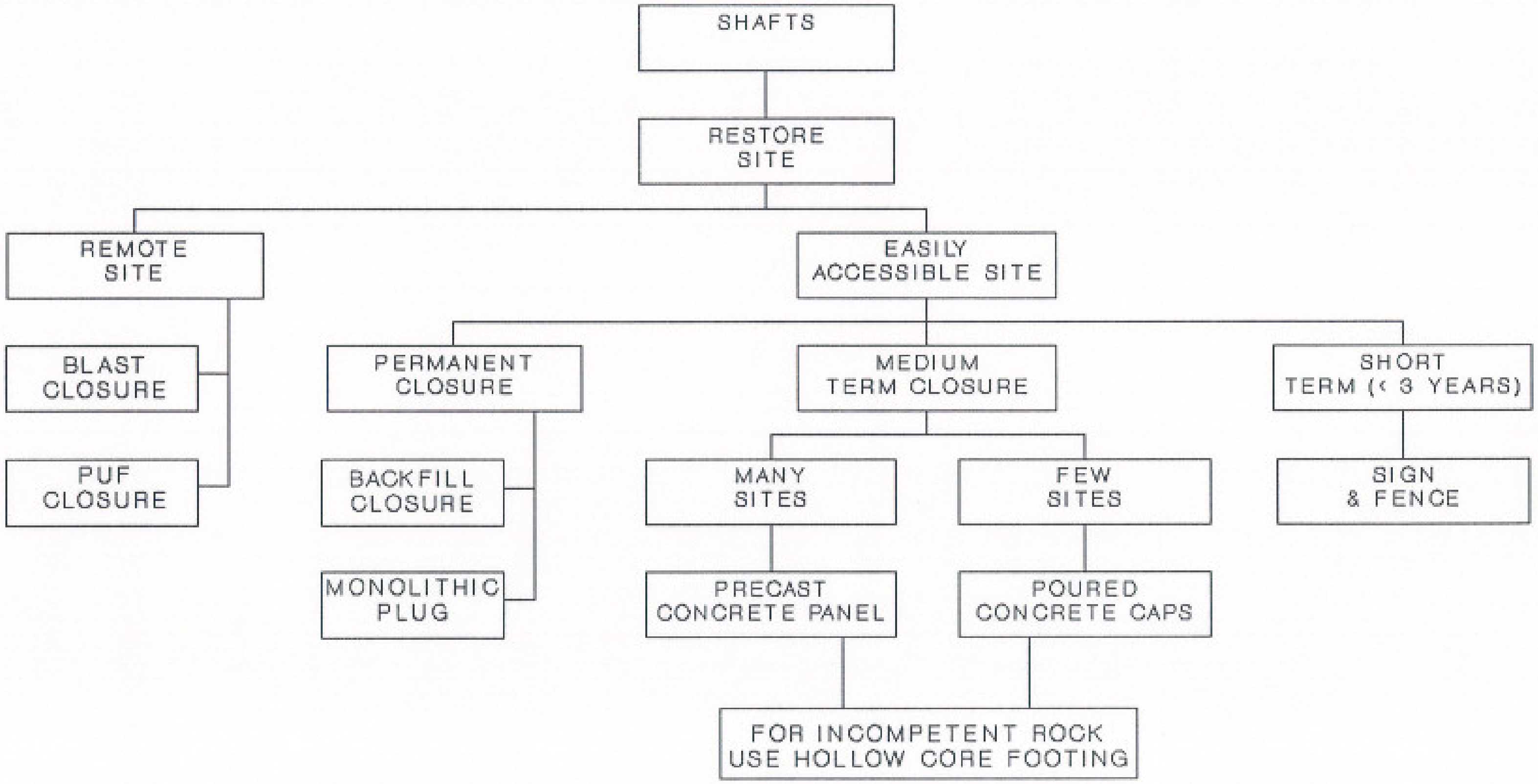
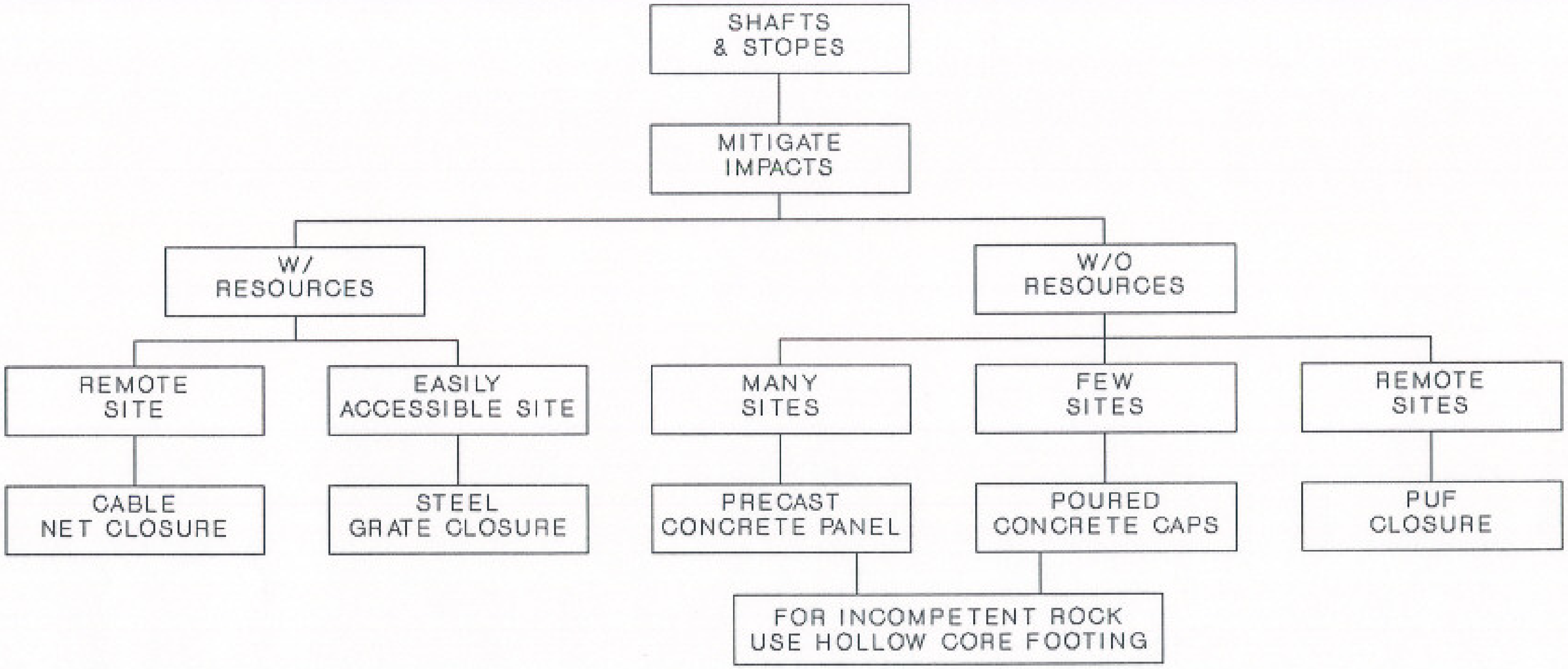


TABLE IID

<u>DECISION TREE - SHAFTS, MITIGATE IMPACTS</u>



Erosion and Sedimentation Control

For small projects generally less than 2 acres, erosion and sedimentation control will primarily consist of diverting water around disturbed areas and dissipating water energy to prevent erosion. The decision matrix of Table III can assist in selecting the appropriate control measures. The left hand column lists erosion and sedimentation control measures, and the top row lists various applications. A tick appears at the intersection of row and column when a particular control measure is appropriate for the above application.

Larger projects require complete landform design including landscaping, estimates of runoff, and hydraulic analysis. The first subsection of Erosion and Sedimentation Control outlines the design process. After identifying the particular needs, Table III can help locate applicable erosion and sedimentation control measures.

TABLE III
DECISION MATRIX FOR EROSION AND SEDIMENTATION CONTROL

	Applications					
					Project	
Control Measures	Erosion	Sediment	Channel	Land Form	Large	Small/ Remote
Topsoil Removal & Storage	X			X	X	
Slope Erosion Control	X	X		X	X	
Drop Structures	X	X			X	
Diversion Ditches	X				X	
Culverts	X		X		X	
Basins		X			X	
Handbuilt Slope Structures	X	X	X			X
Handbuilt Drop Structures	X		X			X

Revegetation

The guidance on revegetation is a step-by-step procedure involving:

1) Topsoil replacement.

2) Fertilization and seedbed preparation.

3) Seeding and transplanting.

4) Mulching.

In general, each step is required for a successful project. However, on occasion, some steps may not be necessary. In particular, fertilization should be avoided where possible because it may not promote sustainable vegetation.

There are a number of seeding and mulching alternatives to choose from. Table IV summarizes the advantages and disadvantages of various seeding methods.

The mulching alternatives are listed in the left hand column of the decision matrix, Table V. The top row lists various mulch qualities. The matrix cells indicate whether a particular mulch possess the above qualities. For some qualities, a mulch either has the quality or not, and a positive response is indicated by a tick. For the other qualities, there are varying degrees which is indicated with a cell value of high (H), medium (M), or low (L). In addition, four of the mulches have special applications which are given in the table footnotes.

To choose a mulch, first characterize the desired mulch qualities, and then find in the matrix the mulch with the closest match.

TABLE IV

SEEDING METHODS - ADVANTAGES/DISADVANTAGES

(Thorne, 1987, p. 57)

Characteristics	Drilling			Broadcasting		
	Machine	Hand	Hydroseeding	Other Machines	Hand	Aerial
Topography	Steep slopes and access are problems; if slopes are greater than 3:1, broadcasting recommended	Less limited	Can handle steep terrain, depending on distance	May be limited by steep terrain	Less limited	Unlimited
Obstructions	Limits use	Unlimited	Unlimited	Somewhat limited	Unlimited	Unlimited
Compacted Soil	Possible	Possible	Not acceptable	Not acceptable	Not acceptable	Not acceptable; soil must be rough enough for wind and rain to cover seeds
Seeding Depth	Variable and controlled	Variable; somewhat less controlled	Lays on top of the soil	No direct control; depends on soil	No direct control	No direct control
Seed Size	Variable if drills can be adjusted	Variable if hand-held machines can be adjusted	Small seed	Variable	Variable	Variable
Season	Limited by moisture	Limited by moisture	Limited by low expected mois-	Less limited	Less limited	Less limited
Precipitation	Slightly critical	Slightly critical	Very critical; more success when annual precip. exceeds 12-14 inches	Very critical	Very critical	Very critical
Soil Texture	Not critical	Not critical	Critical	Critical	Critical	Critical
Seed Distribution	Uniform	Uniform if person is well trained; seeds can be precisely placed	Less uniform	Less uniform	Not uniform but can be specific to one area	Not uniform
Mulching	Separate treatment	Separate	Same treatment possible but not advised	Separate	Separate	Separate
Cost	Medium	Depends on how many people needed	High	Low	Depends on number of crews needed	Low if surface area to be covered is extensive
Equipment	Special in some cases	Some hand-held equipment available	Scarce	Available	Some hand-held equipment available	Various types available; can be contracted out

TABLE IV
(continued)

Characteristics	Drilling			Broadcasting		
	Machine	Hand	Hydroseeding	Other Machines	Hand	Aerial
Seed Rate	Less than broadcasting; drastically disturbed sites such as spoils require much heavier seeding rates than do sites where topsoil and some plant cover are intact. Examples: 10-15 lb/acre drilled on north-facing gentle slopes with small grass seed; 25-30 lb/acre if species seed is large; 40-45 lb/acre if conditions are severe, such as south-facing steep slopes	Same as machine drilling	More; as much as double the drilling rate	More	More	More; 1/3 more than drilling
Trash in Seeds	Must be cleaned from seeds	Must be cleaned from seeds	Cleaning not critical	Cleaning not critical	Cleaning not critical	Cleaning not critical
Time required/acre to seed	Middle range	High range	Low range	Low range	High range	Lowest

TABLE V

DECISION MATRIX FOR MULCH

LEGEND; X - Yes
H - High
M - Medium
L - Low

MULCH QUALITIES	Live	Straw/Hay	Bark	Wood Chips	Sawdust	Hydromulch	Leaves	Manure	Sewage Sludge	Mats/Fabric
Requires Anchoring		X			X		X			X
Provides Erosion Protection	M	M	M	M	L	L	L	L	L	H
Provides Nutrients	H	L	M	M	M	L	H	H	H	L
Effective Time of Erosion Protection	H	M	H	H	H	L	L	L	L	H
Contains Benefical Seed	X	X					X			
Contains Unwanted Seed		X								
May Require Fertilizer Additions		X	X	X	X					
Special Applications	X					X	X			X
Slope Constraints					X		X	X		
Cost	M	L	H	H	H	H	M	M	L	H
Moisture Retention	H	M	H	H	H	L	L	L	L	H