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DEVELOPMENT OF SURFACE-MINE
COST-ESTIMATING EQUATIONS

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DEVELOPMENT OF SURFACE-MINE
COST-ESTIMATING EQUATIONS

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Prepared for

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Section 1

INTRODUCTION

In a previous report, entitled "Work Plan for Revising the RAMC Mine Costing Methodology" (dated 16 June 1980), it was stated that "...the approach chosen for improving the RAMC mine costing methodology is as follows:"

- Develop a set of regional model mines (both surface and underground) which reflect mining conditions and preference for each major producing district.
- Develop regional equations relating capital and operating costs to various system components.
- Develop the input data necessary for each estimating relationship.

The present report documents the results of this effort for the case of surface mines. Section 2 presents a summary of the results that have been obtained, Section 3 outlines how the cost estimating equations were developed, Sections 4 through 8 present results for each of the five model mine regions, respectively, and Appendix A contains detailed engineering work-ups for each of the five surface mines.

Section 2
SUMMARY OF RESULTS

Table 2.1 presents selected characteristics of the five surface model mines. Based on detailed engineering work-ups (presented in Appendix A), the following model mine costs (in 1980 dollars) were calculated for a 30-year mine life:

Central Appalachia

Initial capital	=	\$3,910,470
Deferred capital	=	3,220,000
Annual operating	=	2,924,148

Northern Appalachia

Initial capital	=	\$10,718,052
Deferred capital	=	7,305,000
Annual operating	=	4,143,482

Mid-West

Initial capital	=	\$40,628,666
Deferred capital	=	14,753,500
Annual operating	=	11,227,809

Far-West

Initial capital	=	\$49,296,785
Deferred capital	=	17,125,840
Annual operating	=	22,926,398

Campbell County

Initial capital	=	\$39,526,377
Deferred capital	=	30,735,000
Annual operating	=	32,708,591

Table 2.2 shows the correspondence between the current NCM (and RAMC) supply regions and the five surface model mine regions.

The cost estimating equations for each of the five regions were developed as follows: First, engineering equations (described in Section 3) were used to estimate primary equipment costs for the

Table 2.1. Surface Model Mine Characteristics

	Region				
	Central Appalachia	Northern Appalachia	Mid-West	Far-West	Campbell County
Description	100,000 tpy Steep Slope	100,000 tpy Hillside Mine	600,000 tpy Area Mine	3x10 ⁶ tpy Area Mine	5x10 ⁶ tpy Pit Mine
Coal Seam Thickness	40"	50"	6'	30'	Variable
Overburden Thickness	5' to 75'	90'	120'	90'	Variable
Overburden Ratio	12:1	22:1	24:1	3:1	1/2:1
Recovery Factor (%)	90	95	95	95	98

Table 2.2. NCM Supply Regions vs Surface Model Mine Regions

Surface Model Mine Region	NCM Supply Regions
Central Appalachia	SV, VA, EK, IN, AL
Northern Appalachia	PA, OH, MD, NV
Mid-West	WK, IL, IN, IA, MO, KN, AR, OK
Far-West	TX, ND, SD, EM (except Powder River), WM, WY (except Powder River), CN, CS, AZ, NM, AK, WA, UT
Campbell County	EM (Powder River), WY (Powder River)

stripping function and for the coal loading and hauling function for the base case mine and for several mines with different annual production levels and/or different overburden removal requirements. Deferred costs were then determined through application of the base case depreciation schedules, and direct labor costs were easily established once the equipment quantities (and, hence, manpower requirements) were determined. The data points were then fit with appropriate functional forms (described in Section 3), and these were then multiplied by appropriate adjustment factors so that the resulting equations yielded the model mine costs for initial and deferred capital and annual operating cost. (The validity of this scaling process is based on the assumption that total initial and deferred capital costs are proportional to the initial and deferred costs for the primary equipment types that were considered [e.g., draglines, overburden trucks, shovels, bulldozers, front-end loaders, etc.] and that annual operating cost is proportional to the direct labor costs that were determined based on primary equipment quantities.)

The resulting cost estimating equations are shown below. Let

R = overburden ratio

T = annual mine output (MMTONS)

C_I = initial capital cost (millions of 1980 dollars)

C_D = deferred capital cost (millions of 1980 dollars)

C_A = annual operating cost (millions of 1980 dollars)

Then, the equations for each of the five regions are as follows:

Central Appalachia

$$C_I = 2.365 RT + 2.815 T^{.419}$$

$$C_D = 1.947 RT + 2.318 T^{.419}$$

$$C_A = 1.945 RT + 1.549 T^{.419}$$

Northern Appalachia

$$C_I = 2.030 + 3.949 RT$$

$$C_D = 3.239 + 1.848 RT$$

$$C_A = 4.143 \text{ (independent of } R \text{ and } T)$$

Mid-West

$$C_I = 2.671 \text{ RT} + 2.713 \text{ T}^{.436}$$

$$C_D = .1637 \text{ RT} + 15.32 \text{ T}^{.436}$$

$$C_A = 5.607 + 6.406 \text{ T}^{.256}$$

Far-West

$$C_I = 4.391 \text{ RT} + 3.259 \text{ T}$$

$$C_D = .1712 \text{ RT} + 8.268 \text{ T}^{.577}$$

$$C_A = 9.262 + 4.555 \text{ T}$$

Compbell County

$$C_I = 11.943 \text{ RT} + 1.934 \text{ T}$$

$$C_D = 3.190 \text{ RT} + 4.552 \text{ T}$$

$$C_A = 6.967 \text{ RT} + 3.058 \text{ T}$$

Section 3

DEVELOPMENT OF COST ESTIMATING EQUATIONS

An engineering approach has been used to estimate principal equipment costs (and associated direct labor costs) for both base case and non-base case mines in each of the five regions. First, equipment capacities and quantities needed to handle demands other than base case demands were determined utilizing standard engineering equations. Then, graphs relating 1980 equipment costs to equipment capacities were developed on the basis of cost information collected during the development of the base cases. For example, the cost of a 5 cubic yard, 45 cubic yard, and 60 cubic yard dragline was established during the work-ups of the base case mines. These costs provided three points from which the relationship between dragline capacity and cost could be established. Between points, cost was assumed to vary linearly with capacity (this assumption seems to be safe; similar graphs developed by Adler* indicate that the relationship between equipment capacity and 1974 capital costs was approximately linear for all equipment types). The cost versus capacity graphs were used to determine the capital costs of the equipment selected for the non-base case mines. Deferred costs were determined through application of the base case depreciation schedules, and direct labor costs were easily established once the equipment quantities (and hence manpower requirements) were determined.

The questions used to calculate the required equipment capacities and quantities are as follows:

- Front-end Loaders: $LMO = \frac{60 C_B EF}{t_c}$, where LMO = loose material output, or the amount of loose material to be moved in an hour (loose cubic yards/hour).

*L. Adler and H.E. Naumann, Analyzing Excavation and Materials Handling Equipment, Research Division, Bulletin 53, Virginia Polytechnic Institute, 1970.

C_B = bucket capacity

E = efficiency

F = bucket fill factor

t_c = cycle time (minutes)

- Shovels and Draglines: $LMO = \frac{3600 C_D E F}{t_s D A}$; where LMO = loose material output (loose cubic yards/hour).

C_D = bucket capacity

E = efficiency

F = bucket fill factor

t_s = cycle time (seconds)

D = depth of cut correction

A = angle of swing correction

- Trucks: $N = \frac{(TCT)(NL)}{(NP)(LCT)}$, where

N = number of trucks of a given capacity required

TCT = truck cycle time (minutes)

NL = number of loaders used to load trucks

NP = number of passes required to fill truck

(NP = the truck's capacity divided by the loader's true capacity)

LCT = loader cycle time (minutes)

The various correction factors (such as efficiency and bucket fill) represent operating and geological conditions, and hence these factors were not varied from the base case. Cycle times were determined from published tables* relating cycle time to equipment size. (Truck travel, dumping, and spotting time was kept constant and equal to the base case times). The relationship between LMO and V (the volume of overburden removed per year), or T (the annual production) depends on the operating schedule (which was not varied from the base case) and the swell factor of the material under consideration (.77 for overburden and .74 for coal).

*L. Adler and H.E. Naumann, Analyzing Excavation and Materials Handling Equipment, Research Division, Bulletin 53, Virginia Polytechnic Institute, 1970.

The initial truck capacities for the base case mines were selected by determining the most popular truck sizes through conversations with truck manufacturers. In order to remain consistent with this approach, the quantity of trucks, rather than the truck size, was varied for the non-base cases. In reality, typical truck capacities may vary somewhat as production varies. The effect of this variation on cost, however, is believed to be slight when compared with the large cost variations one can expect as a result of the large range of "typical" haul lengths.

After the primary equipment quantities and costs were determined for both the stripping function and the coal loading and hauling function, the associated direct labor costs were determined based on manpower requirements. At this point, then, the following quantities were known for both the base case and non-base case mines:

- C_{IS} = initial stripping capital cost;
- C_{ILH} = initial coal loading and hauling capital cost;
- C_{DS} = deferred stripping capital cost;
- C_{DLH} = deferred coal loading and hauling capital cost;
- C_{SL} = annual stripping labor cost; and
- C_{LHL} = annual coal loading and hauling labor cost.

The several data points for each cost element were then fit with an appropriate functional form. (Stripping related costs were assumed to be a function of the annual amount of overburden removed, V , and coal loading and hauling related costs were assumed to be a function of annual production, T .) Finally, total initial capital cost (C_I), deferred capital cost (C_D), and annual operating cost (C_A) were determined by the relationships

$$\begin{aligned} C_I &= K_I (C_{IS} + C_{ILH}), \\ C_D &= K_D (C_{DS} + C_{DLH}), \text{ and} \\ C_A &= K_A (C_{SL} + C_{LHL}), \end{aligned}$$

where the constants K_I , K_D , K_A are chosen so that the cost estimating equations would yield the correct cost values for the base case mine, based on the detailed engineering work-ups reported in Appendix A.

The remainder of this section is divided into subsections outlining the cost factors for each of the model mines. For the most part, these sections differ by the type of equipment used in each region. For example, overburden trucks are only used in conjunction with shovel operations. In the case of our model mines, this applies to Central Appalachia and Campbell County, Wyoming. The Northern Appalachian terrace pit mines and the Mid-West and Far-West area mines use draglines coupled with coal loaders and trucks.

Section 4

CENTRAL APPALACHIAN CONTOUR MINING

COSTS ASSOCIATED WITH THE STRIPPING FUNCTION

Equipment Needs

- Overburden trucks. Central Appalachian base case mine (24 cubic yards): Number of passes required to fill truck = $\frac{24 \text{ cubic yards}}{(13 \text{ cubic yards})(.4)} = 5$ Assume truck cycle time = 6.0 minutes. Number of trucks = $\frac{6 \text{ minutes}}{5(.65 \text{ minutes})} = 2$

- Front-end Loaders. To obtain the size of the front-end loaders required by the Central Appalachian mines the following equation was used:

$$\text{Loose material output} = \frac{60 C_B EF}{t_m} \quad \text{where}$$

C_B = bucket capacity

E = efficiency

F = fill factor

t_m = cycle time

Assume: $E = 8$

$F = 40$ percent for FELs excavating blasted rock

Typical cycle times for FELs loading hauling units:
.6-.7 minutes.

In the case of the Central Appalachian base case mine:

$$\begin{aligned} \text{LMO} &= \frac{\text{Bank cubic yards}}{\text{Swell Factor}} = \frac{295 \text{ cubic yards/hour}}{.77} = 383 \text{ cubic yards/hour} \\ 383 &= \frac{60 C_B (.8)(.4)}{.65}, \quad C_B = 13 \text{ cubic yards} \end{aligned}$$

Initial Capital Costs

The stripping costs for a Central Appalachian contour mine are a direct function of the numbers and type of equipment used and the amount of overburden handled. For our 100,000 ton per year base case mine, one 13 cubic yard front-end loader (cost \$348,800), two 24 cubic yard haul

trucks (cost \$550,000), and two-thirds of a bulldozer (cost \$143,300) are required to handle the overburden (1,320,000 cubic yards per year). Hence, the total stripping cost for the base case mine is \$1,041,800.

If the annual tonnage requirements or the overburden ratio are increased such that the handling requirements grow to 2,000,000 cubic yards of material per year, the stripping cost would be:

$$LMO = \frac{8333 \text{ cubic yards/day} + 439 \text{ cubic yards/day}}{(20 \text{ hours/day}) .77} = 570 \text{ cubic yds/hr}$$

Use two 10 cubic yards FELs

$$\text{Number of passes required to fill truck} = \frac{24 \text{ cubic yds}}{(10 \text{ cubic yds})(.4)} = 6$$

$$\text{Number of trucks} = \frac{(6 \text{ minutes}) 2}{6 (.65 \text{ minutes})} = 4$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Front-end loader	10	2	317,900	635,800
Truck	10	4	275,000	1,100,000
Bulldozer	10	1	215,000	215,000
				<u>\$1,995,000</u>

At a volume of 1,000,000 cubic yards of overburden per year, stripping costs equal:

$$LMO = \frac{4167 \text{ cubic yards/day} + 439 \text{ cubic yards/day}}{(20 \text{ hours/day}) .77} = 299 \text{ cubic yds/hr}$$

Use one 11 cubic yard FEL

$$\text{Number of passes required to fill truck} = \frac{24 \text{ cubic yds}}{(11 \text{ cubic yds})(.4)} = 6$$

$$\text{Number of trucks} = \frac{6 \text{ minutes}}{6 (.65 \text{ minutes})} = 2$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Front-end loader	10	1	328,200	328,200
Truck	10	2	275,000	550,000
Bulldozer	10	-	-	<u>143,300</u>
				\$1,021,500

Direct Labor Costs

The direct labor costs for each of the overburden scenarios presented above are as follows:

A. V = 1,320,000 cubic yards/year

	Rate	Quantity	<u>Days</u> Year	Annual Cost
Loader Operator	78.37	2	240	34,837
Truck Operator	71.01	4	240	68,170
Dozer Operator	71.01	.66	240	<u>22,723</u>
				\$125,730

B. V = 2,000,000 cubic yards/year

	Rate	Quantity	<u>Days</u> Year	Annual Cost
Loader Operator	78.37	4	240	71,470
Truck Operator	71.01	8	240	136,339
Dozer Operator	71.01	2	240	<u>34,085</u>
				\$241,894

C. V = 1,000,000 cubic yards/year

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Loader Operator	78.37	2	240	34,033
Truck Operator	71.01	4	240	68,170
Dozer Operator	71.01	.66	240	<u>22,723</u>
				\$124,926

COSTS FOR COAL LOADING AND HAULING

Capital Costs

The first step in defining coal loading and hauling costs is to identify the number of coal trucks necessary to move a given output. The number of trucks needed is a direct function of the coal truck cycle time (TCT). In the case of the Central Appalachian base case mine the TCT is derived as follows:

$$\text{Tons per dipper} = (13 \text{ cu yds})(.5)\left(\frac{1400 \text{ lbs}}{\text{cy yd}}\right)\left(\frac{1 \text{ ton}}{2000 \text{ lbs}}\right) = 4.55$$

$$\text{Number of passes to fill truck} = \frac{25 \text{ tons}}{4.55 \text{ tons}} = 6$$

$$2 = \frac{\text{TCT}}{6(.65)}$$

$$\text{TCT} = 7.8 \text{ mins.}$$

The coal loading and hauling costs for the base case mine are:

Annual tonnage T = 100,000 tons.

	Dep. Schedule	Quantity	\$ Per	Total Amount
Loaders	10	-	-	25,800
Trucks	10	2	210,000	<u>420,000</u>
				\$445,800

For a 200,000 ton per year mine the loading and hauling capital costs are:

$$LMO = 405 \text{ cu yds/hr}$$

Use 14 cu yd FEL

$$\text{Tons/dipper} = (14 \text{ cu yds})(.5)\left(\frac{.7 \text{ tons}}{\text{cu yd}}\right) = 4.9$$

$$\text{Number of passes to fill truck} = \frac{25}{4.9} = 6$$

$$N = \frac{7.8}{6(.65)} = 2 \text{ trucks}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Loaders	10	-	-	52,700
Trucks	10	2	210,000	<u>420,000</u>
				\$472,700

A 300,000 ton per year contour mine has loading and hauling capital costs of:

$$LMO = 429 \text{ cu yds}$$

Use 15 cu yd FEL

$$\text{Tons/dipper} = (15 \text{ cu yds})(.5)\left(\frac{.7 \text{ tons}}{\text{cu yd}}\right) = 5.25$$

$$\text{Number of passes to fill truck} = \frac{25}{5.2} = 5$$

$$N = \frac{7.15}{5(.65)} = 3 \text{ trucks}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Loaders	10	-	-	76,000
Trucks	10	3	210,000	<u>630,000</u>
				\$706,000

Direct Labor Costs

The direct labor costs associated with the loading and hauling function of a contour mine are as follows:

A. Base Case (100,000 tons/year)

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Loader Operator	78.37	-	235	2,722
Truck Operator	71.01	2	235	<u>33,375</u>
				\$36,097

B. 200,000 tons/year

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Loader Operator	78.37	-	235	5,083
Truck Operator	71.01	2	235	<u>33,375</u>
				\$38,458

C. 300,000 tons/year

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Loader Operator	78.37	-	235	7,109
Truck Operator	71.01	3	235	<u>50,062</u>
				\$57,171

DEFERRED CAPITAL COSTS

Since the depreciation schedule for each of the primary equipment types is the same (10 years), deferred capital costs are equal to twice the initial capital expenditures for a 30-year mine life.

COST ESTIMATING EQUATIONS

Stripping Capital

The stripping capital costs are as follows:

<u>V (MM cu yd/yr)</u>	<u>C_{IS} (MM \$)</u>	<u>C_{IS}/V</u>
1.00	1.0215	1.0215
1.32	1.0418	.7892
2.00	1.9950	.9975

We see that C_{IS} is approximately linear in V . Using an average of the first two values in column 3, we obtain

$$C_{IS} = .8934 V,$$

and since $V \approx 1.1$ RT, the final result is

$$C_{IS} = .9827 \text{ RT.}$$

Stripping Labor

The stripping labor costs are:

<u>V</u>	<u>C_{SL}</u>	<u>C_{SL}/V</u>
1.00	.12493	.12493
1.32	.12573	.09525
2.00	.24189	.12095

Using an average of the last two values in column 3, we obtain

$$C_{SL} = .1081 V = .1081 (1.1 \text{ RT}) = .1189 \text{ RT}$$

Load and Haul Capital

The coal loading and hauling costs are:

<u>T (MM Tons/yr)</u>	<u>C_{ILH} (MM \$)</u>	<u>C_{ILH}/T</u>
.1	.4458	4.458
.2	.4727	2.364
.3	.7060	2.353

C_{ILH} is not linear in T. By fitting the values at T = .1 and T = .3 with an equation of the form $y = ax^b$, we obtain:

$$C_{ILH} = 1.170 T^{.419}$$

Load and Haul Labor

The coal loading and hauling labor costs are:

<u>T</u>	<u>C_{LHL}</u>	<u>C_{LHL}/T</u>
.1	.036097	.36097
.2	.038458	.19229
.3	.057171	.19057

Fitting the values at T = .1 and T = .3, we obtain:

$$C_{LHL} = .0947 T^{.419}$$

Stripping Deferred Capital

$$C_{DS} = 2 C_{IS} = 1.9654 RT$$

Load and Haul Deferred Capital

$$C_{DLH} = 2 C_{ILH} = 2.340 T^{.419}$$

Total Initial Capital

$$C_I = K_I (C_{IS} + C_{ILH}) = K_I (.9827 RT + 1.170 T^{.419})$$

For the base case mine, $C_I = 3.9105$, $R = 12$, and $T = .1$. Solving for K_I , we obtain

$$K_I = 2.406.$$

$$\text{Hence, } C_I = 2.365 RT + 2.815 T^{.419}$$

Total Deferred Capital

$$C_D = K_D (C_{DS} + C_{DLH}) = K_D (1.9654 RT + 2.340 T^{.419}).$$

For the base case mine, $C_D = 3.22$, $R = 12$, and $T = .1$. Solving for K_D , we obtain $K_D = .991$. Hence,

$$C_D = 1.947 RT + 2.318 T^{.419}$$

Annual Operating Cost

$$C_A = K_A (C_{SL} + C_{LHL}) = K_A (.1189 RT + .0947 T^{.419}).$$

For the base case mine, $C_A = 2.924$, $R = 12$, and $T = .1$. Solving for K_A , we obtain $K_A = 16.36$. Hence,

$$C_A = 1.945 RT + 1.549 T^{.419}$$

Section 5

NORTHERN APPALACHIAN TERRACE PIT MINE

STRIPPING FUNCTION COSTS

Capital Costs

Unlike Central Appalachian contour mining the primary stripping method is based on the use of small draglines. The basic engineering equation for computing the size dragline needed for a given operation is:

$$\text{Loose material output} = \frac{3600 C_d E F}{T_s D A} \quad \text{where}$$

C_d = dipper capacity

D = depth of cut correction ($D = 1.0$ for mining)

E = efficiency = .75

F = bucket fill factor = .80

A = angle of swing correction = 1

For our 100,000 ton per year base case mine the dragline requirement is:

$$\text{LMO} = \frac{279 \text{ cubic yards/hour}}{.77} = 362 \text{ cubic yards/hour}$$

$$362 = \frac{3600 C_d (.75)(.8)}{48}$$

$$C_d = 9 \text{ cubic yards}$$

Besides the dragline, the other stripping equipment needs are a cable handler and support bulldozers. The stripping costs for the base case mine are:

$$V = \underline{2,310,000 \text{ cubic yards of overburden per year}}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Dragline	20	1	3,500,000	3,500,000
Cable Handler	20	1	50,000	50,000
Bulldozer	10	-	-	216,700
				<u>3,766,700</u>

Looking at two more data points (2,000,000 and 3,000,000 cubic yards) and assuming bulldozer costs to be 6 percent of the total other costs the following costs were derived:

$$V = \underline{3,000,000 \text{ cubic yards/year}}$$

$$LMO = \frac{3,000,000 \text{ cubic yards/year}}{(345 \text{ days/year})(24 \text{ hours/day}) \cdot .77} = 471 \text{ cubic yards/hour}$$

$$471 = \frac{3600 C_d (.75) (.8)}{62}$$

$$C_d = 14 \text{ cubic yards}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Dragline	20	1	5,000,000	5,000,000
Cable Handler	20	1	50,000	<u>50,000</u>
				\$5,050,000

$$\text{Bulldozer} = .06 (\$5,050,000) = \$303,000$$

$$\text{Total} = \$5,050,000 + \$303,000 = \$5,353,000$$

$$V = \underline{2,000,000 \text{ cubic yards}}$$

$$LMO = \frac{2,000,000 \text{ cubic yards/year}}{(345 \text{ days/year})(24 \text{ hours/day}) \cdot .77} = 314 \text{ cubic yards/hour}$$

$$314 = \frac{3600 C_d (.75) (.8)}{47}$$

$$C_d = 7 \text{ cubic yards}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Dragline	20	1	2,700,000	2,700,000
Cable Handler	20	1	50,000	50,000
				<u>\$2,750,000</u>

$$\text{Bulldozer} = 0.6 (\$2,750,000) = \$165,000$$

$$\text{Total} = \$2,750,000 + 165,000 = \$2,915,000$$

Direct Labor Costs

The direct labor costs for the three cases presented above are:

A. Base Case ($V = 2,310,000$ cubic yards/year)

	Rate	Quantity	<u>Days</u> Year	Annual Cost
Dragline Operator	78.37	3	345	81,113
Dragline Oiler	73.65	3	345	76,228
Dozer Operator	71.01	.66	220	<u>10,415</u>
				\$167,756

B. $V = 3,000,000$ cubic yards/year

	Rate	Quantity	<u>Days Year</u>	Annual Cost
Dragline Operator	78.37	3	345	81,113
Dragline Oiler	73.65	3	345	76,228
Dozer Operator	71.01	.66	220	<u>10,415</u>
				\$167,756

C. V = 2,000,000 cubic yards/year

	Rate	Quantity	<u>Days Year</u>	Annual Cost
Dragline Operator	78.37	3	345	81,113
Dragline Oiler	73.65	3	345	76,228
Dozer Operator	71.01	.66	220	<u>10,415</u>
				\$167,756

COAL LOADING AND HAULING COSTS

Initial Capital Costs

For a Northern Appalachian mine the coal loading and hauling function is performed by front-end loaders and trucks. For the base case mine a 2 cubic yard loader is needed coupled with two coal trucks base on 15 minute cycle times. The capital costs for coal loading and hauling for the Northern Appalachian base case mine and two additional mines are as follows:

A. Base Case (100,000 tons/year)

	Dep. Schedule	Quantity	\$ Per	Cost
Loader	10	1	215,000	215,000
Trucks	10	2	325,000	<u>650,000</u>
				\$865,000

B. 200,000 tons/year

$$\frac{200,000 \text{ tons/year}}{(220 \text{ days/yr})(18 \text{ hrs/day})} = 51 \text{ tons/hour}$$

$$LMO = \frac{51 \text{ tons/hr}}{.7 \text{ tons/cu yd}} = 73 \text{ cu yds/hr}$$

$$73 = \frac{60 C_B (.9) (.5)}{.65}$$

$$C_B = 2 \text{ cu yds}$$

$$\text{Cu yds/dipper} = (2 \text{ cu yds})(.5) = 1$$

$$\text{Number of passes to fill truck} = \frac{36 \text{ cu yds}}{1 \text{ cu yd}} = 36$$

$$N = \frac{38.4}{36(.65)} = 2 \text{ trucks}$$

	Dep. Schedule	Quantity	\$ Per	Cost
Loader	10	1	230,000	230,000
Trucks	10	2	325,000	<u>650,000</u>
				\$880,000

C. 300,000 tons/year

$$\frac{300,000 \text{ tons/year}}{(220 \text{ days/yr})(18 \text{ hrs/day})} = 76 \text{ tons/hr}$$

$$LMO = \frac{76 \text{ tons/hr}}{.7 \text{ tons/cu yd}} = 109 \text{ cu yds/hr}$$

$$109 = \frac{60 C_B (.9) (.5)}{.65}$$

$$C_B = 3 \text{ cu yds}$$

$$\text{Cu yds/dipper} = 1.5$$

$$\text{Number of passes to fill truck} = \frac{36 \text{ cu' dys}}{1.5 \text{ cu yds}} = 24$$

$$N = \frac{30.6}{24(.65)} = 2$$

	Dep. Schedule	Quantity	\$ Per	Cost
Loader	10	1	245,000	245,000
Trucks	10	2	325,000	<u>650,000</u>
				\$895,000

Direct Labor Costs

The direct labor costs for the above mines are as follows:

A. Base Case

	Rate	Quantity	<u>Days</u> Year	Annual Cost
Loader Operator	71.01	2	220	31,244
Truck Operator	71.01	4	220	<u>62,489</u>
				\$93,733

B. 200,000 tons/year

	Rate	Quantity	<u>Days</u> Year	Annual Cost
Loader Operator	71.01	2	220	31,244
Truck Operator	71.01	4	220	<u>62,489</u>
				\$93,733

C. 300,000 tons/year

	Rate	Quantity	<u>Days</u> Year	Annual Cost
Loader Operator	71.01	2	220	31,244
Truck Operator	71.01	4	220	<u>62,489</u>
				\$93,733

DEFERRED CAPITAL COSTS

Stripping Costs

Based on the depreciation schedules for draglines (20 years), cable handlers (20 years), and bulldozers (10 years), the deferred stripping capital costs are computed as follows:

A. Base Case

$$\begin{aligned}\text{Cost} &= .5 (3,500,000) + .5 (50,000) + 2 (216,700) \\ &= \$2,208,400\end{aligned}$$

B. V = 3,000,000

$$\begin{aligned}\text{Cost} &= .5 (5,000,000) + .5 (50,000) + 2 (303,000) \\ &= \$3,131,000\end{aligned}$$

$$C. \quad V = 2,000,000$$

$$\begin{aligned} \text{Cost} &= .5 (2,700,000) + .5 (50,000) + 2 (165,000) \\ &= \$1,709,000 \end{aligned}$$

Coal Loading and Hauling Costs

Since the depreciation schedule is 10 years for both the loaders and trucks used in the coal loading and hauling function, the deferred capital costs for a 30-year mine life are twice the initial capital costs.

COST ESTIMATING EQUATIONS

Stripping Capital

<u>V</u>	<u>C_{IS}</u>	<u>C_{IS}/V</u>
2.00	2.9150	1.4575
2.31	3.7667	1.6306
3.00	5.3530	1.7843

C_{IS} is approximately linear in V . Using the base case value, plus the fact that $V \approx 1.05 \text{ RT}$, we obtain

$$C_{IS} = (1.6306)(1.05 \text{ RT}) = 1.712 \text{ RT}.$$

Stripping Labor

<u>V</u>	<u>C_{SL}</u>
2.00	.1678
2.31	.1678
3.00	.1678

We see that $C_{SL} = .1678$, independent of V (i.e., independent of R and T).

Load and Haul Capital

<u>T</u>	<u>C_{ILH}</u>	<u>C_{ILH}/T</u>
.1	.865	8.65
.2	.880	4.40
.3	.895	2.98

Since C_{ILH} varies so slowly with T , we decided to use the base case value for all T . Thus,

$$C_{ILH} = .880.$$

Load and Haul Labor

<u>T</u>	<u>C_{LHL}</u>
.1	.09373
.2	.09373
.3	.09373

$C_{LHL} = .09373$, independent of T .

Stripping Deferred Capital

<u>V</u>	<u>C_{DS}</u>	<u>C_{DS}/V</u>
2.00	1.7050	.8525
2.31	2.2084	.9560
3.00	3.1310	1.0437

C_{DS} is approximately linear in V . Using the base case value, we have:

$$C_{DS} = (.9560)(1.05 RT) = 1.004 RT$$

Load and Haul Deferred Capital

<u>T</u>	<u>C_{DLH}</u>	<u>C_{DLH}/T</u>
.1	1.73	17.30
.2	1.76	8.80
.3	1.79	5.97

Since C_{DLH} varies so slowly with T , we decided to use the base case value for all T . Thus,

$$C_{DLH} = 1.76.$$

Total Initial Capital

$$C_I = K_I (C_{IS} + C_{ILH}) = K_I (1.712 RT + .880).$$

For the base case mine, $C_D = 7.305$, $R = 22$, and $T = .1$. Solving for K_D , we obtain

$$K_D = 1.841.$$

$$\text{Hence, } C_D = 1.848 RT + 3.239$$

Total Deferred Capital

$$C_D = K_D (C_{DS} + C_{DLH}) = K_D (1.004 RT + 1.76).$$

For the base case mine, $C_D = 7.305$, $R = 22$, and $T = .1$. Solving for K_D , we obtain

$$K_D = 1.841.$$

$$\text{Hence, } C_D = 1.848 RT + 3.239.$$

Annual Operating Cost

$$C_A = K_A (C_{SL} + C_{LHL}) = K_A (.1678 + .09373).$$

For the base case mine, $C_A = 4.143$. Thus, $K_A = 4.143/.26153 = 15.84$, and

$$C_A = 4.143, \text{ independent of } R \text{ and } T.$$

Section 6
MIDWEST AREA MINING

STRIPPING COSTS

Capital Costs

Area mining is by definition dragline mining. The major equipment used in the stripping function are a dragline and several support bulldozers. The dragline size for the base case operation is estimated at:

$$LMO = \frac{1826 \text{ cubic yards/hour}}{.77} = 2371 \text{ cubic yards/hour}$$

$$2371 = \frac{3600 C_d (.75) (.8)}{90}$$

$$C_d = 100 \text{ cubic yards}$$

The capital costs for the base case and two similar mines are as follows:

A. Base Case (V = 15,120,000 cubic yards/year)

	Dep. Schedule	Quantity	\$ Per	Total Amount
Dragline	30	1	32,000,000	32,000,000
Bulldozer	7	-	-	<u>366,700</u>
				\$32,366,000

Assume bulldozer capital cost is 1 percent of dragline cost for other mines.

B. V = 12,000,000 cubic yards/year

$$LMO = \frac{12,000,000 \text{ cubic yards/year}}{(345 \text{ days/year})(24 \text{ hours/day}) .77} = 1882 \text{ cubic yards/hour}$$

$$1882 = \frac{3600 C_d (.75) (.8)}{90}$$

$$C_d = 80 \text{ cubic yards}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Dragline	30	1	25,700,000	<u>25,700,000</u> \$25,700,000

Bulldozer = .01 (\$25,700,000) = \$257,000

TOTAL: \$25,700,000 + \$257,000 = \$25,957,000

C. $V = 18,000,000$ cubic yards/year

$$LMO = \frac{18,000,000 \text{ cubic yards/year}}{(345 \text{ days/year})(24 \text{ hours/day})(.77)} = 2823 \text{ cubic yards/hr}$$

$$2823 = \frac{3600 \text{ cubic yard}(.75)(.8)}{90}$$

$$C_d = 118 \text{ cubic yards}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Dragline	30	1	38,200,000	<u>37,500,000</u> \$37,500,000

Bulldozer: .01 (\$37,500,000) = \$375,000

TOTAL: \$37,500,000 + \$375,000 = \$37,875,000

Direct Labor

The direct labor costs corresponding to the above cases are:

A. Base Case ($V = 15,120,000$ cubic yards/year)

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Dragline Operator	78.37	3	345	81,113
Dragline Oiler	73.65	3	345	76,228
Dozer Operator	71.01	2	240	<u>34,085</u>
				\$191,426

B. V = 12,000,000 cubic yards/year

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Dragline Operator	78.37	3	345	81,113
Dragline Oiler	73.65	3	345	76,228
Dozer Operator	71.01	2	240	<u>34,085</u>
				\$191,426

C. V = 18,000,000

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Dragline Operator	78.37	3	345	81,113
Dragline Oiler	73.65	3	345	76,228
Dozer Operator	71.01	2	240	<u>34,085</u>
				\$191,426

COAL LOADING AND HAULING

Capital Costs

For mid-west area mines coal loading and hauling is accomplished using coal shovels and trucks. The cost for the 600,000 ton/year base case mine is:

	Dep. Schedule	Quantity	\$ Per	Total Amt.
Shovel	30	1	560,000	560,000
Trucks	5	4	317,000	1,268,000
				<u>\$1,828,000</u>

Costs for similar operations are:

B. 300,000 tons/year

$$\frac{300,000 \text{ tons/year}}{(220 \text{ days/yr})(18 \text{ hrs/day})} = 76 \text{ tons/hr}$$

$$\text{LMO} = \frac{(76 \text{ tons/hr})}{.7 \text{ tons/cu yd}} = 109 \text{ cu yds/hr}$$

$$109 = \frac{3600 C_d (.92)}{(23)(1.2)(.863)}$$

$$C_d = 1 \text{ cu yd}$$

$$\text{Tons/dipper} = (1 \text{ cu yd})(1)\left(\frac{.7 \text{ tons}}{\text{cu yd}}\right) = .70 \text{ tons}$$

$$\text{Number of passes to fill truck} = \frac{25 \text{ tons}}{.70 \text{ tons}} = 36$$

$$N = \frac{2178}{36(23)} = 3 \text{ trucks}$$

	Dep. Schedule	Quantity	\$ Per	Total Amt.
Shovel	30	1	400,000	400,000
Trucks	5	3	317,000	951,000
				<u>\$1,351,000</u>

C. 1,000,000 tons/year

$$\frac{1,000,000 \text{ tons/year}}{(220 \text{ days/yr})(18 \text{ hrs/day})} = 253 \text{ tons/hr}$$

$$\text{LMO} = \frac{253 \text{ tons/hr}}{.7 \text{ tons/cu yd}} = 361 \text{ cu yds/hr}$$

$$361 = \frac{3600 C_d (.92)}{26(1.2)(.863)}$$

$$C_d = 3 \text{ cu yds}$$

$$\text{Tons/dipper} = (3 \text{ cu yds})\left(\frac{.7 \text{ tons}}{\text{cu yd}}\right) = 2.1 \text{ tons}$$

$$\text{Number of passes to fill truck} = \frac{25}{2.1} = 12$$

$$N = \frac{1662}{12(26)} = 6 \text{ trucks}$$

	Dep. Schedule	Quantity	\$ Per	Total Amt.
Shovel	30	1	700,000	700,000
Trucks	5	6	317,000	1,902,000
				<u>\$2,602,000</u>

Direct Labor

Direct Labor costs for the above mines are:

A. Base Case

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Shovel Operator	78.37	2	220	34,483
Shovel Oiler	73.65	2	220	32,406
Truck Operator	71.01	8	220	<u>124,978</u>
				\$191 867

B. 300,000 tons/year

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Shovel Operator	78.37	2	220	34,483
Shovel Oiler	73.65	2	220	32,406
Truck Operator	71.01	6	220	<u>93,733</u>
				\$160,622

C. 1,000,000 tons/year

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Shovel Operator	78.37	2	220	34,483
Shovel Oiler	73.65	2	220	32,406
Truck Operator	71.01	12	220	<u>187,466</u>
				\$254,355

DEFERRED CAPITAL COSTS

Stripping Costs

Since the depreciation schedule for the dragline is 30 years, the only deferred stripping cost that needs to be considered for a 30-year mine life is that for bulldozers. Since bulldozers have a depreciation schedule of 7 years, the deferred stripping costs are $3 \frac{2}{7}$ x initial bulldozer cost. Hence, deferred stripping costs for the three cases are:

A. Base Case (V = 15,120,000)

$$\text{Cost} = (3 \frac{2}{7})(366,700) = \$1,205,000$$

B. V = 12,000,000

$$\text{Cost} = (3 \frac{2}{7})(257,000) = \$844,400$$

C. $V = 18,000,000$

$$\text{Cost} = (3 \frac{2}{7})(375,000) = \$1,232,000$$

Coal Loading and Hauling Costs

Since the depreciation schedule for the shovel is 30 years, the only deferred cost to be considered is that for the trucks which have a depreciation schedule of 5 years. Thus, the deferred cost = 5 x initial truck cost. For the three cases, we have:

A. Base Case (T = 600,000)

$$\text{Cost} = (5)(1,268,000) = \$6,340,000$$

B. T = 300,000

$$\text{Cost} = (5)(951,000) = \$4,755,000$$

C. T = 1,000,000

$$\text{Cost} = (5)(1,902,000) = \$9,510,000$$

COST ESTIMATING EQUATIONS

Stripping Capital

<u>V</u>	<u>C_{IS}</u>	<u>C_{IS}/V</u>
12.00	25.957	2.1631
15.12	32.366	2.1406
18.00	37.875	2.1042

C_{IS} is approximately linear in V. Using the base case value, plus the fact that $V \approx 1.05 \text{ RT}$, we have:

$$C_{IS} = (2.1406)(1.05 \text{ RT}) = 2.2476 \text{ RT}$$

Stripping Labor

<u>V</u>	<u>C_{SL}</u>
12.00	.1914
15.12	.1914
18.00	.1914

C_{SL} = .1914, independent of V.

Load and Haul Capital

<u>T</u>	<u>C_{ILH}</u>	<u>C_{ILH}/T</u>
.3	1.351	4.503
.6	1.828	3.047
1.0	2.602	2.602

C_{ILH} is not linear in T ; rather, it varies as a power of T less than one. By fitting the cost values associated with $T = .3$ and $T = .6$, we derive:

$$C_{ILH} = 2.284 T^{.436}$$

Load and Haul Labor

<u>T</u>	<u>C_{LHL}</u>	<u>C_{LHL}/T</u>
.3	.16062	.5354
.6	.19187	.3198
1.0	.25436	.2544

By fitting the cost values associated with $T = .3$ and $T = .6$ we obtain:

$$C_{LHL} = .2187 T^{.256}$$

Stripping Deferred Capital

<u>V</u>	<u>C_{DS}</u>	<u>C_{DS}/V</u>
12.00	.844	.0704
15.12	1.205	.0799
18.00	1.232	.0685

C_{DS} is approximately linear in V . Using the base case value, we obtain:

$$C_{DS} = (.0797)(1.05 RT) = .0837 RT.$$

Load and Haul Deferred Capital

<u>T</u>	<u>C_{DLH}</u>	<u>C_{DLH}/T</u>
.3	4.755	15.85
.6	6.340	10.57
1.0	9.510	9.51

By fitting the cost values associated with $T = .3$ and $T = .6$ with a function of the form $y = ax^b$, we obtain:

$$C_{DLH} = 7.837 T^{.415}$$

Total Initial Capital

$$C_I = K_I (C_{IS} + C_{ILH}) = K_I (2.2476 RT + 2.284 T^{.436})$$

For the base case mine, $C_I = 40.629$, $R = 24$, and $T = .6$. Solving for K_I , we obtain $K_I = 1.188$. Hence,

$$C_I = 2.671 RT + 2.713 T^{.436}$$

Total Deferred Capital

$$C_D = K_D (C_{DS} + C_{DLH}) = K_D (.0837 RT + 7.837 T^{.419})$$

For the base case mine, $C_D = 14.754$, $R = 24$, and $T = .6$. Solving for K_D , we obtain $K_D = 1.955$. Hence,

$$C_D = .1637 RT + 15.32 T^{.415}$$

Annual Operating Cost

$$C_A = K_A (C_{SL} + C_{LHL}) = K_A (.1914 + .2187 T^{.256})$$

For the base case mine, $C_A = 11.228$, $R = 24$, and $T = .6$. Solving for K_A , we obtain $K_A = 29.29$. Hence,

$$C_A = 5.607 + 6.406 T^{.256}$$

Section 7

FAR WEST AREA MINE

STRIPPING

Capital Costs

As with the mid-west area mine the primary method of stripping for a large scale area mine is a dragline operation. The computed bucket size for the far west base case operation is:

Far West Base Case Mine: (E = .78, F = .85)

$$LMO = \frac{1141 \text{ cubic yards/hour}}{.77} = 1482 \text{ cubic yards/hour}$$

$$1482 = \frac{3600 C_d (.78)(.85)}{90}$$

$$C_d = 57 \text{ cubic yards}$$

The capital costs of stripping for the base case and two additional mines are:

A. Base Case (V = 9,450,000 cubic yards/year)

	Dep. Schedule	Quantity	\$ Per	Total Amount
Dragline	30	1	18,500,000	18,500,000
Bulldozer	10	1	378,240	378,240
				<u>\$18,878,240</u>

Assume bulldozer capital costs are 2 percent of dragline costs for other mines.

B. V = 12,000,000 cubic yards/year

$$C_d = 80 \text{ cubic yards}$$

	Dep. Schedule	Quantity	\$Per	Total Amount
Dragline	30	1	25,700,000	27,700,000

TOTAL: \$25,700,000 + .02 (25,700,000) = \$26,214,000

C. $V = 6,000,000$ cubic yards/year

$$LMO = \frac{6,000,000 \text{ cubic yards/year}}{(345 \text{ days/year})(24 \text{ hours/day})(.77)} = 941 \text{ cubic yards/hour}$$

$$941 = \frac{3600 C_D (.78)(.89)}{90} \quad \text{\$}$$

$$C_D = 36 \text{ cubic yards}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Dragline	30	1	11,800,000	11,800,000
				<u>11,800,000</u>

TOTAL: $\$11,800,000 + .02 (\$11,800,000) = \$12,036,000$

Direct Labor

The direct labor stripping costs for the above mines are:

A. Base Case ($V = 9,450,000$ cubic yards/year)

	Rate	Quantity	$\frac{\text{Days}}{\text{Year}}$	Annual Cost
Dragline Operator	78.37	3	345	81,113
Dragline Oiler	73.65	3	345	76,228
Dozer Operator	71.01	1	345	<u>24,498</u>
				<u>\$181,839</u>

B. V = 12,000,000 cubic yards/year

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Dragline Operator	78.37	3	345	81,113
Dragline Oiler	73.65	3	345	76,228
Dozer Operator	71.01	1	345	<u>24,498</u>
				\$181,839

C. 6,000,000 cubic yards/year

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Dragline Operator	78.37	3	345	81,113
Dragline Oiler	73.65	3	345	76,228
Dozer Operator	71.01	1	345	<u>24,498</u>
				\$181,839

COAL LOADING AND HAULING

Coal loading and hauling in a large scale area mine is accomplished by using coal shovels and trucks. The size of the shovel for the base case mine is:

$$LMO = 369 \text{ cubic yards/hour}$$

$$369 = \frac{60C_B(.8)(.4)}{.65}$$

$$C_B = 13 \text{ cubic yards}$$

The coal loading and hauling capital costs for the base case mine are:

A. Base Case (3,000,000 tons/year)

	Dep. Schedule	Quantity	\$ Per	Total Amt.
Shovels	20	1	2,364,000	2,364,000
Trucks	7	5	394,000	1,970,000
				<u>\$4,334,000</u>

Capital costs for two additional area mines are:

B. 2,000,000 tons/year

$$\frac{2,000,000 \text{ tons/year}}{(220 \text{ days/yr})(15 \text{ hrs/day})} = 606 \text{ tons/hr}$$

$$LMO = \frac{606 \text{ tons/hr}}{.7 \text{ tons/cu yd}} = 866 \text{ cu yds/hr}$$

$$866 = \frac{3600(.83)(.9) C_d}{27}$$

$$C_d = 9 \text{ cubic yards}$$

$$\text{Tons/dipper} = (9 \text{ cu yds})(.9) \left(\frac{.7 \text{ tons}}{\text{cu yd}} \right) = 5.67$$

$$\text{Number of passes to fill truck} = \frac{150}{5.67} = 27$$

$$N = \frac{46.17}{27(.45)} = 4 \text{ trucks}$$

	Dep. Schedule	Quantity	\$ Per	Total Amt.
Shovels	20	1	1,760,000	1,760,000
Trucks	7	4	394,000	1,576,000
				<u>\$3,336,000</u>

C. 4,000,000 tons/year

$$\frac{4,000,000 \text{ tons/year}}{(220 \text{ days/yr})(15 \text{ hrs/day})} = 1212 \text{ tons/hr}$$

$$LMO = \frac{1212 \text{ tons/hr}}{.7 \text{ tons/cu yd}} = 1731 \text{ cu yds/hr}$$

$$1731 = \frac{3600(.83)(.9) C_d}{55}$$

$$C_d = 36 \text{ cu yds}$$

$$\text{Tons/dipper} = (36 \text{ cu yds}(.9))(\frac{.7 \text{ tons}}{\text{cu yd}}) = 22.68$$

$$\text{Number of passes to fill truck} = \frac{150}{22.68} = 7$$

$$N = \frac{40.44}{7(.92)} = 7 \text{ trucks}$$

	Dep. Schedule	Quantity	\$ Per	Total Amt.
Shovels	20	1	4,080,000	4,080,000
Trucks	7	6	394,000	2,364,000
				<u>\$6,444,000</u>

Direct Labor

The coal loading and hauling direct labor costs for these mines are:

A. Base Case

	Rate	Quantity	Days Year	Annual Cost
Shovel Operator	78.37	2	235	36,834
Shovel Oiler	73.65	2	235	34,616
Truck Operator	71.01	10	235	<u>166,874</u>
				<u>\$238,324</u>

B. 2,000,000 tons/year

	Rate	Quantity	<u>Days Year</u>	Annual Cost
Shovel Operator	78.37	2	235	36,834
Shovel Oiler	73.65	2	235	34,616
Truck Operator	71.01	8	235	<u>133,499</u>
				\$204,949

C. 4,000,000 tons/year

	Rate	Quantity	<u>Days Year</u>	Annual Cost
Shovel Operator	78.37	2	235	36,834
Shovel Oiler	73.65	2	235	34,616
Truck Operator	71.01	14	235	<u>233,623</u>
				\$305,073

DEFERRED CAPITAL COSTS

Stripping Costs

Since the dragline has a 30 year depreciation schedule, and the bulldozers have a 10 year depreciation schedule, the deferred stripping cost for a 30-year mine life = 2 x initial bulldozer cost. For the three cases, we have:

A. Base Case (V = 9,450,000)

$$\text{Cost} = (2)(378,240) = \$756,480$$

B. V = 12,000,000

$$\text{Cost} = (2)(514,000) = \$1,028,000$$

C. $V = 6,000,000$

$$\text{Cost} = (2)(236,000) = \$472,000$$

Coal Loading and Hauling Costs

Since shovels have a 20 year depreciation schedule, and trucks have a 7 year depreciation schedule, the deferred coal loading and hauling cost may be calculated for the three cases as follows:

A. Base Case ($T = 3,000,000$)

$$\text{Cost} = (.5)(2,364,000) + (3 \frac{2}{7})(1,970,000) = \$7,654,900$$

B. $T = 2,000,000$

$$\text{Cost} = (.5)(1,760,000) + (3 \frac{2}{7})(1,576,000) = \$6,058,300$$

C. $T = 4,000,000$

$$\text{Cost} = (.5)(4,080,000) + (3 \frac{2}{7})(2,364,000) = \$9,807,400$$

COST ESTIMATING EQUATIONS

Stripping Capital

<u>V</u>	<u>C_{IS}</u>	<u>C_{IS}/V</u>
6.00	12.036	2.006
9.45	18.878	1.998
12.00	26.214	2.185

C_{IS} is approximately linear in V . Using the base case value, plus the fact that $V \approx 1.05 \text{ RT}$, we have

$$C_{IS} = (1.998)(1.05 \text{ RT}) = 2.098 \text{ RT}$$

Stripping Labor

<u>V</u>	<u>C_{SL}</u>
6.00	.1818
9.45	.1818
12.00	.1818

We see that $C_{SL} = .1818$, independent of V (hence, R and T).

Load and Haul Capital

<u>T</u>	<u>C_{ILH}</u>	<u>C_{ILH}/T</u>
2	3.336	1.668
3	4.334	1.445
4	6.444	1.611

C_{ILH} is approximately linear in T . Using an average of the first two values in column 3, we obtain

$$C_{ILH} = 1.557 T$$

Load and Haul Labor

<u>T</u>	<u>C_{LHL}</u>	<u>C_{LHL}/T</u>
2	.2049	.1025
3	.2383	.0794
4	.3051	.0763

C_{LHL} is approximately linear in T . Using an average of the first and third values in column 3, we obtain

$$C_{LHL} = .0894 T$$

Stripping Deferred Capital

<u>V</u>	<u>C_{DS}</u>	<u>C_{DS}/V</u>
6.00	.4720	.0787
9.45	.7565	.0801
12.00	1.0280	.0857

C_{DS} is approximately linear in V . Using the base case value, we obtain

$$C_{DS} = (.0801)(1.05 RT) = .0841 RT$$

Load and Haul Deferred Capital

<u>T</u>	<u>C_{DLH}</u>	<u>C_{DLH}/T</u>
2	6.058	3.029
3	7.655	2.552
4	9.807	2.452

By fitting a function of the form $y = ax^b$ to the values associated with $T = 2$ and $T = 3$, we obtain

$$C_{dlh} = 4.061 T^{.577}$$

Total Initial Capital

$$C_I = K_I (C_{IS} + C_{ILH}) = K_I (2.098 RT + 1.557 T)$$

For the base case mine, $C_I = 49.297$, $R = 3$, and $T = 3$. Solving for K_I , we obtain $K_I = 2.093$. Hence,

$$C_I = 4.391 RT + 3.259 T.$$

Total Deferred Capital

$$C_D = K_D (C_{DS} + C_{DLH}) = K_D (.0841 RT + 4.061 T^{.577})$$

For the base case mine, $C_D = 17.126$, $R = 3$, and $T = 3$. Solving for K_D , we obtain $K_D = 2.036$. Hence,

$$C_D = .1712 RT + 8.268 T^{.577}$$

Annual Operating Cost

$$C_A = K_A (C_{SL} + C_{LHL}) = K_A (.1818 + .0894 T)$$

For the base case mine, $C_A = 22.926$ and $T = 3$. Solving for K_A , we obtain $K_A = 50.95$. Hence,

$$C_A = 9.262 + 4.555 T$$

Section 8

CAMPBELL COUNTY WYOMING

STRIPPING FUNCTION COSTS

Capital Costs

Campbell County Wyoming is unique in its method of mining. Because of the relatively low overburden and thick seams mining is accomplished through open pit truck and shovel operations. The stripping costs for a 5,000,000 ton per year base case mine moving 2,550,000 cubic yards of overburden per year is:

	Dep. Schedule	Quantity	\$ Per	Total Amount
Shovels	30	5	3,550,000	17,750,000
Trucks	7	8	260,000	2,080,000
Dozers	7	-	-	192,000
				<u>\$20,022,000</u>

Assuming bulldozer costs are 1 percent of total stripping capital costs, the costs for two similar Campbell County operations are:

$$R. \quad V = 2,000,000 \text{ cubic yards/year}$$

$$LMO = \frac{2,000,000 \text{ cubic yards/year}}{(345 \text{ days/year})(18 \text{ hours/day})(.77)} = 418 \text{ cubic yds/hr}$$

$$N = \frac{LMO}{122} = \frac{418}{122} = 4 \text{ shovels}$$

$$\text{Number of trucks} = \frac{(15 \text{ minutes})(4)}{21(.5)} = 6$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Shovels	30	4	3,550,000	14,200,000
Trucks	7	6	260,000	<u>1,560,000</u>
				\$15,760,000

Bulldozer = .01 (\$15,760,000) = 157,000

Total = \$15,917,600

C. V = 3,000,000 cubic yards/year

$LMO = \frac{3,000,000 \text{ cubic yards/year}}{(345 \text{ days/year})(18 \text{ hours/day}) .77} = 627 \text{ cubic yards/hour}$

$N = \frac{LMO}{122} = \frac{627}{122} = 6 \text{ shovels}$

Number of trucks = $\frac{(15 \text{ minutes})(6)}{21 (.5)} = 9$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Shovels	30	6	3,550,000	21,300,000
Trucks	7	9	260,000	<u>2,340,000</u>
				\$23,640,000

Bulldozer = .01 (\$23,640,000) = \$236,400

Total = \$23,876,400

Direct Labor

The direct labor costs for these operations are:

A. Base Case (V = 2,550,000 cubic yards/year)

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Shovel Operators	78.37	15	345	405,565
Shovel Oilers	73.65	15	345	381,139
Truck Operators	71.01	24	345	587,963
Dozer Operators	71.01	1.35	240	<u>23,007</u>
				\$1,397,674

B. V = 2,000,000 cubic yards/year

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Shovel Operators	78.37	12	345	324,452
Shovel Oilers	73.65	12	345	304,911
Truck Operators	71.01	18	345	440,972
Dozer Operators	71.01	1.35	240	<u>23,007</u>
				\$1,093,342

C. V = 3,000,000 cubic yards/year

	Rate	Quantity	$\frac{\text{Days}}{\text{Year}}$	Annual Cost
Shovel Operators	78.37	18	345	486,678
Shovel Oilers	73.65	18	345	457,367
Truck Operators	71.01	27	345	661,458
Dozer Operators	71.01	1.35	240	23,007
				<u>\$1,628,510</u>

COAL LOADING AND HAULING COSTS

Capital Costs

The coal loading and hauling capital costs for a base case and two additional mines are as follows:

A. Base Case (T = 5,000,000 tons/year)

$$\frac{5,000,000 \text{ tons/yr}}{(220 \text{ days/yr})(22 \text{ hrs/day})} = 1033 \text{ tons/hr}$$

$$\text{LMO} = \frac{(1033 \text{ tons/hr})}{.7 \text{ tons/cu yd}} = 1476 \text{ cu yds/hr}$$

$$1476 = \frac{60 \text{ CB} (.9)(.5)}{.65}$$

CB = 36 cu yds, or three 12 cu yd FELs

$$\text{Tons per dipper} = (12 \text{ cu yds}) (.5) \left(\frac{.7 \text{ tons}}{\text{cu yd}} \right) = 4.2$$

$$\text{Number of passes to fill truck} = \frac{40}{4.2} = 10$$

$$N = \frac{\text{TCT}(3)}{10(.65)} = \frac{52(3)}{10(.65)} = 24 \text{ trucks}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Loaders	7	3	362,000	1,086,000
Trucks	7	24	225,000	<u>5,400,000</u>
				\$6,484,000

B. T = 4,000,000 tons/year

$$\frac{4,000,000 \text{ tons/yr}}{(220 \text{ day/yr})(22 \text{ hrs/day})} = 826 \text{ tons/hr}$$

$$LMO = \frac{826 \text{ tons/hr}}{.7 \text{ tons/cu yd}} = 1181 \text{ cu yds/hr}$$

$$1181 = \frac{60 C_B (.9)(.5)}{.65}$$

$C_B = 29$, or two 15 cu yd FELs

$$\text{Tons per dipper} = (15 \text{ cu yds})(.5) \left(\frac{.7 \text{ tons}}{\text{cu yd}} \right) = 5.25$$

$$\text{Number of passes to fill truck} = \frac{40}{5.25} = 8$$

$$N = \frac{50.7 (2)}{8 (.65)} = 20 \text{ trucks}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Loaders	7	2	394,000	788,000
Trucks	7	20	225,000	<u>4,500,000</u>
				\$5,288,000

C T = 6,000,000 tons/year

$$\frac{6,000,000 \text{ tons/yr}}{(220 \text{ days/yr})(22 \text{ hrs/day})} = 1240 \text{ tons/hr}$$

$$LMO = \frac{1240 \text{ tons/hr}}{.7 \text{ tons/cu yd}} = 1771 \text{ cu yds/hr}$$

$$1771 = \frac{60 C_B (.9)(.5)}{.65}$$

$C_B = 43$, or three 15 cu yd FELs

$$\text{Tons per dipper} = (15 \text{ cu yds})(.5) \left(\frac{.7 \text{ tons}}{\text{cu yd}} \right) = 5.25$$

$$\text{Number of passes to fill truck} = \frac{40}{5.25} = 8$$

$$N = \frac{50.7 (3)}{8 (.65)} = 30 \text{ trucks}$$

	Dep. Schedule	Quantity	\$ Per	Total Amount
Loaders	7	3	394,000	1,182,000
Trucks	7	30	325,000	<u>6,750,000</u>
				\$7,932,000

Loading and Hauling Direct Labor

A. Base Case

	Rate	Quantity	<u>Days</u> Year	Annual Cost
Loader Operators	71.01	9	240	153,382
Truck Operators	71.01	63	240	<u>1,073,671</u>
				\$1,227,053

B. 4,000,000 tons/yr

	Rate	Quantity	<u>Days</u> Year	Annual Cost
Loader Operators	71.01	6	240	102,254
Truck Operators	71.01	51	240	<u>869,162</u>
				\$971,416

C. 6,000,000 tons/yr

	Rate	Quantity	<u>Days</u> <u>Year</u>	Annual Cost
Loader Operators	71.01	9	240	153,382
Truck Operators	71.01	88	240	<u>1,499,731</u>
				\$1,653,113

DEFERRED CAPITAL COSTS

Stripping Costs

Since the depreciation schedules for shovels, trucks, and dozers are 30 years, 7 years, and 7 years, respectively, the deferred capital costs for a 30-year mine life = $3 \frac{2}{7}$ x the sum of initial truck cost and dozer cost. For the three cases, we have:

A. Base Case (V = 2,550,000)

$$\text{Cost} = (3 \frac{2}{7})(2,080,000 + 192,000) = \$7,465,100$$

B. V = 2,000,000

$$\text{Cost} = (3 \frac{2}{7})(1,560,000 + 157,000) = \$5,641,600$$

C. V = 3,000,000

$$\text{Cost} = (3 \frac{2}{7})(2,340,000 + 236,400) = \$8,465,300$$

Coal Loading and Hauling Costs

Since the depreciation schedule for both loaders and trucks is 7 years, the deferred capital cost for coal loading and hauling for a 30-year mine = $3 \frac{2}{7}$ x initial capital cost. For the three cases considered, we have:

A. Base Case (T = 5,000,000)

$$\text{Cost} = (3 \frac{2}{7})(6,484,000) = \$21,304,600$$

B. T = 4,000,000

$$\text{Cost} = (3 \frac{2}{7})(5,288,000) = \$17,374,900$$

C. T = 6,000,000

$$\text{Cost} = (3 \frac{2}{7})(7,932,000) = \$26,062,300$$

COST ESTIMATING EQUATIONS

Stripping Capital

<u>V</u>	<u>C_{IS}</u>	<u>C_{IS}/V</u>
2.00	15.760	7.880
2.55	20.022	7.852
3.00	23.640	7.880

C_{IS} is approximately linear in V. Using the base case value, plus the fact that V ≈ 1.02 RT, we obtain

$$C_{IS} = (7.852)(1.02 \text{ RT}) = 8.009 \text{ RT}$$

Stripping Labor

<u>V</u>	<u>C_{SL}</u>	<u>C_{SL}/V</u>
2.00	1.0933	.5467
2.55	1.3977	.5481
3.00	1.6285	.5428

C_{SL} is approximately linear in V. Using the base case value, we obtain

$$C_{SL} = (.5481)(1.02 \text{ RT}) = .5591 \text{ RT}$$

Load and Haul Capital

<u>T</u>	<u>C_{ILH}</u>	<u>C_{ILH}/T</u>
4	5.288	1.3220
5	6.484	1.2968
6	7.932	1.3220

C_{ILH} is approximately linear in T. Using the base case value, we obtain

$$C_{ILH} = 1.2968 \text{ T}$$

Load and Haul Labor

<u>T</u>	<u>C_{LHL}</u>	<u>C_{LHL}/T</u>
4	.9714	.2429
5	1.2271	.2454
6	1.6531	.2755

C_{LHL} is approximately linear in T. Using the base case value, we obtain

$$C_{LHL} = .2454 T$$

Stripping Deferred Capital

<u>V</u>	<u>C_{DS}</u>	<u>C_{DS}/V</u>
2.00	5.6416	2.8208
2.55	7.4651	2.9275
3.00	8.4653	2.8218

C_{DS} is approximately linear in V. Using the base case value, we obtain

$$C_{DS} = (2.9275)(1.02 RT) = 2.986 RT$$

Load and Haul Deferred Capital

Since $C_{DLH} = 3 \frac{2}{7} \times C_{ILH}$, we have:

$$C_{ILH} = (3 \frac{2}{7})(1.2968 T) = 4.261 T$$

Total Initial Capital

$$C_I = K_I (C_{IS} + C_{ILH}) = K_I (8.009 RT + 1.2968 T)$$

For the base case mine, $C_I = 39.526$, $R = .5$, and $T = 5$. Solving for K_I , we obtain $K_I = 1.491$. Hence,

$$C_I = 11.943 RT + 1.934 T.$$

Total Deferred Capital

$$C_D = K_D (C_{DS} + C_{DLH}) = K_D (2.986 RT + 4.261 T)$$

For the base case mine, $C_D = 30.735$, $R = .5$, and $T = 5$. Solving for K_D , we obtain $K_D = 1.068$. Hence,

$$C_D = 3.190 RT + 4.552 T$$

Annual Operating Cost

$$C_A = K_A (C_{SL} + C_{LHL}) = K_A (.5591 RT + .2454 T)$$

For the base case mine, $C_A = 32.709$, $R = .5$, and $T = 5$. Solving for K_A , we obtain $K_A = 12.46$. Hence,

$$C_A = 6.967 RT + 3.058 T$$

Appendix A

ESTIMATED WORKING CAPITAL, INITIAL AND DEFERRED
CAPITAL INVESTMENT AND ANNUAL OPERATING
COST FOR SURFACE MODEL MINES

Surface Model Mine

Engineering Specifications and Description

	Central Appalachia	Northern Appalachia	Mid- West	Far- West	Campbell County
Description	100,000 tpy Steep Slope	100,000 tpy Hillside Mine	600,000 tpy Area Mine	3x10 ⁶ tpy Area Mine	5x10 ⁶ tpy Pit Mine
Coal Seam Thickness	40"	50"	6'	30'	Var.
Overburden Thickness	5' to 75'	90'	120'	90'	Var.
Overburden Ratio	12:1	22:1	24:1	3:1	½:1
Recovery Factor	90	95	95	95	98
No. of strippable Seams	1	1	1	1	6-10
No. of Cuts	1	3	30	30	-
No. of Lifts Necessary	1	2	2	2	-

100,000 tpy C.A. Mine

Estimated Working Capital
and Total Capital Investment

Estimated Working Capital

Direct Labor	3 mos.	62,963
Operating Supplies	3 mos.	331,065
Payroll Overhead	3 mos.	28,333
Indirect Cost	4 mos.	78,800
Fixed Cost	.5% CS*	11,963
Spare Parts	25% CS	598,125
Miscellaneous	5% CS	<u>119,625</u>
Total Working Capital		1,230,870

Total Estimated Capital Investment

Total Mine Cost	2,392,500
Interest (12%)	<u>287,100</u>
Subtotal	2,679,600
Working Capital	1,230,870
Initial Capital	3,910,470
Deferred Capital	<u>3,220,000</u>
Total Capital Investment	7,130,470

*CS = Total mine cost.

100,000 tpy C.A. Mine

Capital and Labor Cost

Description	Quantity	Dollars Per or Each	Total Cost	Yearly Dep.
Front End Loader	1	320,000	320,000	32,000
Bull Dozer with Ripping Blade	2	215,000	430,000	43,000
Mobile Drill Rig	1	75,000	75,000	7,500
Coal Hauling Truck (25 ton)	2	210,000	420,000	42,000
Overburden Off-Highway Truck	1	275,000	275,000	27,500
Powder and Cap Magazine	1	-	9,000	900
Seeding Truck	1	60,000	60,000	6,000
Oil and Diesel Fuel Station	1	-	5,000	500
Bulk Explosive Loading Machine	1	57,500	57,500	5,750
Electrical Substation 7.5 KV	1	115,000	115,000	11,500
Sediment Pond and Ditches	-	62,000	62,000	3,100
Pickup Truck	2	10,500	21,000	4,200
Buildings	-	25,000	25,000	2,500
Mine-Access Roads	-	14,000	14,000	1,900
Engineering Services	-	4,000	4,000	400
Total Construction			1,892,500	191,350
Overhead, Administration			500,000	
Total Mine			2,392,500	

Description	Quantity	Daily Wage	Annual Cost
Loader Operator	1	78.37	18,416.95
Dozer Operator	2	71.01	33,374.70
Driller Operator	1	71.01	16,687.35
Driller Helper	1	71.01	16,687.35
Shooter	1	71.01	16,687.35
Shooter Helper	1	71.01	16,687.35
Truck Driver	3	71.01	16,687.35
Mechanic	2	73.65	34,615.50
Total	12	-	169,843.90
Mine Superintendent	1	-	25,000.00
Mine Maintenance	1	-	25,000.00
Security, Miscellaneous	2	-	32,000.00
Total	4		82,000.00

100,000 tpy C.A. Mine

Estimated Annual Operating Cost

Labor Cost	
Contract	169,850
Salary	<u>82,000</u>
Total	251,850
Depreciation	191,350
Operating Cost (see detail)	1,324,258
Power and Water	35,000
Reclamation	27,500
Payroll Overhead (45%)	113,332
Union Welfare	343,742
Royalty	35,000
Black Lung Benefit	25,000
Reclamation	35,000
License and Bond	16,000
Indirect Cost (15% Labor+Opr Cost)	236,416
Fixed Cost (2% Construction)	<u>37,850</u>
Total	2,924,148

100,000 tpy C.A. Mine

Estimated Operating Cost Detail

Description	Dollars Per or Each	Total Cost
Haul Road Construction		13,470
Clearing and Scalping		3,750
Top Soiling		31,475
Drilling and Shooting		479,110
Overburden Removal		606,280
Loading and Hauling		93,550
Back Filling and Grading		7,665
Revegetation and Seeding		14,120
Contingency and Additional Landscaping		74,838
Acreage Bonding and Permits	1,000/Acre	<u>16,000</u>
		1,324,258

100,000 tpy C.A. Mine

Engineering Analysis
Front-end Loader

Material Characteristics

1. Type of material/condition: Earth and rock mixture
2. Weight (bank) = 2500 lbs/cu yd.
3. Swell factor = .77
4. Weight (loose) = 1920 lbs/cu yd.

Operating Conditions

5. Estimated operating efficiency = .80
6. Production Schedule:
$$\frac{100,000 \text{ tpy} \times 1.1}{240 \text{ days/year}} = 110,000 \text{ tons/year uncovered}$$
$$\frac{110,000 \text{ tons/year}}{240 \text{ days/year}} = 458.3 \text{ tons/day uncovered}$$
$$\text{Overburden ratio} = 12:1$$
$$\frac{458.33 \text{ tons/day} \times 12 \text{ cu yds/ton}}{(10 \text{ hrs/day})} = 5500 \text{ cu yd./day}$$
$$\frac{5500 \text{ cu yd./day}}{(10 \text{ hrs/day})} = 550 \text{ cu yds./hr.}$$
7. Adjusted production schedule = 440 cu yds./hr.
8. Bucket size = 7 cu yd.
9. Height of working place = Unlimited
10. Width of working place = 40 ft.
11. Floor quality = rough, Grade = 3%
12. Type of haul unit = truck
13. Capacity of haul unit = 24 cu yd. (25 tons)
14. Bucket fill factor = .40
15. Stability factor = .50
16. Lifting power = 10,752 lbs.

100,000 tpy C.A. Mine

Mine Calculations

Contour Strip (haulback method)

Seam Height = 40"
Contour on ∇ 22° slope

Recovery = 90%

Tons Per Acre

1. $\frac{(43,560 \text{ ft}^2/\text{acre})(84 \text{ lb/ft}^3)}{2,000 \text{ lb/ton}} = 1829.52 \text{ tons/acre-ft.}$
2. $(1829.52 \text{ tons/acre-ft})(3.33 \text{ ft}) = 6098 \text{ tons/acre}$
3. $(6098 \text{ tons/acre})(.90) = 5488 \text{ recoverable tons/acre}$

Overburden Ratio

1. Average height of overburden Assume: 5' of cover-start
 $\frac{5 + 75}{2} = 40.0'$ 75' of cover-stop
2. $\frac{(43,560 \text{ ft}^2/\text{acre})(40 \text{ ft})}{27 \text{ ft}^3/\text{yd}^3} = 64,533.3 \text{ cu yds./acre}$
3. $\frac{64,533.3 \text{ cu/A}}{5,488 \text{ tons/A}} = 11.75 = \text{Overburden Ratio}$

Daily tonnage

$$\frac{100,000 \text{ tpy}}{235 \text{ days}}$$

$$= 425 \text{ tons per day}$$

100,000 tpy C.A. Mine

Mine Calculations (Cont.)

Equipment

- 1 Front-end Loader, Caterpillar 988
- 1 Bulldozer with ripper, Caterpillar D-9
- 1 Mobile Drill Rig
- 2 25 ton Coal Hauling Trucks, Mack rear dump
- 1 Seeding Truck
- 2 Powder Magazines (1 cap, 1 anfo)
- 1 Overburden Off-highway Truck (50 ton)
- 2 Pickup Trucks

Annual Engineering Data

		<u>Total</u>
Scalped Area (acres)	6.28	25.8
Coal Yield (tons)	24,250.00	100,000.0
Total Topsoil (Lcyds)	10,150.00	41,742.0
Total Overburden (Lcyds)	438,000.00	1,801,275.0
Pit Topsoil (Lcyds)	7,150.00	29,404.0
Total Backfill (Lcyds)	366,000.00	1,505,175.0
Pit Fill Factor	1.00	1.00
Offsite Spoil (Lcyds)	9,210.00	37,876.0

30 x 1 yr. mine life = 30 yr. mine life.

Figure A.1. Artist's Conception of Single Seam, Single Cut Haulback Mining Method

Figure A.2. First Cut Overburden Blasting Pattern Used to Prevent Casting of Spoil Downslope

100,000 tpy N.A. Mine

Estimated Working Capital and
Total Capital Investment

Estimated Working Capital

Direct Labor	3 mos.	243,175
Operating Supplies	3 mos.	1,035,870
Payroll Overhead	3 mos.	109,430
Indirect Cost	4 mos.	130,468
Fixed Cost	.5% CS	39,566
Spare Parts	2.5% CS	197,830
Miscellaneous	1.25% CS	<u>98,915</u>
Total		1,855,250

Total Estimated Capital Investment

Total Mine Cost	7,913,200
Interest (12%)	<u>949,600</u>
Subtotal	8,862,800
Working Capital	1,855,250
Estimated Initial Capital	10,718,052
Estimated Deferred Capital	<u>7,305,000</u>
Total Capital Investment	18,023,052

100,000 tpy N.A. Mine

Capital Summary

Description	Quantity	Dollars Per or Each	Total Cost	Yearly Dep.
Walking Dragline 5 cyd bucket	1	2,100,000	2,100,000	105,000
Front-end Loader	1	215,000	215,000	21,500
Bulldozer	1	325,000	325,000	32,500
Explosive Loading Truck	1	210,000	210,000	21,000
Mobile Drill	1	600,000	600,000	60,000
Coal Hauling Truck	4	325,000	1,300,000	130,000
Overburden Hauling Truck	4	-	-	-
Powder Magazine	1	50,000	50,000	2,500
Pickup Truck	2	10,500	21,000	4,200
Utility Truck	2	15,000	30,000	6,000
Cable Handler and Reel	1	50,000	50,000	2,500
Pump (portable)	2	15,000	30,000	3,000
Flood Lights and Towers	-	-	35,000	1,750
Communications	-	-	7,000	350
Substation (15,000 kva)	1	-	115,000	5,750
Disconnect Skid	1	-	12,000	600
Breaker Skid	1	-	10,000	500
Substation (150 kva)	1	-	55,000	2,750
Office and Bath House	-	-	175,000	8,750
Shop and Warehouse	-	-	65,000	3,250
Oil and Fuel Storage	-	-	22,000	1,100
Initial Haul Road Const.	-	-	220,000	11,000
Site Preparation	-	-	125,000	6,250
Exploration	-	-	40,000	2,000
Power Lines, 10 miles	-	-	750,000	37,500
Railway spur and Supply yard	-	-	600,000	30,000
			7,162,000	499,750
Engineering			35,000	
Overhead (10%)			716,200	
Total Mine			7,913,200	
Interest during const. (12%)			949,600	85,040
Subtotal			8,862,800	584,790

100,000 tpy N.A. Mine

Labor Cost

Personnel	Shift			Total	Daily Wage	Annual Cost
	1	2	3			
Dragline Operator (345)	1	1	1	3	78.37	81,113
Dragline Oiler (345)	1	1	1	3	73.65	76,228
Front-end Loader (220)	-	1	1	2	71.01	31,244
Bulldozer Opr. (220)	-	1	1	2	71.01	31,244
Driller (220)	1	1	1	3	71.01	46,867
Driller Helper (220)	1	1	1	3	71.01	46,867
Shooter (220)	1	1	1	3	71.01	46,867
Shooter Helper (220)	1	1	1	3	71.01	46,867
Explosive Truck Opr.	-	1	1	2	71.01	31,244
Road Grader Driver	-	1	-	1	71.01	15,622
Supply Truck Driver	-	1	-	1	69.35	15,257
Mechanic	2	2	2	6	73.65	106,056
Electrician	1	1	1	3	78.37	51,724
Welder	-	1	-	1	71.01	15,622
Utilityman	1	1	1	3	69.35	45,771
Total Contract				39		688,600
Annual Wage						
Superintendent	-	1	-	1	32,000	32,000
General Pit Foreman	-	1	-	1	27,000	27,000
Maintenance Super-						
intendent	-	1	-	1	27,000	27,000
Maintenance Foreman	1	-	1	2	21,000	42,000
Pit Foreman	1	-	1	2	21,000	42,000
Safety Inspector	1	1	1	3	19,000	57,000
Warehouse Manager	-	1	-	1	17,500	17,500
Mine Clerk	1	1	1	3	13,200	39,600
				13		284,100
Total						972,700

100,000 tpy N.A. Mine

Annual Operating Cost

Labor Cost

Contract	\$ 688,600
Salary	<u>284,100</u>
Total	972,700

Depreciation

584,790

Operating Supplies

Spare Parts	1,107,850
Fuel, Oil, and Lubrication	277,000
Drill Bits	7,800
Tires	23,000
Explosives	82,500
Miscellaneous	<u>138,500</u>
Total	1,636,650

Power and Water 48,500

Reclamation 56,000

Payroll Overhead (45%) 437,715

Union Welfare 432,715

Royalty, Strip License and Bond 10,000

Indirect Cost (15%) 391,402

Fixed Cost (2% of C.S.) 158,265

Total \$4,143,482

Moving Costs/Year

\$ 8,000

Material Characteristics

1. Type of material and condition = earth and rock mixture
2. Weight (bank) = 3200 lbs/cu yd.
3. Swell factor = .77
4. Weight (loose) = 2460 lbs/cu yd.

Operating Conditions

1. Depth of excavation = 90'
2. Dumping height = 45'
3. Reach (maximum) = 75'
4. Area of bench = 80'x120'
5. Angle of swing = 120°
6. Weather conditions = Various
7. Operator efficiencies (estimated) = .75
8. Estimated bucket fill factor = .80
9. Production requirements =
 $100,000 \text{ tpy} \times 1.05 = 105,000 \text{ tpy uncovered}$
 $105,000 \text{ tons/year} \div 345 \text{ days/year} = 304 \text{ tons/day}$
overburden ratio = 22:1
 $(22)(304) = 6696 \text{ cu yds/day}$
 $\frac{6696 \text{ cu yds/day}}{24 \text{ hrs/day}} = 278.98 \text{ cu yds/hr.}$
10. Bucket capacity = 5 cu yds.
11. Empty weight (bucket) = 10,875 lbs (5.43 tons)
12. Power requirements = 750 kva

100,000 tpy N.A. Mine

Engineering Analysis,
Front-end Loader (loading only)

Material Characteristics

1. Type of material/condition = Bituminous coal
2. Weight (bank) = 1900 lbs/cu yd.
3. Swell factor = .74
4. Weight (loose) = 1400 lbs/cu yd.

Operating Conditions

5. Estimated operating efficiency = .90
6. Production schedule =
 $100,000 \text{ tpy} \times 1.05 = 105,000 \text{ tpy}$
 $105,000 \div 220 = 477.2 \text{ tpd}$
 $\frac{477.2 \text{ tpd}}{(.90)(18 \text{ hrs/d})} = 29.5 \text{ ts/hr.}$
 $29.5 \text{ ts/hr.} \times 58,922.6 \text{ lbs/hr.} \div 1400 \text{ lbs/cu yd.} = 42 \text{ cu yd/hr.}$
7. Adj. production schedule = 42 cu yd./hr.
8. Height of working place = 40'
9. Width of working place = 75'
10. Bucket size = 1 cu yd.
11. Floor quality = smooth, hard
12. Grade of working area = 3%
13. Type of haul unit = truck
14. Capacity of haul unit = 3.6 cu yd.

TYPICAL STRIP MINE
POWER DISTRIBUTION SYSTEM

NORTH APP. HILLSIDE MINE

600,000 tpy M.W. Mine

Estimated Working Capital and
Total Capital Investment

Estimated Working Capital

Direct Labor	469,290
Operating Supplies	643,079
Payroll Overhead	211,180
Indirect Cost	222,474
Fixed Cost	191,934
Spare Parts	479,836
Miscellaneous	<u>23,993</u>
Total	2,241,786

Total Estimated Capital Investment

Total Mine Cost	34,274,000
Interest	<u>4,112,880</u>
Subtotal	38,386,880
Working Capital	<u>2,241,786</u>
Est. Initial Capital Investment	40,628,666
Est. Deferred Capital Investment	<u>14,753,500</u>
Total Capital Investment	55,382,166

600,000 tpy M.W. Mine

Capital Summary

Item	Qty	Dollars Per or Each	Total Cost	Yearly Dep.
Walking Dragline (60 yds)	1	19,200,000	19,200,000	640,000
Coal Loading Shovel	1	5,600,000	5,600,000	186,667
Drill (overburden)	1	750,000	750,000	75,000
Tractor Scraper	1	325,000	325,000	46,430
Bull Dozers	2	550,000	1,100,000	157,143
Front-end Loader	2	300,000	600,000	85,715
Grader-Scraper	1	265,000	265,000	37,857
Trucks-Coal Hauler	4	317,000	1,268,000	253,600
Utility Truck-Water	1	50,000	50,000	10,000
Crane Truck	1	72,500	72,500	14,500
Utility Truck-Supply	2	21,000	42,000	8,400
Pickup Trucks	5	10,500	52,500	10,500
Cable Reefer	1	71,000	71,000	2,367
Prospect Drill Complete	1	132,000	132,000	13,200
Power Line, 5 mi & Main Trans.	-	600,000	600,000	20,000
Pit Power System	-	525,500	525,500	17,517
Railway Spur and Yard, Tracks	-	1,130,500	1,130,500	37,684
Bath House and Office	-	450,000	450,000	15,000
Shop and Warehouse	-	450,000	450,000	15,000
Haulage Roads	-	100,000	100,000	3,334
Spares and Shop Tools	-	1,250,500	1,250,000	41,667
Site Preparation	-	85,000	85,000	2,833
Total			34,119,000	1,694,410
Engineering			35,000	
Overhead and Administration			120,000	
Subtotal			34,274,000	
Interest (12%)			4,112,880	142,262
Est. Capital Summary			38,386,880	1,836,672
Def. Cap. =			14,753,500	

600,000 tpy M.W. Mine

Labor Summary

Personnel	Days Per Year	Daily Rate	Shift			Total	Daily Wage	Annual Wage
			1	2	3			
Dragline Operator	345	78.37	1	1	1	3	235.11	81,113
Dragline Oiler	345	73.65	1	1	1	3	220.95	76,228
Shovel Operator	220	78.37	1	1	1	3	235.11	51,724
Shovel Oiler	220	73.65	1	1	1	3	220.95	48,609
Bulldozer Operator	240	71.01	2	2	2	6	426.06	102,255
Driller Operator	220	71.01	1	1	1	3	213.03	46,867
Driller Helper	220	71.01	1	1	1	3	213.03	46,867
Shooter	220	71.01	1	1	1	3	213.03	46,867
Shooter Helper	220	71.01	1	1	1	3	213.03	46,867
Front-end Loader Opr.	240	71.01	2	2	2	6	426.06	102,255
Grader-Scraper Opr.	240	71.01	1	1	1	3	213.03	51,127
Coal Hauling Truck Opr.	220	71.01	-	4	4	8	568.08	124,978
Road Watering Trk. Opr.	220	71.01	-	1	-	1	71.01	15,622
Utility Truck Opr.	240	69.35	1	1	1	3	208.05	49,932
Crane Truck Operator	220	69.35	-	1	1	2	138.70	30,514
Mechanic	240	73.65	3	3	3	6	662.85	159,084
Electrician	220	78.37	1	1	1	3	235.11	51,725
Utilityman	220	69.35	2	2	2	6		91,542
						70		1,173,258
							Annual Wage	
Mine Superintendent	240	-	-	1	-	1	40,000.00	40,000
General Pit Foreman	240	-	1	1	1	3	32,000.00	96,000
Mine Maint. Suptndt.	240	-	-	1	-	1	32,000.00	32,000
Pit Foreman	240	-	2	1	2	5	26,500.00	132,500
Maintenance Foreman	240	-	2	1	2	5	26,500.00	132,500
Safety Inspector	240	-	1	2	1	4	23,000.00	92,000
Mining Engineer	240	-	-	1	-	1	21,000.00	21,000
Warehouse Manager	240	-	-	1	-	1	25,000.00	25,000
Shop Foreman	240	-	1	1	1	3	23,500.00	70,500
Warehouse Clerk	240	65.00	1	1	1	3	15,600.00	46,800
Mine Clerk	240	65.00	-	1	-	1	15,600.00	15,600
								703,900
								1,877,158

600,000 tpy M.W. Mine

Annual Operating Cost

Labor Cost

Contract	1,173,258
Salary	<u>703,900</u>
Total	1,877,158

Depreciation

1,836,672

Operating Cost

Spare Parts	1,919,344
Fuel, Oil, and Lubrications	250,000
Drill Bits and Supplies	41,000
Tires, Belts, etc.	68,500
Explosives	197,500
Miscellaneous	<u>95,970</u>
Total	2,572,314

Power and Water	105,000
Reclamation	95,000
Payroll Overhead (45%)	844,720
Union Welfare	2,061,786
Royalty, Strip License, Bonding	400,000
Indirect Cost (15% labor, supplies)	667,421
Fixed Cost (2% C.S.)	<u>767,738</u>
Total	11,227,809

Material Characteristics

1. Earth and rock mixture
2. Weight (bank) = 3,000 lbs/cu yd.
3. Swell Factor = .77
4. Weight (loose) = 2,310 lbs/cu yd.

Operating Conditions

5. Depth of excavation = 120'
6. Dumping height (maximum) = 105'
7. Reach (maximum) = 250'
8. Area of working place = 350' x 120'
9. Average angle of swing = 90°
10. Weather conditions = average
11. Estimated efficiency factor = .75
12. Bucket fill factor = .80
13. Production requirements =
$$600,000 \text{ tons/year} \times 1.05 = 630,000 \text{ tons/year coal uncovered}$$
$$630,000 \text{ tons/year} \div 345 \text{ days/year} = 1826 \text{ tons/day}$$
$$\text{Overburden ratio} = 24:1$$
$$1826 \text{ tons/day} \times 24 = 43,824 \text{ cu yds./day}$$
$$43,824 \text{ cu. yds./day} \div 24 \text{ hrs/day} = 1826 \text{ cu yds./ hr.}$$
14. Bucket size = 60 cu yds.
15. Weight of empty bucket = 121,714 lbs (61 tons)
16. Power requirements = 12,000 AC KVA
17. Operating costs breakdown:

Electrical	18%
Bucket	27%
Wire rope	13%
Mechanical	28%
Grease & Oil	14%

Material Characteristics

1. Type of material = Bituminous Coal
2. Material Condition = Easy digging
3. Weight (bank) = 1900 lbs/cu yd.
4. Swell factor = .74
5. Weight (loose) = 1400 lbs/cu yd.

Operating Conditions

6. Bank height = 5'
7. Dumping height = 30'
8. Area of working place = 90' x 100'
9. Height restriction of working area = none
10. Average angle of swing = 60°
11. Weather conditions = variable
12. Estimated operating efficiency = 92%
13. Bucket fill factor = 100%
14. Production requirements =

$$600,000 \text{ tons/year} \times 1.05 = 630,000 \text{ tons/year}$$

$$220 \text{ days/year} = 2863 \text{ tons/day}$$

$$\frac{2863 \text{ ton/day}}{(.92) 18 \text{ hrs/day}} = 172.89 \text{ tons/hr.}$$

$$= 345,773 \text{ lbs/hr.} \div 1400 \text{ lbs/cu yd.}$$

$$= 250 \text{ cu yds./hr.}$$
15. Bucket size = 2 cu yd.
(struck)
16. Optimum depth of cut = 11.0' (for 2 cu yd. bucket)

TYPICAL STRIP MINE POWER DISTRIBUTION SYSTEM

Figure A.3. Multiple Seam Two Lifts, Two Passes
Dragline Positioned on Interburden For
For Second Pass

TYPICAL MID WEST AREA MINE

Figure A.4. Dragline Stripping Interburden
from Spoil Side

3,000,000 tpy F.W. Mine

Estimated Working Capital and
Total Capital Investment

Estimated Working Capital

Direct Labor	3 mos.	496,500
Operating Supplies	3 mos.	1,157,090
Payroll Overhead	3 mos.	400,250
Indirect Cost	4 mos.	330,675
Fixed Cost	.5%	5,350
Spare Parts	(5% C.S.)	2,679,350
Miscellaneous	(1.5% C.S.)	<u>803,800</u>
Total Working Capital		5,873,015

Total Estimated Capital Investment

Total Mine Cost	38,771,220
Interest	4,652,550
Subtotal	43,423,770
Working Capital	<u>5,873,015</u>
Initial Capital Investment	49,295,785
Deferred Capital Investment (Includes equipment replacement at end of 7,10, and 20 years)	17,125,840
Total Capital Investment	66,422,625

3,000,000 tpy F.W. Mine

Capital Summary and
Depreciation Schedule

Item	Qty	Dollars Per or Each	Total Cost	Yearly Dep.
Walking Dragline (45 cu yd)	1	14,580,000	14,580,000	486,000
Coal Loading Shovels, B-E 155B	2	2,364,000	4,728,000	236,400
Overburden Drill	2	157,600	315,200	31,520
Front-end Loader	1	394,000	394,000	39,400
Tractor Bulldozer	3	378,240	1,134,720	113,472
Tractor-Scraper	1	400,000	400,000	40,000
Road Grader	1	275,800	275,800	27,500
Coal Hauling Trks, 150 ton	5	394,000	1,970,000	281,430
Water Truck, Sprinkler	1	78,800	78,800	7,880
Truck Crane	1	80,000	80,000	8,000
Supply Truck	2	22,000	44,000	6,286
Pickup Truck	7	10,500	73,500	14,700
Power Line 10 miles, substation	-	945,800	945,800	47,290
Pit Electric System	-	1,182,000	1,182,000	59,100
Prospect Truck	1	157,600	157,600	22,515
Railway Spur	-	1,260,800	1,260,800	63,040
Office and Bathhouse, shop	-	1,103,200	1,103,200	55,160
Coal Hauling Roads	-	275,800	275,800	13,790
Spare Parts, Tools	-	1,576,000	1,576,000	315,200
Misc.	-	5,910,000	5,910,000	591,000
Total			36,471,220	2,459,963
Engineering			800,000	40,000
Overhead and Administration			1,500,000	75,000
Subtotal			38,771,220	2,574,963
Interest (12%)			4,652,550	155,085
Net Estimate			43,423,770	2,730,048

3,000,000 tpy F.W. Mine

Labor Cost

Personnel	Days Per Year	Shift			Total	Daily Wage	Total Cost	Annual Cost
		1	2	3				
Dragline Operator	345	1	1	1	3	78.37	235.11	81,112.95
Dragline Oiler	345	1	1	1	3	73.65	220.95	76,227.75
Bulldozer Operator	345	1	1	1	3	71.01	213.03	73,495.35
Driller (O.B.)	220	1	1	1	3	71.01	213.03	46,866.60
Driller Helper (O.B.)	220	1	1	1	3	71.01	213.03	46,866.60
Shooter (O.B.)	220	1	1	1	3	71.01	213.03	46,866.60
Shooter Helper (O.B.)	220	1	1	1	3	71.01	213.03	46,866.60
Tractor Scraper Opr.	220	-	1	1	2	71.01	142.02	31,244.4
Driller (coal)	220	-	1	1	2	71.01	142.02	31,244.4
Driller Helper (coal)	220	-	1	1	2	71.01	142.02	31,244.4
Shovel Operator	235	-	1	1	2	78.37	156.74	36,834
Shovel Oiler	235	-	1	1	2	73.65	147.30	34,615.5
Front-end Loader Opr.	235	1	1	1	3	71.01	213.03	50,062
Shooter (coal)	235	1	1	-	2	71.01	142.02	33,375
Shooter Helper (coal)	235	1	1	-	2	71.01	142.02	33,375
Truck Driver (coal)	235	1	6	5	12	71.01	852.12	200,250
Mobile Equip. Opr.	220	2	4	4	10	71.01	710.10	156,222
Mechanic	220	3	3	3	9	73.65	662.85	145,827
Electrician	220	1	1	1	3	78.37	235.11	51,724
Welder	220	1	1	1	3	71.01	213.03	46,867
Utility Man	220	2	2	2	6	69.35	416.1	91,542
					81			1,392,727
							Annual Wage	
Superintendent	-	-	1	-	1	-	40,000	40,000
General Pit Forman	-	1	1	1	3	-	35,000	105,000
Maint. Supertndt.	-	-	1	-	1	-	35,000	35,000
Pit Forman	-	2	1	2	5	-	22,000	110,000
Maint. Foreman	-	2	2	2	6	-	22,000	132,000
Mining Engineer	-	-	1	-	1	-	18,000	18,000
Safety Inspector	-	1	1	1	3	-	18,000	54,000
Warehouse Manager	-	-	1	-	1	-	20,000	20,000
Shop Clerk	240	1	1	1	3	55.00	13,200	39,600
Mine Clerk	240	1	1	1	3	55.00	13,200	39,600
					27			593,220
Total								1,985,927

3,000,000 tpy F.W. Mine

Estimated Annual Operating Cost

Item	Annual Cost	Comments
Labor		
Contract	1,392,727	Based on 1978 VMWA contract, March 27, 1980 costs.
Salary	<u>593,200</u>	
Total	1,985,927	
Depreciation	2,730,048	
Operating Supplies		
Machine Parts & Supplies	2,746,880	
Drill, R&S	650,240	
Explosives	650,240	
Road Material	256,000	
Fuel Oil, Lubrication	<u>325,000</u>	
Total	4,628,360	
Power and Water	936,000	
Reclamation Fund	588,800	
Payroll overhead (45%)	1,601,033	
Royalty, Fees, License (15%)	803,800	
Welfare	9,948,525	
Black Lung Benefit (.25¢)	750,000	
Reclamation	1,050,000	
Indirect Cost (15% labor + supplies)	992,150	
Fixed Cost (2% C.S.)	<u>1,071,733</u>	
Total	22,926,398	

Material Characteristics

1. Type of material/condition = earth and rock mixture
2. Weight (bank) = 2,500 lbs/cu yd.
3. Swell factor = .77
4. Weight (loose) = 1,920 lbs/cu yd.

Operating Conditions.

5. Depth of excavation = 90'
6. Dumping height (maximum) = 180'
7. Reach (maximum) = 120'
8. Area of work bench =
9. Average swing angle anticipated = 90°
10. Weather conditions = variable
11. Estimated operating and management efficiency = .78
12. Estimated bucket fill factor = .85
13. Production requirements

$$3,000,000 \text{ tpy} \times 1.05 = 3,150,000 \text{ tpy uncovered}$$

$$\frac{3,150,000}{345 \text{ days}} = 9,130 \text{ ton/day uncovered}$$

$$9,130 \text{ tons/day} \times \frac{3 \text{ cu yds.}}{1 \text{ ton}} = 27,391.3 \text{ cu yds./day}$$

$$@ .78 \text{ efficiency} = 1,463.2 \text{ cu yd./hr.}$$

14. Bucket capacity = 45 cu yd.

Material Conditions

1. Type of material = Coal
2. Material condition = Blasted
3. Weight (bank) = 1,900 lbs/cu yd.
4. Swell factor = .74
5. Weight (loose) = 1,400 lbs/cu yd.

Operating Conditions

6. Bank height = 30'
7. Dumping height = 30'
8. Area of working place = 40' x 100'
9. Height restriction = None
10. Average angle of swing = 90°
11. Weather conditions = variable
12. Estimated operating efficiency = .83
13. Estimated bucket fill factor = .90
14. Production requirements:

$$\frac{3,000,000 \text{ tpy}}{220 \text{ day/year}} = 13,636.4 \text{ tons/day}$$

$$\frac{13,636.4 \text{ tons/day}}{15 \text{ hrs/day}} = 909 \text{ tons/hr.}$$
$$= 1,298.7 \text{ cu yd./hr.}$$

15. Bucket capacity = 14 cu yd.
16. No. of haul units = 6

TYPICAL STRIP MINE
POWER DISTRIBUTION SYSTEM

5,000,000 tpy C.C. Mine

Estimated Working Capital and
Total Capital Investment

Estimated Working Capital

Direct Labor	889,875
Operating Supplies	853,752
Payroll Overhead	400,443
Indirect Cost	348,726
Fixed Cost	181,876
Spare Parts	397,094
Miscellaneous	<u>79,419</u>
Total Working Capital	3,151,185

Total Estimated Capital Investment

Total Mine Cost	32,477,850
Interest	<u>3,897,342</u>
Subtotal	36,375,192
Working Capital	3,151,185
Initial Capital	39,526,377
Deferred Capital	<u>30,735,000</u>
Total Capital Investment	70,261,377

5,000,000 tpy C.C. Mine

Capital Summary

Item	Dep. Sched	Qty	Dollars Per or Each	Total Amount	Yearly Dep.
Strip Loading Shovel					
B-E 195	30	4	3,550,000	14,200,000	473,334
Front-end Loader	7	2	320,000	640,000	91,430
Tractor-Scraper	7	2	290,000	580,000	82,860
Bulldozer	7	2	575,000	1,150,000	164,290
Overburden Hauling Trks.	7	6	260,000	1,560,000	222,860
Coal Hauling Trucks	7	24	225,000	5,400,000	771,430
Water Truck	5	1	35,000	35,000	7,000
Road Scraper-Tractor	7	2	245,000	490,000	70,000
Truck Crane	7	1	87,000	87,000	12,430
Lubrication Truck	5	1	42,000	42,000	8,400
Mechanic Truck	5	1	27,000	27,000	5,400
Welding Truck	5	1	31,000	31,000	6,200
Electrician Truck	5	1	25,000	25,000	5,000
Supply Truck	5	2	18,500	37,000	7,400
Pickup Trucks	5	7	10,500	73,500	14,700
Power Lines & Main Pit					
Trans.	30	-	950,000	950,000	31,667
Cable Reeler	30	4	82,500	330,000	11,000
Railway Spur & Loading					
Facilities	30	-	1,650,000	1,650,000	55,000
Offices and Bathhouse	30	-	450,000	450,000	15,000
Shop and Warehouse	30	-	600,000	600,000	20,000
Lighting System,					
Sewage Disp.	30	-	150,000	150,000	5,000
Pit Electric System	30	-	550,000	550,000	18,334
Road Construction,					
Haulage, etc.	30	-	205,000	205,000	6,834
Site Preparation	30	-	60,000	60,000	2,000
Exploration, Prospect					
Drill	30	-	125,000	125,000	4,167
Spares and Shop Tools	30	-	900,000	900,000	30,000
Miscellaneous	30	-	1,420,000	1,420,000	47,334
Total Construction				31,676,500	
Engineering	30			75,000	2,500
Admin. & Overhead (2%)	30			635,350	21,180
				32,477,850	
Interest (12%)	30			3,897,342	129,920
Estimated Total				36,375,192	2,342,660
Deferred Capital				30,735,000	

5,000,000 tpy C.C. Mine

Labor Summary

Personnel	Days Per Year	Daily Rate	Shift			Total	Daily Wage	Annual Cost
			1	2	3			
Strip Shovel Opr.	345	78.37	4	4	4	12	940.44	324,450
Strip Shovel Oiler	345	73.65	4	4	4	12	883.80	304,911
Front-end Loader Opr.	240	71.01	2	2	2	6	426.06	102,255
Tractor-Scraper Opr.	240	71.01	-	2	2	4	284.04	68,169
Bulldozer Opr.	240	71.01	-	2	2	4	284.04	68,170
Truck Driver	240	71.01	6	21	21	48	3408.48	818,035
Water Truck Operator	220	69.35	-	1	-	1	69.35	14,377
Road-Scraper Opr.	220	71.01	-	2	-	2	142.02	31,245
Truck Crane Opr.	220	71.01	-	1	-	1	71.01	15,663
Utilityman	220	69.35	6	4	6	16	1109.60	244,112
Mechanic	240	73.65	10	4	4	18	1325.70	318,168
Electrician	240	78.37	1	1	1	3	235.11	56,427
Service Truck Opr.	220	69.35	5	5	5	15	1040.25	228,855
Lampman, Bathhouse	240	69.35	1	1	1	3	208.05	49,932
Driller	240	71.01	1	1	1	3	213.03	51,128
Driller Helper	240	71.01	1	1	1	3	213.03	51,128
						150		2,746,983
							Annual Wage	
Mine Superintendent			-	1	-	1	38,000.00	38,000
General Pit Foreman			1	1	1	3	34,000.00	102,000
Mine Maint. Supertd.			-	1	-	1	36,000.00	36,000
Pit Foreman			2	2	2	6	30,000.00	180,000
Pit Maint. Foreman			2	2	2	6	30,000.00	180,000
Safety Director			-	1	-	1	28,000.00	28,000
Safety Inspector			1	1	1	3	24,000.00	72,000
Warehouse Manager			-	1	-	1	22,000.00	22,000
Supply Yard Foreman			1	1	1	3	21,000.00	63,000
Mining Engineer			-	1	-	1	21,000.00	21,000
Mine Clerk			-	1	-	1	18,000.00	18,000
Warehouse Clerk			1	1	1	3	17,500.00	52,500
						30		812,500
Total								3,559,500

5,000,000 tpy C.C. Mine

Annual Operating Cost

Labor Cost

Contract	2,746,983
Salary	<u>812,500</u>
Total	3,559,500

Depreciation 2,342,660

Operating Cost

Spare Parts	1,588,375
Fuel, Oil, and Lubrication	635,350
Tires, and Truck Parts	476,513
Explosives	390,094
Miscellaneous	<u>317,675</u>
Total	3,415,006

Power and Water 590,000

Reclamation 75,000

Payroll Overhead (45%) 1,601,775

Union Welfare 16,600,970

Royalty, Strip License, Bond 2,750,000

Indirect Cost (15%) 1,046,176

Fixed Cost (2%) 727,504

32,708,591

5,000,000 tpy C.C. Mine

Engineering Analysis, Strip
Shovel

Material Characteristics

1. Type of material/condition = Earth and rock mixture
2. Weight (bank) = 2,500 lbs/cu yd.
3. Swell factor = .77
4. Weight (loose) = 1,920 lbs/cu yd.

Operating Conditions

5. Bank height = Variable
6. Dumping height = 30'
7. Area of work place = variable
8. Height = 0
9. Average angle of swing = 90°
10. Weather conditions = good
11. Estimated operating efficiency = .83
12. Estimated bucket fill factor = .79
13. Production requirements
 - $5,000,000 \times 1.02 = 5,100,000$ tons/year uncovered
 - $\frac{5,100,000}{345 \text{ days/year}} = 14,782.6$ tons/day
 - Overburden ratio = $\frac{1}{2}:1$
 - $\therefore$ overburden removed = 7,391.3 cu yds/day
 - $\frac{7,391.3 \text{ cu yds/day}}{(.83) 4 (18 \text{ hrs/day})} = 123.7$ cu yds/day per shovel
14. Bucket capacity = $1\frac{1}{2}$ cu yd.

5,000,000 tpy C.C. Mine

Engineering Analysis, Front-end
Loader

Material Characteristics

1. Type of material/condition = Coal
2. Weight (bank) = 1,900 lbs/cu yd.
3. Swell factor = .77
4. Weight (loose) = 1,400 lbs/cu yd.

Operating Characteristics

5. Estimated Operating Efficiency = .90
6. Production schedule
$$\frac{5,000,000 \text{ tons/year}}{220 \text{ days/year}} = 22,727.27 \text{ tons/day}$$
$$\frac{22,727.27 \text{ tons/day}}{22 \text{ hrs./day}} = 1,033.0 \text{ tons/hr.}$$
$$2 \text{ loaders} = 516.5 \text{ tons/hr/loader}$$
$$= 737.9 \text{ cu yd./hr/loader}$$
7. Bucket capacity = 10 cu yds.