APPENDIX C

GUIDANCE FOR EQUIPMENT SELECTION

04/05/00

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INTRODUCTION

The selection and matching of equipment for a surface mining operation is a complex task requiring a knowledge of equipment productivity for the reclamation tasks that are typically encountered. Proper selection of equipment allows completion of reclamation tasks in an efficient manner and results in the lowest possible performance bond.

Factors governing equipment productivity are capacity; cycle time (the time required to complete the operation); and site conditions such as space limitations, grades, and material characteristics that affect the performance of the machinery. Equipment selection involves evaluating the advantages and disadvantages in using different types of equipment to perform reclamation tasks. Familiarity with earthmoving equipment suitable for surface mining reclamation can be gained through review of equipment production and cost-estimating guides available from firms such as Terex, Caterpillar, Komatsu, and others. The estimator, once familiar with the uses and capabilities of various pieces of earthmoving equipment, will be faced with the task of comparing two or more combinations of equipment to determine which is the most efficient for the reclamation task at hand.

EARTHMOVING EQUIPMENT

I. Track-type Tractors

Bulldozers outfitted with either semi-universal or universal (reclamation) blades for backfilling and rough grading and straight blades for final or contour grading, are normally appropriate for reclamation activities requiring dozers. In choosing a particular dozer, the estimator must consider the volume of material to be handled, the space available to maneuver the machine and any size restrictions needed because of the quality of the access roads to the site.

Additionally, dozers can be equipped with a ripper for breakage of consolidated material prior to dozing. The seismic velocity of material may be used to determine whether the material can be ripped. However, because this information is rarely available in permit applications, stratigraphic information from borehole logs and cross-sections must be used. Most shales, siltstones, interbedded shale and sandstone, and thin-bedded limestone can be ripper with the larger ripper-equipped dozers. However, thick-bedded sandstone, limestone, or conglomerate formations would probably require blasting.

Other reclamation tasks in which rippers are often employed include ripping of the subbase of road and facility areas to eliminate vehicle compaction prior to topsoil replacement. Reclamation plans also require contour ripping of backfill areas prior to topsoil replacement to improve soil cohesion on slopes and/or reduce compaction. In order to achieve the necessary post-mine land use deep (3 to 4 feet) ripping may be required in areas where prime farmland soils are replaced. This compaction elimination allows the necessary root penetration for agricultural crops such as corn and is especially if scrapers are used in replacement of the rooting medium. This ripping activity is conducted with large bulldozers pulling specialty rippers and the reclamation is often estimated on a per-acre basis.

II. Trucks

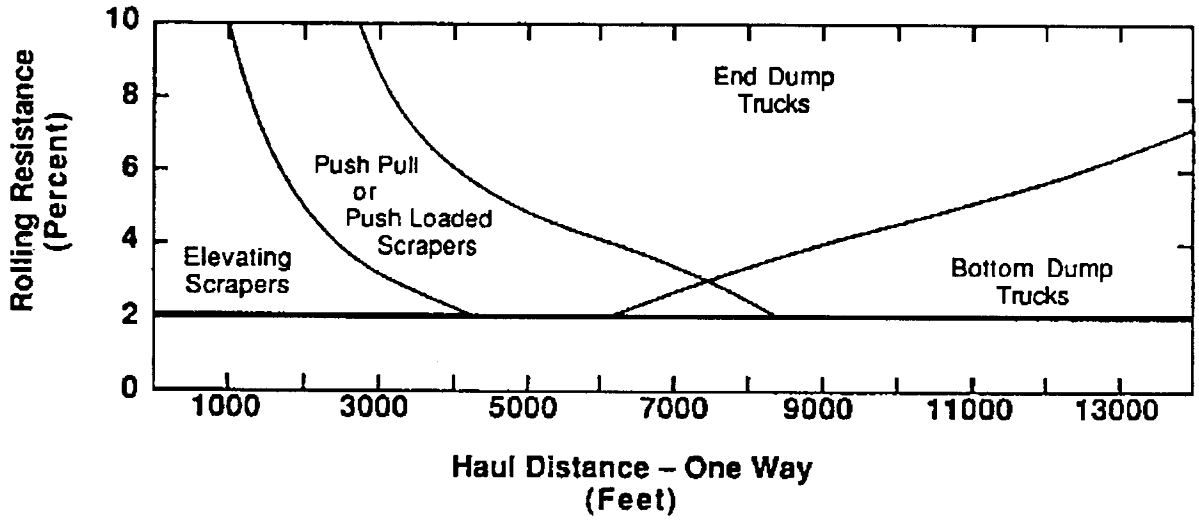
Most reclamation tasks requiring off-highway trucks can be accomplished with trucks having capacities of 35 tons (26 cubic yards) to 150 tons (100 cubic yards). Larger off-road trucks are available with greater capacities. However, these larger trucks are not commonly used in bond forfeiture site reclamation. As with dozers and loaders, selection of trucks is based on the amount of material to be handled and the space available to maneuver the truck. Generally, trucks similar to these used by the operator are the largest that can be selected because of limitations of haul road capabilities.

Bottom dump haul trucks should be considered for spreading large volumes of subsoil material needed to reclaim surface mines especially in prime farmland areas where the hauls are of 10,000 feet or more and prevention of soil compaction is critical (see Figure C-1).

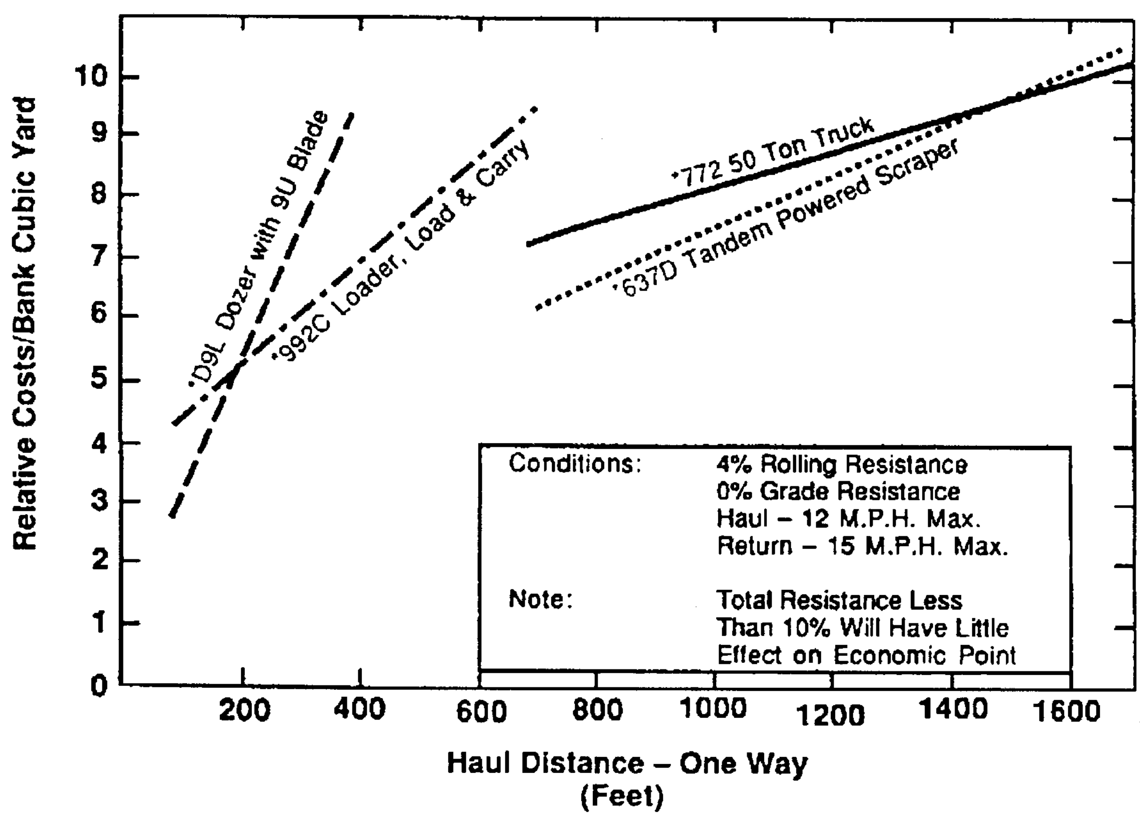
The graph shown in Figure C-2 can be used to estimate speed limits for off-highway trucks with favorable grades and good conditions (firm, smooth roadways with low rolling resistance). When the grade is <u>not</u> favorable (total resistance is a positive number) speed limits are <u>not</u> imposed. For example, for a loaded truck with a (-) 4% total resistance (grade plus rolling resistance), the maximum safe speed would be 35 mph. In comparison, for an empty vehicle with the same favorable grade, the maximum safe speed would be 40 mph.

Figure C-3 can be used to estimate speed limits for off-highway trucks required for safe operation on curves. Based on the road design and the curvature of the turn, the limiting speed can be applied to the curve segment of the haul. If the coefficient of friction and super-elevation are not known, the most conservative curve should be used (coefficient of friction = 0.1 and super-elevation = 0).

Figure C-1 - Application Zones for Representative Reclamation Equipment



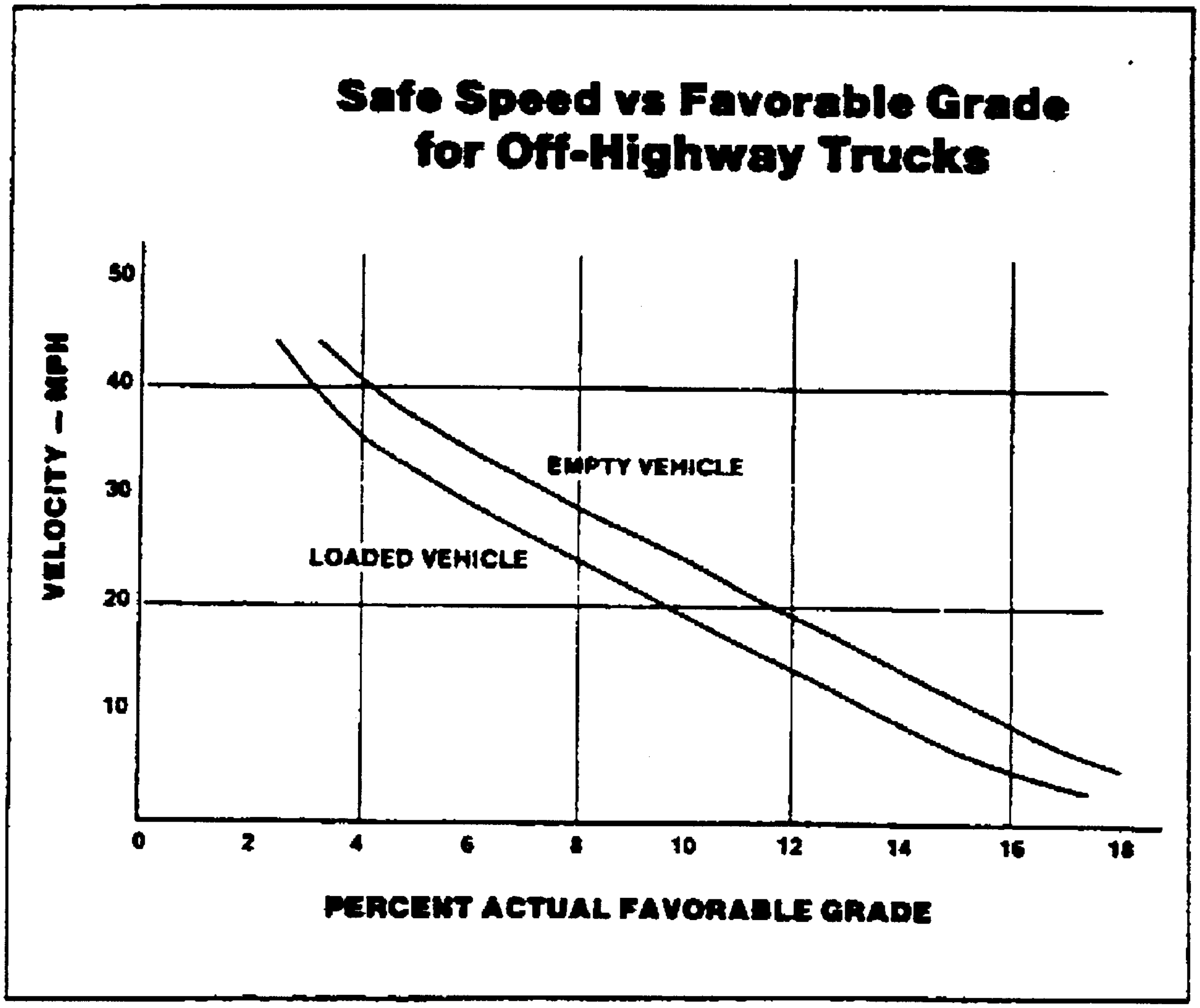
Adapted From
International Harvester, 1975



*Caterpillar Tractor Co., used to illustrate equipment class and does not imply endorsement by the Office of Surface Mining Reclamation and Enforcement

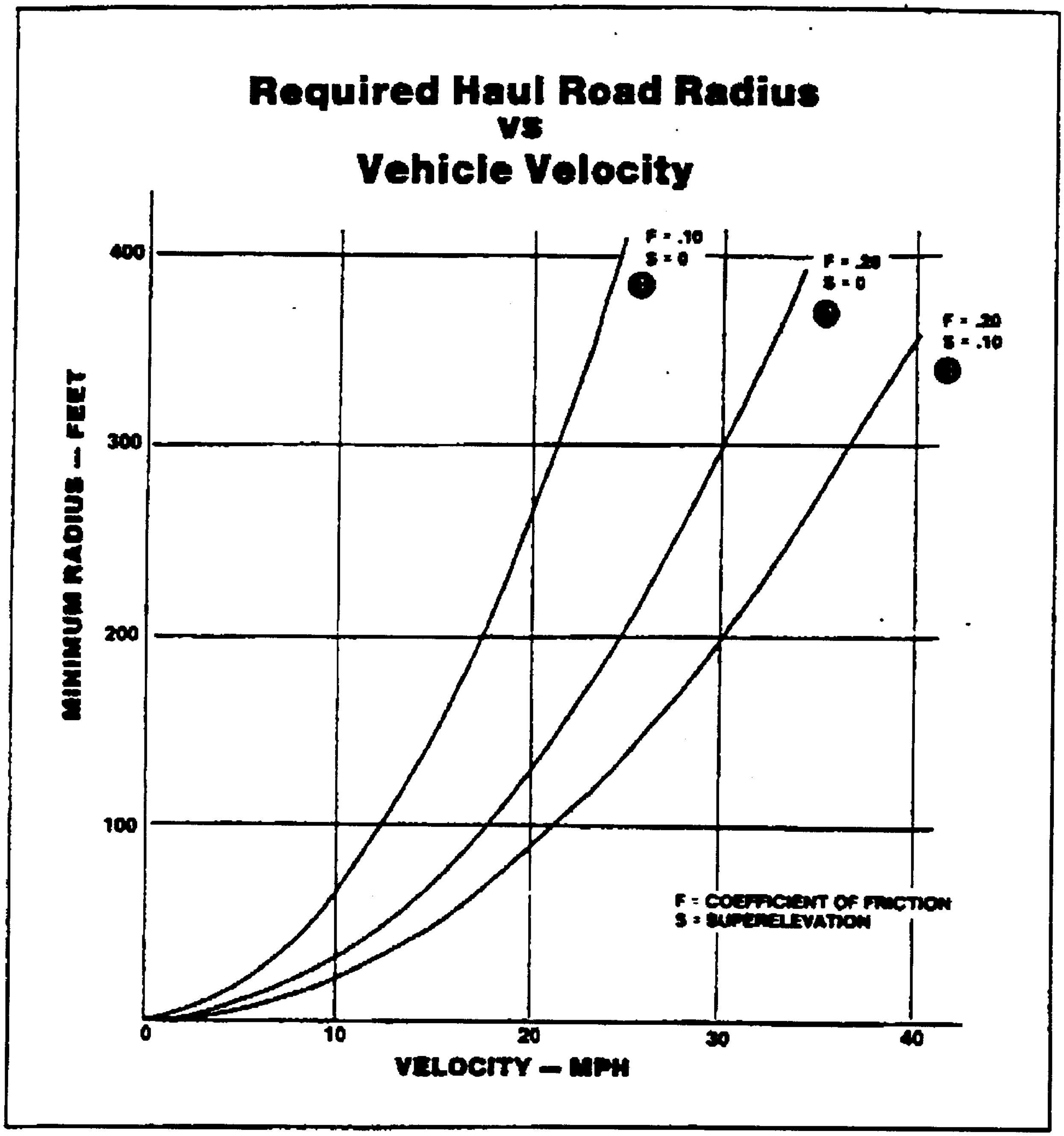
Adapted From
Haley, 1974

Figure C-2 - Safe Downhill Speeds for Off-Highway Equipment.



<u>Source</u>: Vehicle Simulation (VEHSIM) Program User Manual, page E-1, Caterpillar, Inc., 1993.

Figure C-3 - Safe Speeds for Off-Highway Equipment on Curved Road Segments



Source: Vehicle Simulation (VEHSIM) User Program Manual, page F-2, Caterpillar, Inc., 1993 .

III. Excavators

Because of their ability to excavate solid bank material--such as shaley bedrock and compacted fill material--and to work in confined areas, there are certain applications where hydraulic excavators may substitute for wheel loaders. Two types of excavators are used, the front excavator shovel and the backhoe. The front shovel is used to excavate above-grade material while the hydraulic backhoe will excavate below grade. Both machines are useful in reclamation where backfill material must be obtained from the solid bank state or a compacted fill. Backhoes also are useful in cleaning sediment from diversion ditches and siltation structures. The estimator must be careful to ensure that the excavator matches the haul trucks to be used so that excavator loading cycles are minimized.

IV. Scrapers

Scrapers are used for some reclamation activities. Maneuvering space and the volume of material to be moved will dictate the size of the scraper to be selected. If push-pull scrapers are used in pairs, no pushers will be required. However, where large scraper fleets are employed or pusher dozer tasks, such as site cleanup, are available to fill wait times, the non-push-pull scrapers/push dozers combination may be more productive.

Conventional (single-engine) scrapers may be economically substituted for tandem-powered units where grades and rolling resistance are low. Elevating or self-loading scrapers may be used where soft, fine-grained, or unconsolidated materials free of hard rock are encountered. Elevating scrapers have an advantage of working alone without support equipment (other than haul road maintenance) and are well suited for work requiring the flexibility to adjust to small variations in the cut and fill. They have traditionally been used for fine or finish grading. Tandem-powered scrapers can be operated independently if the materials loaded are soft and loading is downhill. However, due to the earthmover's inability to completely fill the bowl in this mode of operation, capacity should be reduced by one-third. When selecting auxiliary equipment, the estimator must determine the requirements for dozer pushers. There must be a match between the scraper selected, the dozer used, and the style of push-loading. Generally, track dozers are used as pushers.

Safety speed limitations presented in Figures C-2 and C-3 should also be applied to the downhill and road curve haulage segments.

V. Motor Graders

Motor graders (motor patrols) can be used in a wide variety of reclamation tasks, but they are used primarily for haul road maintenance. In some instances, it may be cost-effective to use a grader as a substitute for a track dozer for final grading, light leveling work, and diversion ditch construction. Graders used for surface mining can be equipped with a rear-mounted ripper or scarifier.

EQUIPMENT SELECTION OVERVIEW

When making the initial decision about what types of equipment -- for example, dozers versus scrapers--are needed for each earthmoving activity, the estimator should refer to *Worksheet 3*, the Material Handling Plan Summary Sheet. If the one-way haul distance is less than 500 feet, bulldozers of appropriate size will be the optimum equipment for the job in most cases. If the distance is between 500 and 1,000 feet, then scrapers will probably be optimal, assuming underfoot conditions and operating room allow their use and the material does not contain large boulder-size rocks. For distances over 1,000 feet, off-road trucks with compatible wheel loaders or hydraulic shovels become more efficient. Generally, as rolling resistance increases scrapers tend to be less efficient and trucks should be used. As the distance increases to a mile, truck-loader combinations are usually optimal.

After the type of equipment is initially selected, the equipment size must be determined. To do this, the estimator should note the volume and characteristics of material to be moved and the underfoot conditions. The larger pieces of equipment are more appropriate for moving large amounts of materials. Most equipment manufacturers can provide performance books that contain information to guide model selection. When in doubt, select a model and calculate the cost of the job. Next, make the same calculation using a smaller model and again using a larger model. With a little experience, the proper type and size of equipment can usually be determined in the first iteration. However, it is generally good practice to try another iteration with different-sized equipment to make certain that optimal equipment has been selected.

Table C-1 lists advantages and disadvantages of earthmoving equipment typically employed in reclamation of mine sites. Reclamation equipment can also be rated by the suitability to perform backfilling and grading tasks and topsoil removal and replacement (see Tables C-2 and C-3). The influence of haul distance and rolling resistance on the proper selection of reclamation equipment is illustrated in-Figure C-1.

Table C-1.--Advantages and Disadvantages of Reclamation Equipment

Excavators

Wheel Loaders:

1. Can give high production.
2. Larger sizes can handle all types of material, including large blocky material.
3. Where haul distance is less than 800 feet, can operate independently.
4. Have high mobility.
5. Production decreases in poor conditions.

Hydraulic Front Shovels:

1. Can give high production.
2. Can handle all types of material, including large blocky material.
3. Usually require supporting equipment.
4. Have a limited mobility.

Hydraulic Backhoes:

1. Have the ability to dig well below and above grade (i.e., to trim an unstable highwall).
2. Can function in less rigid operating conditions than shovels.
3. May or may not require supporting equipment.
4. Are normally used for handling softer material, but larger units can perform mass excavation of rock.
5. Have a limited mobility.

Scrapers:

1. Have excellent mobility.
2. Are limited to fairly soft and easily broken material for good production, although material up to a 2-foot diameter can be handled.
3. Usually require either pusher tractors or a push-pull team mate for loading assistance.
4. Usually operated without supporting disposal equipment where the distance to the dump area is less than 1 mile.

Bulldozers:

1. Are economically limited to a push distance of 500 feet.
2. Do not require roads.
3. Production decreases rapidly as grade increases.
4. Can operate in poor underfoot conditions.

Haulers

Rear Dump Trucks:

1. Require good roads to minimize tire costs.
2. Can negotiate steep ramps.
3. Usually economically limited to a haul distance of 3 miles.
4. Are very flexible.
5. Can handle coarse, blocky material.

Bottom Dump Trucks:

1. **Require good roads to minimize tire costs.**
2. **Are fast and have a greater economic haul distance than rear dump trucks.**
3. **Are better suited for long, level hauls.**
4. **Requires free-flowing materials.**
5. **Can spread dumped material into furrows, reducing disposal grading requirements.**

Table C-2.--Reclamation Equipment Rating–Regrading and Backfilling

LEGEND

1 Should be considered

2 May be considered

3 May be considered under certain conditions

4 May be considered--special situations

\- Should not be considered

		EQUIPMENT				
		Dozers	Graders	Scrapers	Front-End Loader	Front-End Loader & Trucks
	High Peaks	1	-	2	3	3
Spoil Configuration	Moderate Peaks	1	3	1	1	2
	Low Peaks	1	1	1	1	1
	50'-150'	1	2	1	1	-
	150'-300'	1	-	1	1	-
Transport Distance	300'-500'	2	-	1	2	4
	500'-1000'	-	-	1	3	1
	1000'	-	-	1	-	1
	Flat & Smooth	1	1	1	3	-
	Flat & Rough	1	2	1	2	-
Final Surface Contour	Steep & Smooth	1	-	-	3	-
	Steep & Rough	1	-	-	2	-

Source: Modified from Skelly and Loy, 1975.

Table C-3.--Reclamation Equipment Rating–Topsoil Removal and Replacement

LEGEND

1 Should be considered

2 May be considered

3 May be considered under certain conditions

4 May be considered--special situations

\- Should not be considered

		Dozers	Front-End Loaders	Scrapers			Shovel & Truck	Front-End Loader & Truck
				Elevating	Full-Power	With Push Tractor		
Topsoil Thickness (Removal)	0'-2'	1	1	1	1	1	-	1
	2'-5'	1	1	1	1	1	4	1
Haul Distance	0-300'	1	1	2	2	1	-	-
	300'-500'	2	2	1	1	1	-	-
	500'-1000'	-	-	1	1	1	4	3
	1000'-1500'	-	-	1	1	1	4	2
	1500'-5000'	-	-	2	2	2	4	1

Source: Modified from Skelly and Loy, 1975.

Skelly and Loy, "Economic Engineering Analysis of U.S. Surface Coal Mines and Effective Land Reclamation," U.S. Bureau of Mines Contract Report No. S0241049, 1975.

D. Treatment of
Pollutional Discharges

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CALCULATION OF BOND AMOUNTS FOR LONG-TERM TREATMENT OF POLLUTIONAL DISCHARGES

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The March 31, 1997, acid mine drainage statement calls for the approval of only those permit applications where the operation is designed to prevent off-site material damage to the hydrologic balance and minimize both on- and off-site disturbances to the hydrologic balance. The policy emphasizes that in no case should a permit be approved if the determination of probable hydrologic consequences or other reliable hydrologic analysis predicts the formation of a postmining pollutional discharge that would require continuing long-term treatment without a defined endpoint.

However, the policy also recognizes that unanticipated discharges will develop on occasion despite the use of the best science available. In these situations, the policy requires that the permittee post sufficient financial assurance to cover all foreseeable long-term treatment costs. This assurance may take the form of a conventional bond, a trust fund, or other appropriate instrument that meets the requirements of 30 CFR Part 800.

Costs associated with long-term treatment of pollutional discharges include the capital costs to replace the treatment system, operation and maintenance costs, sampling and analysis costs, labor costs, and an allowance for contingencies. The following items are an example of what may be included in a procedure to calculate the amount of bond required to cover these costs.

1. Evaluate all available hydrologic and geologic data to estimate treatment needs and horizons. Collect additional data if necessary.

2. Determine the average operating life of the treatment facility (conventional or passive) and the capital costs of replacing that facility (a chemical treatment plant or wetland, for example).

3. Determine the annual operating and maintenance costs of the treatment system. For passive systems, these costs would include berm and channel repair expenses.

4. Determine annual monitoring costs (periodic inspection of treatment systems and analysis of effluent samples). Inspection and sampling

frequencies will vary with the type of system and quality of influent, as will the parameters monitored.

5. Calculate the present value of the capital costs of replacing the treatment facility at the end of its useful life. More than one replacement may be necessary.

6. Calculate the present value of annual operation and maintenance costs for the entire period during which treatment will likely be necessary.

7. Calculate the present value of annual monitoring costs (sample collection and analysis) for the entire period during which treatment will likely be necessary.

8. Establish a reasonable contingency factor for unexpected events and cost overruns.

9. Identify the actuarial equations used in Steps 5 through 7 and the basis for the interest and inflation rates selected.

INFORMATION SOURCES

Research publications from universities (such as West Virginia University and Pennsylvania State University), the National Mine Land Reclamation Center, the former U.S. Bureau of Mines and its successor, the Federal Energy Technology Center, and the Tennessee Valley Authority may prove helpful in determining treatment system capital and operation and maintenance costs. In addition, the permittee may be willing to provide historical treatment cost data for the site in question or other mines.

E. Metric Conversion Table

APPENDIX E

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Approximate Conversions to Metric Measures

Symbol	When You Know Number of	Multiply By	To Find Number of	Symbol
		LENGTH		
in	inches	2.54 (exact)	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		WEIGHT (mass)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 pounds)	0.9	metric tons	t

Symbol	When You Know Number of	Multiply By	To Find Number of	Symbol
		VOLUME		
tsp	teaspoon	5	milliliters	mL
Tbsp	tablespoons	15	milliliters	mL
in^3	cubic inches	16	milliliters	mL
fl oz	fluid ounces	30	milliliters	mL
c	cups	0.24	liters	L
pt	pint	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		PRESSURE		
inHg	inches of mercury	3.4	kilopascals	kPa
psi	pounds per square inch	6.9	kilopascals	kPa
		TEMPERATURE (exact)		
°F	degrees Fahrenheit	5/9 (after subtracting 32)	degrees Celsius	°C

Source: U.S. Department of Commerce, National Institute of Standards and Technology.