

## 2.2. SURFACE MINING--CAPITAL COSTS

## 2.2.1. PREPRODUCTION DEVELOPMENT

## 2.2.1.1. CLEARING

The curve for clearing during preproduction development is based on estimated costs for medium-light growth on terrain with a side slope of 20% to 50%. Estimate one tree, 0.33 m in diameter, per 40 m<sup>2</sup>.

The total cost per hectare is the sum of three separate cost curves (labor, supplies, and equipment operation) having a clearing area (X), in total hectares. The curves are valid for operations between 1 and 1,000 ha (from 500 to 1,000 ha, the costs are expected to remain constant), operating one shift per day. This cost is multiplied by the total hectares cleared to obtain the capital cost. The curves include all daily operating and maintenance costs associated with clearing a land surface for further development.

## BASE CURVE

(L) Labor Operating Cost  $(Y_L) = 2,171.220(X)^{-0.120}$

The operating labor costs are distributed as follows:

Direct labor.....	84%
Maintenance labor.....	16%

The direct labor costs consist of the following typical range of personnel:

		Av salary per hour (base rate)
Dozer operator.....	21%	\$16.33
Truck driver.....	6%	15.89
General laborer.....	73%	13.66

The average wage for labor is \$14.58 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost  $(Y_S) = 269.796(X)^{-0.0303}$

For clearing operations from 1 to 500 ha, the supply cost consists of 78% fuel oil (for burning wood and scrub) and 22% tools, cables, and chokers. For operations of 500 to 1,000 ha, the supply cost consists of 83% fuel oil and 17% tools, cables, and chokers.

(E) Equipment Operating Cost  $(Y_E) = 667.618(X)^{-0.0672}$

Equipment operating costs consist of 87% for crawler dozers and 13% for trucks, pickups, and chainsaws.

The general equipment cost component distribution is

	<u>Repair parts</u>	<u>Fuel and lube</u>	<u>Tires</u>
Crawler dozers.....	51%	49%	-
Trucks, pickups, and chainsaws.....	14%	80%	6%

## ADJUSTMENT FACTORS

Brush Factor For light clearing conditions where the growth consists mainly of brush and small trees, multiply the curves by the following factor:

$$\text{Brush factor } (Y_B \text{ LIGHT}) = 0.25$$

For heavy clearing conditions, defined as when clearing a dense growth of trees (diameter of the trees commonly exceeding 0.33 m), multiply the curves by the following factor:

$$\text{Brush factor } (Y_B \text{ DENSE}) = 1.75$$

Side Slope Factor For clearing on terrain with side slopes other than 20% to 50% multiply the curves by the following factors:

For clearing on terrain with side slopes of 0% to 20%,

$$\text{Side slope factor } (Y_S \text{ 0\%-20\%}) = 0.8$$

For clearing on terrain with side slopes of 50% to 100%,

$$\text{Side slope factor } (Y_S \text{ 50\%-100\%}) = 1.2$$

For clearing on terrain with side slopes greater than 100%,

$$\text{Side slope factor } (Y_S \text{ +100\%}) = 2.5$$

Burning Factor When the burning of cleared brush and trees is prohibited due to environmental regulations, the brush and trees will have to be stacked or buried. If burning is prohibited, multiply the costs obtained from the curves by the following factors:

$$\text{Labor factor } (F_L) = 1.2$$

$$\text{Supply factor } (F_S) = 0.2$$

$$\text{Equipment operation factor } (F_E) = 1.2$$

Equipment Factor Where it is necessary to purchase equipment, or have a subcontractor perform the work, multiply the equipment operation value by the following applicable factor in order to obtain the total value of equipment expense for ownership and operation:

Shifts per day.....	1	2	3
Factor.....	1.75	1.56	1.50

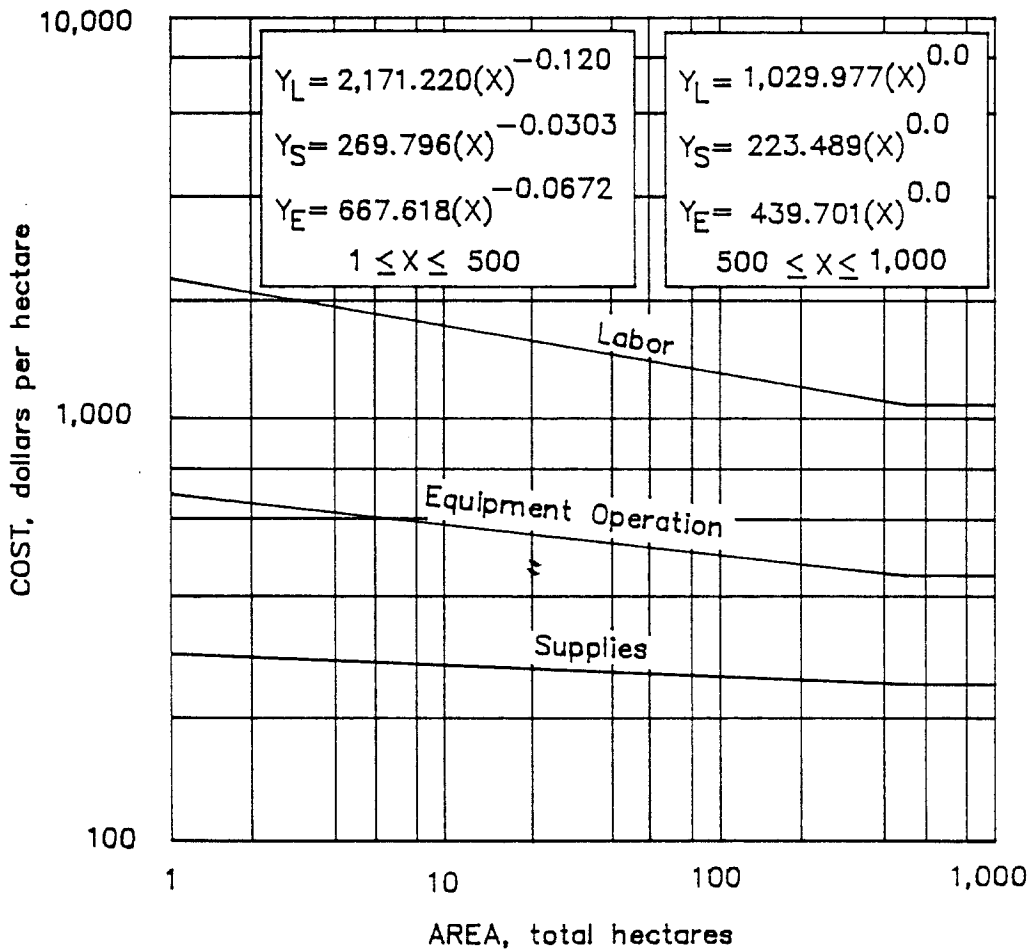
Subcontractor Factor If a subcontractor is used, multiply the costs obtained from the curves by the following factors to compensate for subcontractor's markup.

Labor factor  $(F_L) = 1.5$

Supply factor  $(F_S) = 1.2$

Equipment operation factor  $(F_E) = 1.2$

Surface Mining—Capital Costs



2.2.1.1. Clearing

## 2.2. SURFACE MINING--CAPITAL COSTS

## 2.2.1. PREPRODUCTION DEVELOPMENT

## 2.2.1.3. DRILL AND BLAST OVERBURDEN AND WASTE

The curves have been developed in two parts. For mines excavating from 100 to 8,000 mt of overburden and waste per day, the curves reflect costs for drilling 6-m-high benches with crawler-type percussion drills. Spacing of 2.5-in (6.35-cm) holes is on a pattern of 1.5 by 2 m to a depth of 7 m. The powder factor is 0.30 kg/mt.

For mines excavating from 8,000 to 300,000 mt of overburden and waste per day, drilling is performed with rotary drills having a down pressure of from 13,600 to 56,700 kg. The powder factor varies from 0.11 to 0.20 kg/mt waste with an average of 0.14 kg/mt waste. Holes drilled average 12.25-in (31.12-cm) diameter from a range of 6- to 13.75-in (15.24-34.93-cm) diameter. Costs are based on drilling hard rocks with an average compressive strength (2,100 kg/cm<sup>2</sup>). Bench heights are 12 to 18 m averaging 15 meters. Drilling patterns and overdrilling vary with a range of 100 to 300 mt of blasted material per linear meter of drill hole. Secondary drilling and blasting vary from 0% to 10% of blasted material.

The total cost per metric ton is the sum of three separate cost curves (labor, supplies, and equipment operation) having a production rate (X), in metric tons of overburden and waste blasted per day. The curves are valid for operations between 100 and 300,000 mtpd, operating three shifts per day. This cost is multiplied by the total metric tons of material blasted for development to obtain the capital cost. The curves include all daily operating and maintenance costs associated with drill and blast.

## BASE CURVE

(L) Labor Operating Cost (percussion drill) ( $Y_L$  PERCUSSION) =  $1.747(X)^{-0.091}$   
The operating labor costs are distributed as follows:

Direct labor.....	76%
Maintenance labor.....	24%

The direct labor costs consist of the following typical range of personnel:

	Small (100 to 3,000 mtpd)	Large (3,000 to 8,000 mtpd)	Av salary per hour (base rate)
Drilling crew.....	70%	83%	\$15.22
Blasting crew.....	30%	17%	14.79

The average wage for labor is \$15.41 per worker-hour (including burden and average shift differential).

(L) Labor Operating Cost (rotary drill)  $(Y_L \text{ ROTARY}) = 0.0417(X)^{0.0353}$   
 The operating labor costs are distributed as follows:

Direct labor.....	43%
Maintenance Labor.....	57%

The direct labor costs consist of the following typical range of personnel:

		Av salary per hour (base rate)
Rotary and secondary drilling crews.....	67%	\$15.24
Blasting crew.....	33%	15.00

The average wage for labor is \$15.45 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost (percussion drill)  $(Y_S \text{ PERCUSSION}) = 30.278(X)^{-0.496}$   
 The supply costs include drill bits and steel-related items and blasting supplies in the following cost proportions:

	Small (100 to 3,000 mtpd)	Large (3,000 to 8,000 mtpd)
Drill bits and steel-related items.....	10%	25%
Blasting supplies.....	90%	75%

(S) Supply Operating Cost (rotary drill)  $(Y_S \text{ ROTARY}) = 0.147(X)^{-0.0160}$   
 The supply costs for both curves include drill bits and steel-related items and blasting supplies in the following cost proportions:

	Small (8,000 to 100,000 mtpd)	Large (100,000 to 300,000 mtpd)
Drill bits and steel-related items.....	26%	16%
Blasting supplies.....	74%	84%

(E) Equipment Operating Cost (percussion drill)  $(Y_E \text{ PERCUSSION}) = 1.771(X)^{-0.182}$   
 The equipment operating cost includes power for the drills, fuel and lubrication for trucks and drill compressors, repair parts for drills and supporting equipment, and tire costs for supporting equipment.

The equipment operating costs for percussion drill and blast are 86% for drilling equipment and 14% for trucks.

The general equipment cost component distribution is

	<u>Repair parts</u>	<u>Fuel and lube</u>	<u>Tires</u>
Percussion drills.....	58%	42%	-
Trucks.....	8%	87%	5%

(E) Equipment Operating Cost (rotary drill )  $(Y_E \text{ ROTARY}) = 0.0294(X)0.0567$   
 The equipment operating cost includes power for the drills, fuel and lubrication for trucks and drill compressors, repair parts for drills and supporting equipment, and tire costs for supporting equipment.

The equipment operating costs for rotary drill and blast are 95% for drilling equipment and 5% for trucks.

The general equipment cost component distribution is

	<u>Repair parts</u>	<u>Fuel and lube</u>	<u>Tires</u>	<u>Power</u>
Rotary drills.....	79%	10%	-	11%
Trucks.....	11%	80%	9%	-

ADJUSTMENT FACTORS

Drill-and-Blast Factor (D & B factor) The curves indicate average costs for a wide range of materials, as can be noted above by drill sizes, bit sizes, powder factors, and drill pattern. To determine drilling and blasting costs, consideration must be given to material hardness, abrasiveness, natural fractures and jointing, and maximum-size fragments that can be loaded, hauled, and processed. Where the above conditions are favorable, multiply the costs obtained from the curves by the following factor:

D & B factor  $(F_D \text{ GOOD}) = 0.60$

Where the above conditions are unfavorable, multiply the costs by the following factor:

D & B factor  $(F_D \text{ SEVERE}) = 2.00$

Equipment Factor Where it is necessary to purchase equipment or have a subcontractor perform the work, multiply the cost obtained from the equipment operation curve by the following applicable factor in order to obtain the total value of equipment expense for ownership and operation:

Crawler-type percussion drills:

Shifts per day.....	1	2	3
Factor.....	1.81	1.61	1.54

Rotary drills:

Shifts per day.....	1	2	3
Factor.....	1.63	1.47	1.42

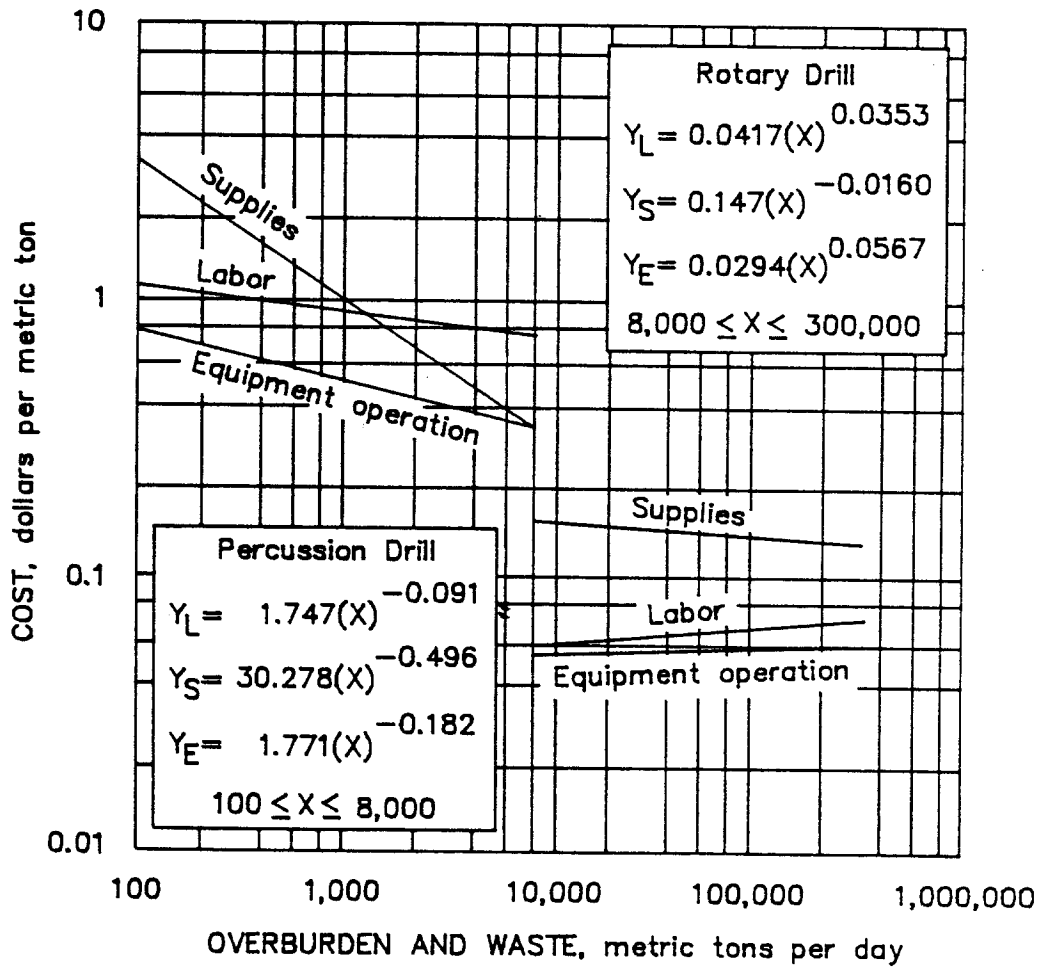
Subcontractor Factor If a subcontractor is used, multiply the costs obtained from the curves by the following factors to compensate for subcontractor's markup.

Labor factor  $(F_L) = 1.50$

Supply factor  $(F_S) = 1.20$

Equipment operation factor  $(F_E) = 1.20$

Surface Mining—Capital Costs



2.2.1.3. Drill and blast  
DRILLS

2.2. SURFACE MINING--CAPITAL COSTS

2.2.1. PREPRODUCTION DEVELOPMENT

2.2.1.4.1. EXCAVATION, LOAD AND HAUL OVERBURDEN AND WASTE  
 BUCKET WHEEL EXCAVATION

The total capital cost per metric ton is the sum of the three separate cost curves (labor, supplies and equipment operation) having a production rate (X), in metric tons of overburden and waste moved per day. The curves are valid for operations between 2,200 and 125,000 mtpd, operating three shifts per day. The cost is multiplied by the total tons of material mined during development to obtain the capital cost. The costs include only the operation of the bucket wheel excavator.

BASE CURVES

The base curve is predicated on excavating overburden or waste material. The daily output of an excavator is based on the operating time and output efficiency of the machine. The base curve assumes an operating time of 50% and an output efficiency of 46%. The operating time is the percent of 24 h that a machine operates each day. The output efficiency is the percent of theoretical capacity that a machine delivers for a particular overburden.

(L) Labor Operating Cost  $(Y_L) = 6.502(X)^{-0.429}$

The operating labor costs are distributed as follows:

Direct labor.....	65%
Maintenance labor.....	35%

The direct labor costs consist of the following typical range of personnel:

		Av salary per hour (base rate)
Bucket wheel operator.....	46%	\$16.78
Bucket wheel helper.....	2%	13.66
Bucket wheel laborer.....	16%	11.68

The average wage for labor is \$15.58 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost  $Y_S = 5.402(X)^{-0.135}$

The supply cost consists of 100% electric power.

(E) Equipment Operating Cost  $Y_E = 0.181(X)^{-0.300}$

The equipment operating cost consists of 100% for repair parts and materials.

ADJUSTMENT FACTORS

Shift Adjustment The curve is based on a three-shift-per-day operation. Typically, bucket wheel excavators are run continuously. For a one- or two-shift operation, decrease the operating costs proportionately.

Operating Time Factor The base case assumes a 50% operating time. Bucket wheel

excavators do not have high availabilities. The range of expected operating time is 41% to 60%. To adjust for different operating times, multiply the labor dollar cost obtained from the curve by the following factor:

$$\text{Labor factor } (F_T) = [50/(T)]^{0.554}$$

where T = new percent operating time.

The equipment operation cost curve and supplies cost curve are not modified.

Output Efficiency Factor The output efficiency is the ratio of the actual production to the theoretical capacity of the bucket wheel excavator. The theoretical capacity is based on the number of bucket discharges per minute and the bucket size. The theoretical capacity is normally expressed in loose cubic meters per hour. The factors that determine the output efficiency are the difficulty of digging (required cutting force), the percentage of clay or compact material in the bank and site-specific details such as climatology. The range of output efficiencies is from 44% to 85%. To adjust for a different output efficiency, multiply the dollar costs obtained from the curves by the following factors:

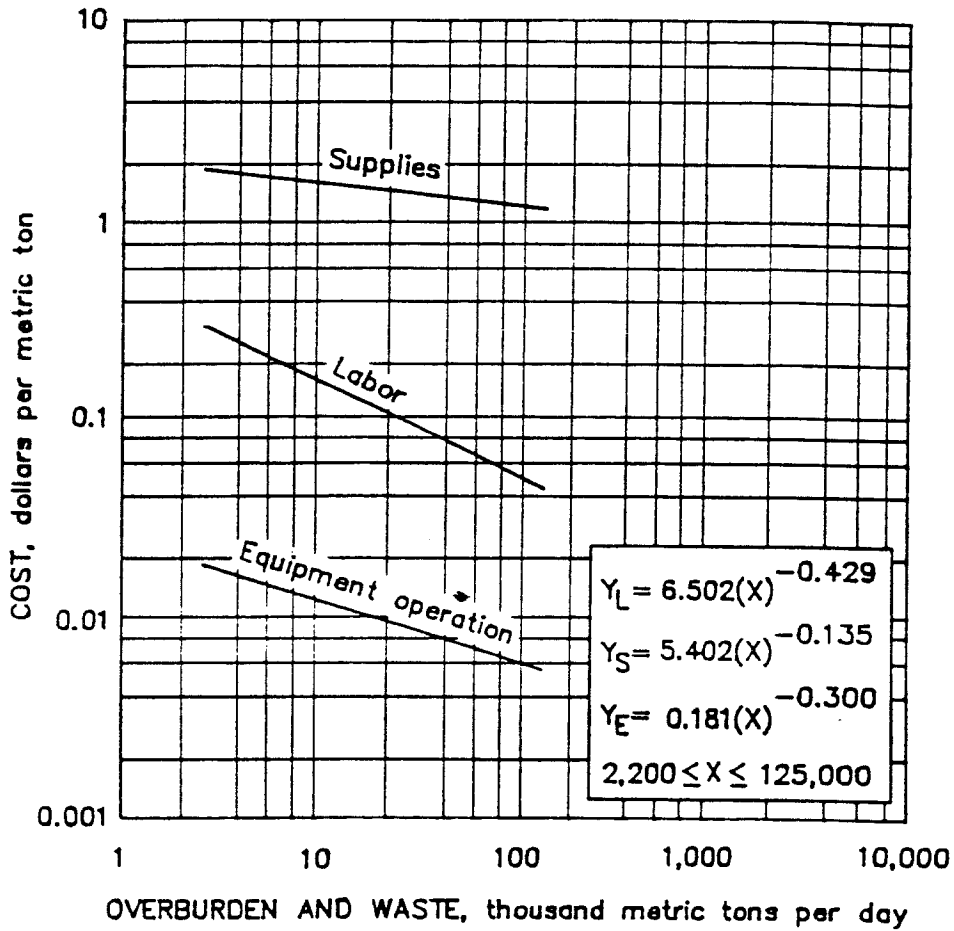
$$\text{Labor factor } (F_L) = [46/(E)]^{0.555}$$

$$\text{Supply factor } (F_S) = [46/(E)]^{0.858}$$

$$\text{Equipment operation factor } (F_E) = [46/(E)]^{0.680}$$

where E = new percent output efficiency.

Surface Mining—Capital Costs



2.2.1.4.1. Excavation, load and haul  
 BUCKET WHEEL EXCAVATION

2.2. SURFACE MINING--CAPITAL COSTS

2.2.1. PREPRODUCTION DEVELOPMENT

2.2.1.4.2. EXCAVATION, LOAD AND HAUL OVERBURDEN AND WASTE  
DRAGLINE

The curve for draglines covers the cost per metric ton for excavating and casting a medium-digging overburden and waste material from a dry pit into a spoil pile. The material is assumed to weigh 2 mt/m<sup>3</sup> for crawler (diesel-powered) draglines and 1.5 mt/m<sup>3</sup> for walking (electric-powered) draglines.

Crawler draglines range in size from 2- to 20-yd<sup>3</sup> capacity; walking draglines, from 16- to 50-yd<sup>3</sup> capacity. One dozer is provided for each dragline operation for cleanup and support.

The total capital cost per metric ton for crawler draglines is the sum of two separate cost curves (labor and equipment operation) and for walking draglines, the sum of three separate cost curves (labor, supplies, and equipment operation) having a production rate (X), in metric tons overburden and waste per day. The curve for crawler draglines is valid for a production range of 2,000 to 15,000 mtpd, operating one shift per day; for walking draglines, the curves are valid for a production range of 15,000 to 150,000 mtpd, operating three shifts per day. This cost is multiplied by the total metric tons of material mined during development to obtain the capital cost. The curves include all costs for operating and maintenance costs associated with dragline excavation.

BASE CURVE

(L) Labor Operating Cost (crawler dragline) (Y<sub>L CRAWLER</sub>) = 43.884(X)-0.637  
The operating labor costs are distributed as follows:

	Small (2,000 to 10,000 mtpd)	Large (10,000 to 15,000 mtpd)
Direct labor.....	59%	56%
Maintenance labor.....	41%	44%

The direct labor costs consist of the following typical range of personnel:

	Small (2,000 to 10,000 mtpd)	Large (10,000 to 15,000 mtpd)	Av salary per hour (base rate)
Dragline operator.....	41%	26%	\$18.11
Oiler.....	24%	22%	15.89
Dozer operator.....	25%	23%	16.33
Utility operator.....	10%	29%	13.66

The average wage for crawler dragline labor is \$16.13 per worker-hour (including burden and average shift differential).

(L) Labor Operating Cost (walking dragline) (Y<sub>L WALKING</sub>) = 12.249(X)-0.458  
The operating labor costs are distributed as follows:

Direct labor.....	62%
Maintenance labor.....	38%

The direct labor costs consist of the following typical range of personnel:

		Av salary per hour (base rate)
Dragline operator.....	30%	<u>\$18.11</u>
Oiler.....	26%	15.89
Dozer operator.....	27%	16.33
Utility operator.....	17%	13.66

The average wage for walking dragline labor is \$16.46 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost (walking dragline) (Y<sub>S WALKING</sub>) = 0.0395(X)<sup>0.003</sup>  
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost (crawler dragline) (Y<sub>E CRAWLER</sub>) = 2.218(X)<sup>-0.312</sup>  
Equipment operating cost distribution for a crawler dragline operation is

Dragline.....	70%
Crawler tractors.....	25%
Pickup trucks.....	5%

(E) Equipment Operating Cost (walking dragline) (Y<sub>E WALKING</sub>) = 0.533(X)<sup>-0.166</sup>  
Equipment operating cost distribution for a walking dragline operation is

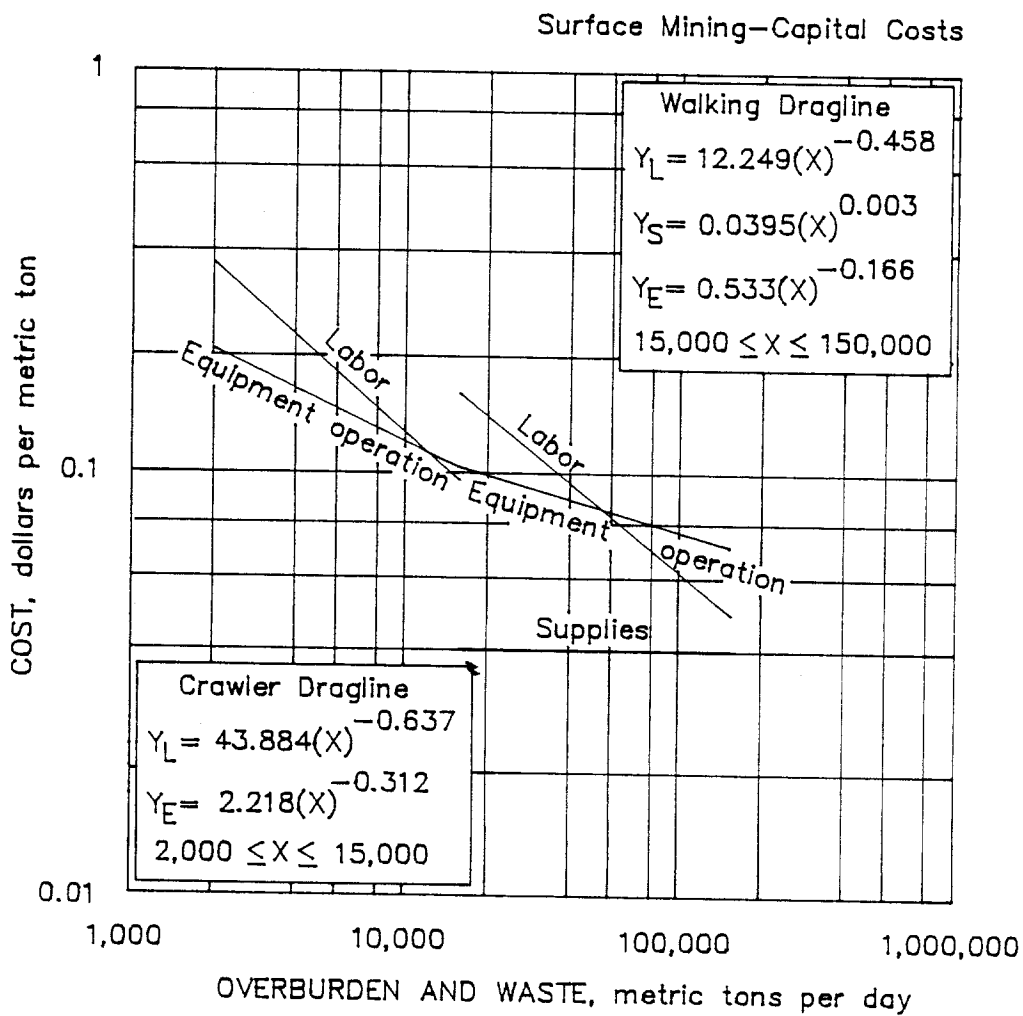
Dragline.....	66%
Crawler tractors.....	31%
Pick-up trucks.....	3%

The general equipment operating cost component distribution for crawler and walking draglines and support equipment is

	<u>Repair parts</u>	<u>Fuel and lube</u>	<u>Tires</u>
Walking draglines.....	94%	6%	-
Crawler draglines.....	65%	35%	-
Crawler dozers.....	49%	51%	-
Rubber-tired support.....	8%	90%	2%

ADJUSTMENT FACTOR

Truck Loading To determine the cost of a crawler dragline operation loading to trucks, use the values obtained from the curve for electric shovels and trucks. Adjust the values by increasing each curve component 25% and combine the equipment operation and supplies curves to account for substitution of diesel fuel for electric power. (NOTE.--Supplies values for the electric shovels and trucks curve include only electric power.)



2.2.1.4.2. EXCAVATION, load and haul  
DRAGLINE

## 2.2. SURFACE MINING - CAPITAL COSTS

## 2.2.1. PREPRODUCTION DEVELOPMENT

2.2.1.4.3. EXCAVATION, LOAD AND HAUL OVERBURDEN AND WASTE  
ELECTRIC SHOVEL AND TRUCKS

The curves show the cost per metric ton for excavating, loading, and hauling both common and shot rock. For common earth excavation, 1 bank m<sup>3</sup> equals 2.08 mt; for shot rock, 1 bank m<sup>3</sup> equals 2.61 mt.

The loading units are electric shovels and diesel front-end loaders ranging in size from 5 to 30 yd<sup>3</sup>, with an average of 15 yd<sup>3</sup>. Rear dump trucks from 35 to 170 st are the main hauling units, with the average size of all trucks at 100 st. The ratio of trucks to loading units averages 6 to 1. The curves reflect an average haul of 2,000 m one way on an 8% grade from a pit 120 m deep on wide, well maintained roads.

The total capital cost per metric ton is the sum of two separate cost curves (labor and equipment operation) having a production rate (X), in metric tons overburden and waste per day. The curves are valid for operations between 8,000 and 300,000 mtpd, operating three shifts per day. This cost is multiplied by the total metric tons of material mined during development to obtain the capital cost. The curves include all daily operating and maintenance costs associated with load and haul.

## BASE CURVE

$$(L) \text{ Labor Operating Cost } (Y_L) = 2.694(X)^{-0.210}$$

The operating labor costs are distributed as follows:

	Small (8,000 to 50,000 mtpd)	Large (50,000 to 300,000 mtpd)
Direct labor.....	61%	53%
Maintenance labor.....	39%	47%

The direct labor costs consist of the following typical range of personnel:

	Small (8,000 to 50,000 mtpd)	Large (50,000 to 300,000 mtpd)	Av salary per hour (base rate)
Shovel operator.....	14%	8%	\$18.11
Oiler.....	6%	4%	15.89
Dozer operator.....	17%	23%	16.33
Grader operator.....	5%	7%	16.33
Front-end loader operator..	3%	1%	16.33
Truck driver.....	52%	57%	15.89
General laborer.....	3%	-	13.66

The average wage for labor is \$16.54 per worker-hour (including burden and average shift differential).

$$(S) \text{ Supply Operating Cost } (Y_S) = 0.188(X)^{-0.220}$$

The supply cost consists of 100% electric power.

(E) Equipment Operating Cost  $(Y_E) = 1.850(X)^{-0.133}$

The equipment operating cost covers the daily operating cost for all excavation, loading, and hauling equipment and includes allowances for repair parts, tires, lubrication, and fuel consumption.

Equipment operating cost distribution for an electric shovel and truck operation is

Shovels.....	7%
Rear-dump trucks.....	70%
Crawler dozers.....	12%
Rubber-tired support.....	11%

The general equipment operating cost component distribution is

	<u>Repair parts</u>	<u>Fuel and lube</u>	<u>Tires</u>
Shovels, electric.....	96%	4%	-
Rear-dump trucks.....	25%	48%	27%
Crawler dozers.....	50%	50%	-
Rubber-tired support.....	35%	47%	18%

ADJUSTMENT FACTORS

Haulage Factor To determine costs for hauls of varying length or depth of pit, multiply the costs obtained from the curves by the following factors:

Labor factor  $(F_L) = 0.117(R)^{0.030}(L)^{0.263}$

Equipment operation factor  $(F_E) = 0.055(R)^{0.047}(L)^{0.353}$

where R = depth of pit, in meters (R = 1.0 for negative or 0% grade from loading point),  
and L = length of haul, in meters.

Equipment Factor Where it is necessary to purchase equipment or have a subcontractor perform the work, multiply the costs obtained from the equipment operation curve by the following applicable factor in order to obtain the total value of equipment expense for ownership and operation:

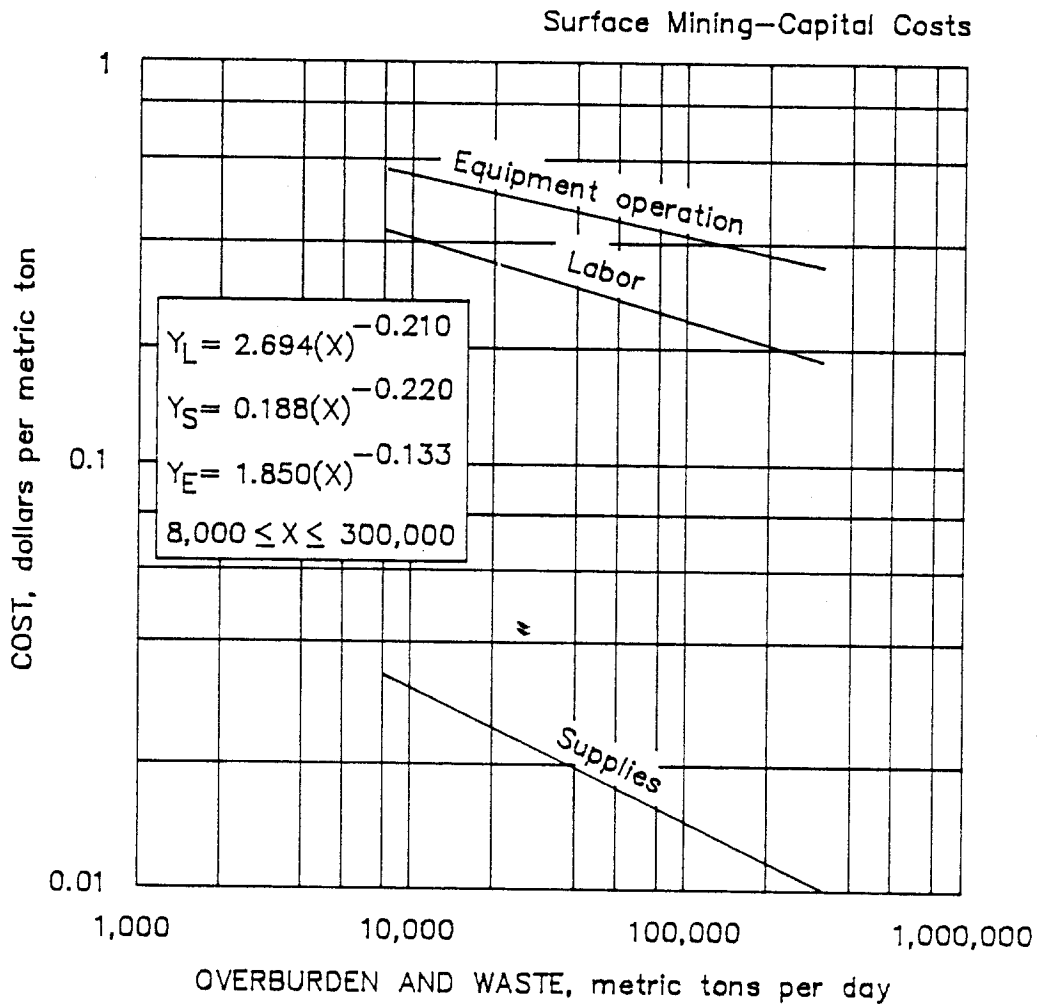
Shifts per day.....	1	2	3
Factor.....	1.89	1.67	1.60

Subcontractor Factor If a subcontractor is used, multiply the costs obtained from the curves by the following factors to compensate for subcontractor's markup.

Labor factor  $(F_L) = 1.50$

Supply factor  $(F_S) = 1.20$

Equipment operation factor  $(F_E) = 1.20$



2.2.1.4.3. Excavation, load and haul  
ELECTRIC SHOVEL AND TRUCKS

## 2.2. SURFACE MINING--CAPITAL COSTS

### 2.2.1. PREPRODUCTION DEVELOPMENT

#### 2.2.1.4.4. EXCAVATION, LOAD AND HAUL OVERBURDEN AND WASTE FRONT-END LOADER OR DIESEL SHOVEL AND TRUCKS

The curve shows the cost per metric ton for loading and hauling both common and shot rock. For common earth excavation, 1 bank m<sup>3</sup> equals 2.08 mt; for shot rock, 1 bank m<sup>3</sup> equals 2.61 mt.

The curve is based on mines using front-end loaders or diesel shovels for loading and trucks for haulage. The loaders and shovels range in size from 1 to 6 yd<sup>3</sup>, and the trucks range from 10 to 35 st. The curves reflect an average haul of 750 m one way on an 8% grade from a pit 60 m deep.

The total capital cost per metric ton is the sum of two separate cost curves (labor and equipment operation) having a production rate (X), in metric tons overburden and waste per day. The curves are valid for operations between 1,000 and 10,000 mtpd, operating two shifts per day. This cost is multiplied by the total metric tons of material mined during development to obtain the capital cost. The curves include all daily operating and maintenance costs associated with excavation, loading, and haulage.

#### BASE CURVE

(L) Labor Operating Cost  $(Y_L) = 37.003(X)^{-0.471}$

The operating labor costs are distributed as follows:

Direct labor.....	70%
Maintenance labor.....	30%

The direct labor costs consist of the following typical range of personnel:

	Small (1,000 to 3,000 mtpd)	Large (3,000 to 10,000 mtpd)	Av salary per hour (base rate)
Loader-shovel crew.....	30%	21%	\$16.24
Truck haulage crew.....	46%	37%	15.89
Dozer operator.....	24%	17%	16.33
Rubber-tired support crew..	-	25%	16.11

The average wage for labor for operations less than 3,000 mtpd is \$16.20 per worker-hour (including burden and average shift differential).

The average wage for labor for operations greater than 3,000 mtpd is \$16.42 per worker-hour (including burden and average shift differential).

(E) Equipment Operating Cost  $(Y_E) = 24.620(X)^{-0.424}$

The equipment operating cost distribution for loader/diesel shovel and truck operation is

Loader-shovel.....	18.1%
Rear-dump truck.....	42.8%
Crawler dozer.....	23.2%
Rubber-tired support.....	15.9%

The general equipment cost component distribution applies to the following equipment:

	<u>Repair parts</u>	<u>Fuel and lube</u>	<u>Tires</u>
Shovel, diesel.....	69.6%	30.4%	-
Frontend loader.....	32.5%	44.2%	23.3%
Rear-dump truck.....	28.1%	51.6%	20.3%
Crawler dozer.....	50.6%	49.4%	-
Rubber-tired support.....	28.5%	62.7%	8.8%

#### ADJUSTMENT FACTORS

Haulage Factor To determine costs for hauls of varying haul length or depth of pit, multiply the costs obtained from the curves by the following factors:

$$\text{Labor factor } (F_L) = 0.155(R)0.030(L)0.263$$

Equipment operation factor  $(F_E) = 0.080(R)0.047(L)0.353$   
 where R = depth of pit, in meters (R = 1.0 for negative or 0% grade from loading point),  
 and L = length of haul, in meters.

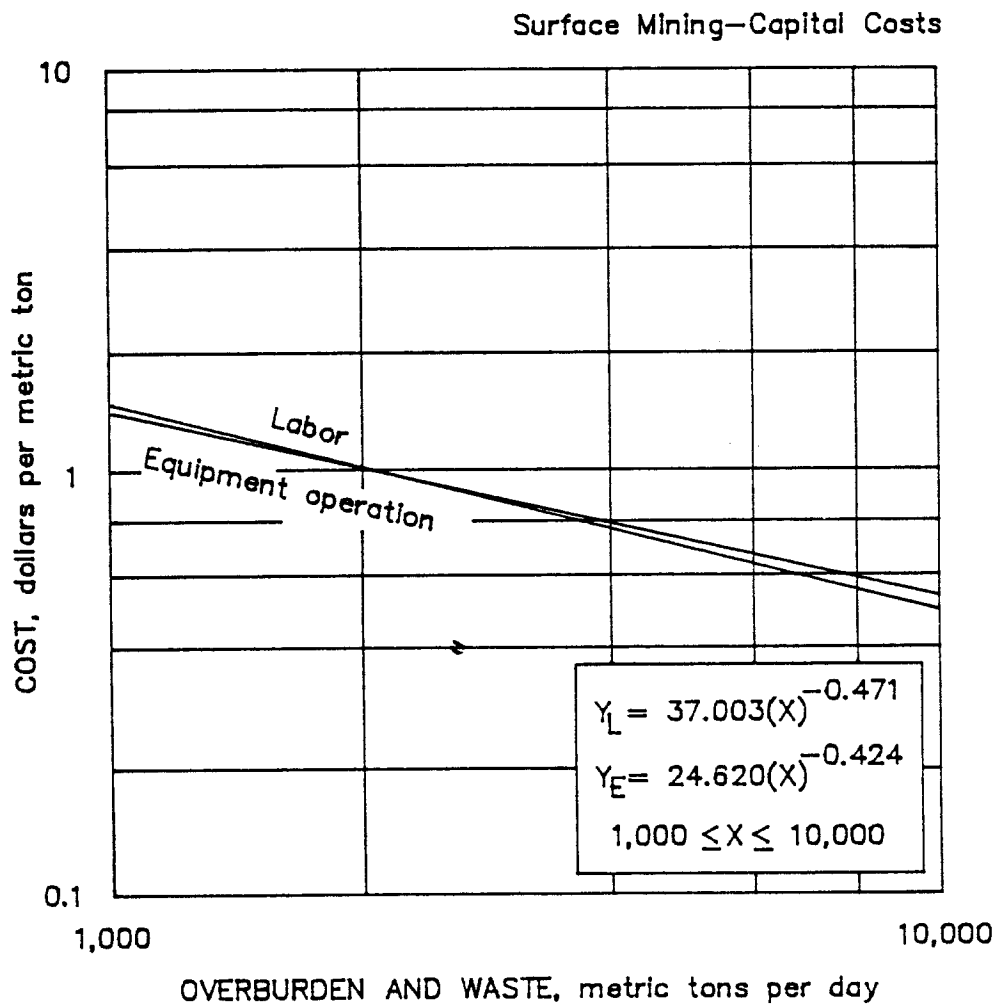
Equipment Factor Where it is necessary to purchase equipment or have a subcontractor perform the work, multiply the cost obtained from the equipment operation curve by the following applicable factor in order to obtain the total value of equipment expense for ownership and operation:

Shifts per day.....	1	2	3
Factor.....	1.84	1.63	1.56

Subcontractor Factor If a subcontractor is used, multiply the costs obtained from the curves by the following factors to compensate for subcontractor's markup.

$$\text{Labor factor } (F_L) = 1.50$$

$$\text{Equipment operation factor } (F_E) = 1.20$$



2.2.1.4.4. Excavation, load and haul  
FRONT-END LOADER OR DIESEL SHOVEL AND TRUCKS

## 2.2. SURFACE MINING--CAPITAL COSTS

## 2.2.1. PREPRODUCTION DEVELOPMENT

2.2.1.4.5. EXCAVATION, LOAD AND HAUL OVERBURDEN AND WASTE  
HYDRAULIC MINING

The operating costs for hydraulic mining are given on a metric ton per day of material slurried. The costs include the operation of the monitors and high-pressure water pumps. Not included in the estimates is the cost for pumping the slurry. The total capital cost per metric ton is the sum of the three separate cost curves (labor, supplies, and equipment operation) having a production rate (X), in metric tons of material slurried per day. The curves are valid for operations between 9,500 and 58,000 mtpd, operating three shifts per day. This cost is multiplied by the total metric tons of material mined during development to obtain the capital cost.

## BASE CURVES

The base curve is for the hydraulic mining of phosphate matrix. The matrix is excavated by draglines and deposited in "pits," where hydraulic mining occurs. The hydraulic monitors (also called guns, giants, or water cannons) break down the matrix for pumping to the processing plant. The monitors are mounted on a pit gun car, which advances with the dragline. The base case assumes an 85% operating time and a water ratio of 0.67 mt of slurried ore per metric ton of water used.

(L) Labor Operating Cost  $(Y_L) = 0.410(X) - 0.230$ 

The operating labor costs are distributed as follows:

Direct labor.....	83%
Maintenance labor.....	17%

The direct labor costs consist of the following typical range of personnel:

		Av salary per hour (base rate)
Monitor operator.....	59%	\$16.78
Monitor helper.....	33%	13.66
Laborer.....	8%	11.68

The average wage for labor is \$15.65 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost  $(Y_S) = 0.883(X) - 0.315$ 

The supply cost consists of 100% electric power.

(E) Equipment Operating Cost  $(Y_E) = 0.022(X) - 0.270$ 

The equipment operation curve consists of monitor repair parts and materials. The repair costs are divided 30% for water pumps and 70% for the monitor systems (hydraulic pumps, controls and monitors).

## ADJUSTMENT FACTORS

Water Ratio Factor Each deposit to be hydraulically mined will require different quantities of water, and therefore, different sizes or numbers of monitors. The more competent (tougher) the deposit, the more water that will be required. The measure of difficulty in slurrying the deposit is the mass ratio of ore excavated to water used. To adjust the base curves for different water requirements, multiply the dollar costs obtained from the curves by the following factors:

$$\text{Labor factor } (F_L) = [0.67/(R)]^{0.050}$$

$$\text{Supply factor } (F_S) = [0.67/(R)]^{1.285}$$

$$\text{Equipment operation factor } (F_E) = [0.67/(R)]^{0.327}$$

where R = new water ratio (mt ore slurried)/(mt water used).

For phosphate, the water ratio can vary from 0.7 to 0.3. For other applications it can vary from 1.5 to 0.2.

Tailings Factor Hydraulic mining can be used to excavate old tailings ponds for the reprocessing of the tailings. This application normally requires higher water pressure and larger monitors. To adjust the base curves for the hydraulic mining of tailings, multiply the dollar costs obtained from the curves by the following factors:

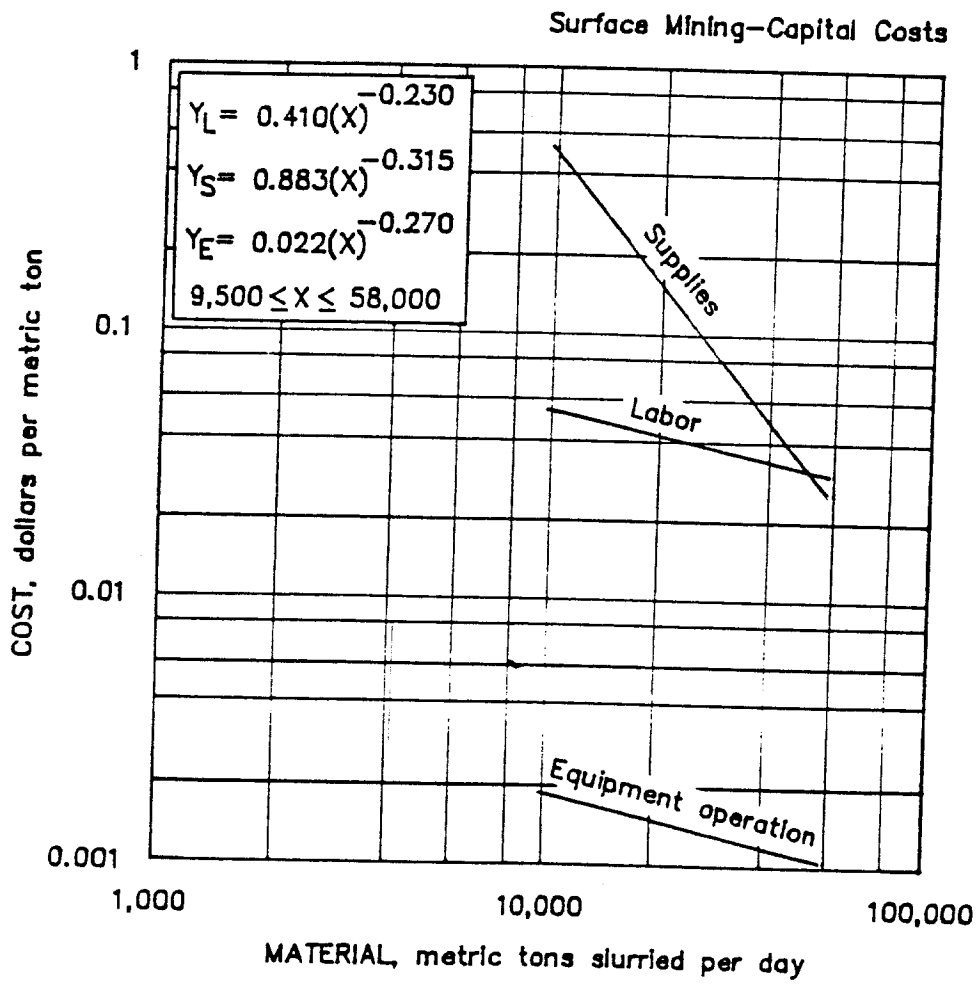
$$\text{Labor factor } (F_L) = 3.32$$

$$\text{Supply factor } (F_S) = 1.51$$

$$\text{Equipment operation factor } (F_E) = 1.12$$

The tailings adjustment is based on a water ratio of 1.22 mt of tailings slurried per mt of water applied.

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## 2.2. SURFACE MINING--CAPITAL COSTS

## 2.2.1. PREPRODUCTION DEVELOPMENT

2.2.1.4.6. EXCAVATION, LOAD AND HAUL OVERBURDEN AND WASTE  
SCRAPERS

The curves show the cost per metric ton for loading and hauling unconsolidated overburden. Scraper production in metric tons per day is based on an assumed material having a weight of 2.2 mt/m<sup>3</sup> and requiring ripping.

The curves are based on a one-way haul of 900 m on a level grade and include a 6% rolling resistance in the pit area using wheel tractor-scrappers ranging in size and type from 150-hp self-loading elevating scrapers to 550-hp twin-engine scrapers.

The total capital cost per metric ton is the sum of two separate cost curves (labor and equipment operation) having a production rate (X), in metric tons of overburden and waste per day. The curves are valid for operations between 2,000 and 300,000 mtpd, operating three shifts per day. This cost is multiplied by the total tons of material mined during development to obtain the capital cost. The curves include all daily operating and maintenance costs associated with load and haul.

## BASE CURVE

(L) Labor Operating Cost  $(Y_L) = 3.831(X)^{-0.265}$

The operating labor costs are distributed as follows:

Direct labor.....	47%
Maintenance labor.....	53%

The direct labor costs consist of the following typical range of personnel:

		Av salary per hour (base rate)
Scraper operator.....	58%	\$17.33
Crawler operator.....	32%	16.33
Rubber-tired support operator.	10%	16.11

The average wage for labor is \$16.64 per worker-hour (including burden and average shift differential).

(E) Equipment Operating Cost  $(Y_E) = 0.602(X)^{-0.0747}$

The equipment operating cost distribution for a scraper operation is

Scraper.....	71%
Crawler-dozer.....	24%
Rubber-tired support.....	5%

The general equipment cost component distribution applies to the following equipment:

	<u>Repair parts</u>	<u>Fuel and lube</u>	<u>Tires</u>
Scraper.....	38%	47%	15%
Crawler-dozer.....	53%	47%	-
Rubber-tired support.....	36%	52%	12%

## ADJUSTMENT FACTORS

Haulage Factor To determine costs for varying haul lengths and grades, multiply the costs obtained from the curves by the following factors:

$$\text{Labor factor } (F_L) = 0.0865(L)^{0.359}(G)^{1.530}$$

Equipment operation factor  $(F_E) = 0.0641(L)^{0.403}(G)^{1.620}$   
 where L = length of haul, in meters,  
 and G = grade [defined as 1.0 plus or minus percent grade/100].

Ripping Factor If no ripping is required, multiply the costs obtained from the curves by the following factor:

$$\text{Ripping factor } (F_R) = 0.85$$

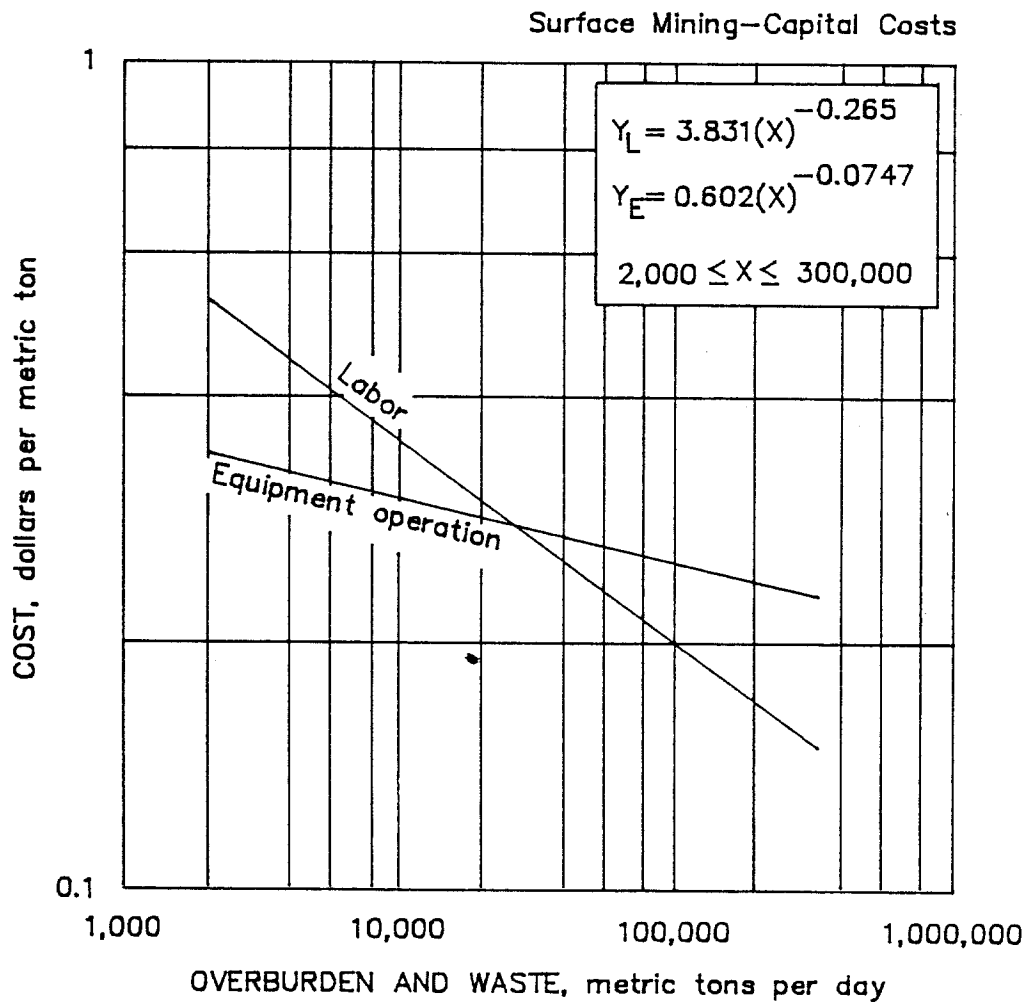
Equipment Factor Where it is necessary to purchase equipment or have a subcontractor perform the work, multiply the cost obtained from the equipment operation curve by the following applicable factor in order to obtain the total value of equipment expense for ownership and operation:

Shifts per day.....	1	2	3
Factor.....	1.76	1.57	1.51

Subcontractor Factor If a subcontractor is used, multiply the costs obtained from the curves by the following factors to compensate for subcontractor's markup:

$$\text{Labor factor } (F_L) = 1.50 \approx$$

$$\text{Equipment operation factor } (F_E) = 1.20$$



2.2.1.4.6. Excavation, load and haul  
SCRAPERS