6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.1. CLEARING

The curve for clearing during site preparation is based on estimated costs for medium-light growth on terrain with a side slope of 20 to 50%, one shift per day. Estimate one tree, 0.33 m in diameter, per 40 m^2.

The total cost is the sum of three separate cost curves (labor, supplies, and equipment operation) having a total clearing area (X), in total hectares. The curves are valid for operations between 1 and 1,000 ha (from 500 to 1,000 ha, costs are expected to remain constant), operating one shift per day. The curves include all daily operating and maintenance cost associated with clearing a land surface for mineral processing plant and support facilities.

BASE CURVE

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

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

Direct labor...............	86%
Maintenance labor..........	14%

The average base salary including burden for labor is as follows:

		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 $14.28 per worker-hour (including burden and average shift differential).

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

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

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

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

The general equipment cost component distribution is as follows:

Description	Repair parts	Fuel and lube	Tires
Crawler dozers.............	51.0%	49.0%	-
Trucks, pickups, and chainsaws.............	14.0%	80.0%	6.0%

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:

Brush factor $(Y_{B\ LIGHT}) = 0.25$

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:

Brush factor $(Y_{B\ HEAVY}) = 1.75$

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%,

Side slope factor $(Y_{S\ 0\%-20\%}) = 0.8$

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

Side slope factor $(Y_{S\ 50\%-100\%}) = 1.2$

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

Side slope factor $(Y_{S\ +100\%}) = 2.5$

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:

Labor factor $(F_L) = 1.2$

Supply factor $(F_S) = 0.2$

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:

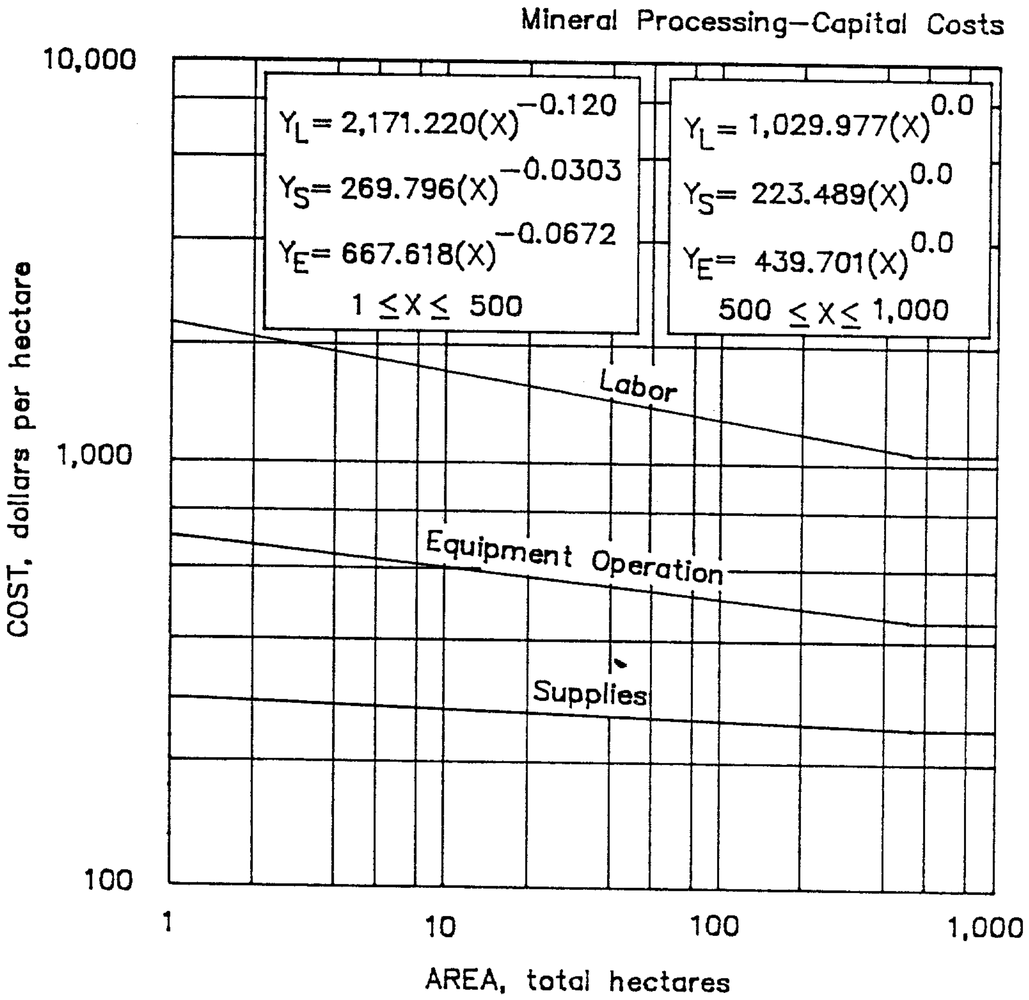
Shifts per day............	1	2	3
Factor....................	1.56	1.42	1.37

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 $(F_E) = 1.2$



6.1.8.1. Clearing

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.3. EARTHFILL DIKES AND SMALL DAMS

Dikes and/or small dams used to contain waste and tailings vary with the terrain and materials to be used, and must meet the regulations for small dam construction. Construction is accomplished using scrapers having an on-site material haul distance between 600 and 1,500 m. No allowance has been made for transport or purchase of suitable fill material. If these costs are not a part of other mining and/or milling operations, the user must determine the cost of fill material. The total cost is based on a single curve having a total embankment (X), in cubic meters of material. The curve is valid for operations between 5,000 and 500,000 m^3, operating two shifts per day.

BASE CURVE

The earthfill dikes and small dams capital cost derived from the curve is a combination of the following costs:

Construction labor cost........	53%
Construction supply cost....... (fill material not included)..	5%
Purchased equipment cost.......	42%

A typical breakdown of the major cost components is

Scrapers........................	42%
Crawler dozers..................	26%
Compactors......................	18%
Rubber tired support............	14%

The total earthfill dikes and small dams capital cost is $(Y_C) = 0.014(X)^{1.420}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 0.00726(X)^{1.420}$

(S) Construction Supply Cost $(Y_S) = 0.00069(X)^{1.420}$

(E) Purchased Equipment Cost $(Y_E) = 0.00575(X)^{1.420}$

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

Direct labor..............	60%
Maintenance labor.........	40%

The average base salary including burden for labor is as follows:

		Av salary per hour (base rate)
Scraper operator...........	24%	$16.33
Dozer operator.............	21%	16.33
Compactor operator.........	23%	16.33
Motor-grader operator......	10%	16.33
Truck driver...............	5%	15.89
Utility worker.............	17%	13.66

The average wage for labor is $16.02 per worker-hour (including burden and average shift differential).

The general equipment operating cost component distribution is as follows:

Description	Repair parts	Fuel and lube	Tires
Scrapers...................	41.0%	41.0%	18.0%
Crawler dozers.............	49.0%	51.0%	-
Compactors.................	55.0%	45.0%	-
Rubber-tired support.......	27.0%	64.0%	9.0%

ADJUSTMENT FACTORS

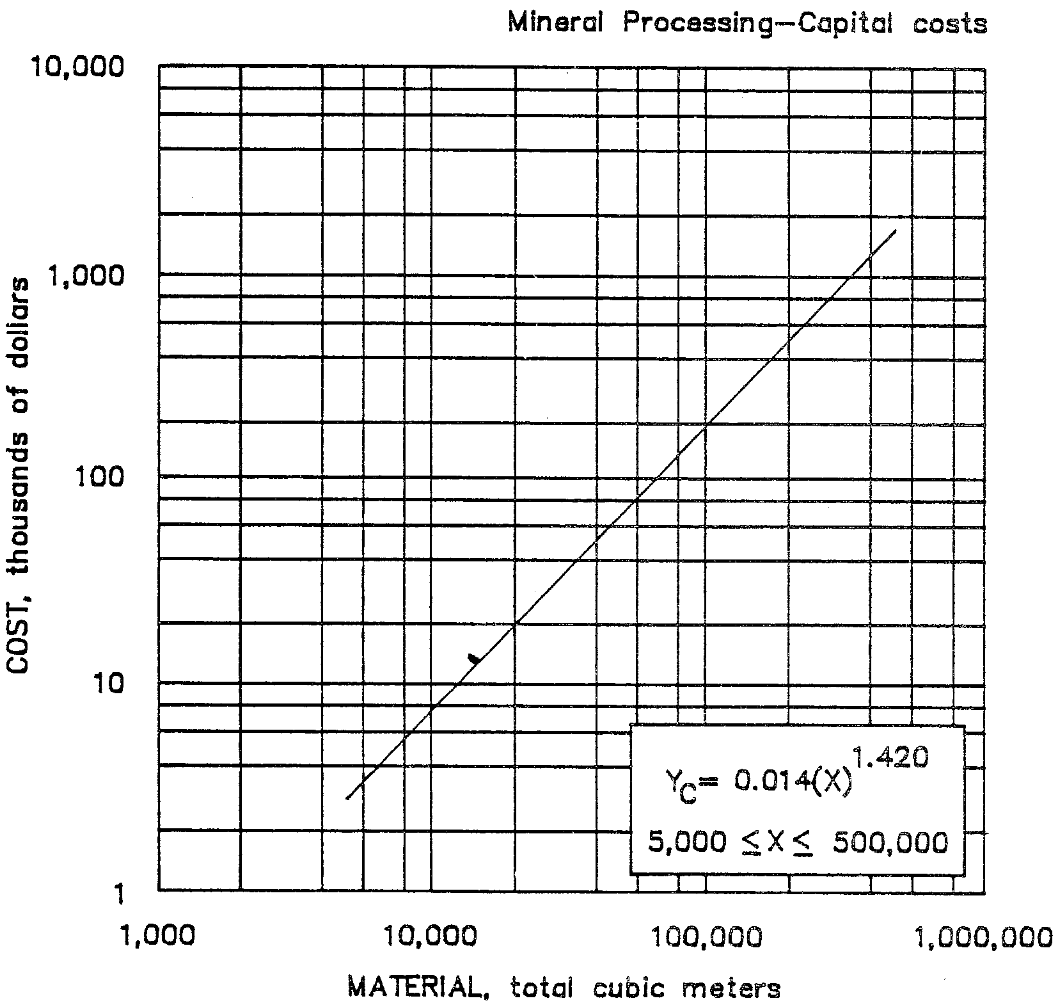
Equipment Factor Where it is necessary to purchase equipment or have a subcontractor perform the work, multiply the equipment operation cost obtained from the curve by the following applicable factor in order to obtain the total value of equipment expense for ownership and operation:

Shifts per day.............	1	2	3
Factor.....................	1.67	1.50	1.48

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 $(F_L) = 1.5$

Equipment operation factor $(F_E) = 1.2$



6.1.8.3. Earthfill dikes and small dams

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.4. ELECTRICAL SYSTEM

The capital cost is for acquisition and installation of the main substation, yard distribution, lighting, and communications for the mill. Major items of equipment include transformers, switchgear, and power lines.

BASE CURVE

The total cost is based on a single curve having an average power demand (X), in kilovolt amperes, for 60 Hz, three-phase electricity. The curve is valid for operations between 100 and 125,000 kV•A. The curve includes all costs associated with acquisition and installation of transformers, switchgear, and power feeder lines.

The capital cost derived from the curve is a combination of the following costs:

Construction labor cost......	5%
Construction supply cost.....	16%
Purchased equipment cost.....	79%

The total capital cost is $(Y_C) = 349.601(X)^{0.839}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 17.480(X)^{0.839}$

(S) Construction Supply Cost $(Y_S) = 55.936(X)^{0.839}$

(E) Purchased Equipment Cost $(Y_E) = 276.185(X)^{0.839}$

The capital costs consist of the following typical range of equipment costs:

	Small (100 to 1,000 kV•A)	Large (1,000 to 125,000 kV•A)
Transformers.....	54%	52%
Switchgear.......	46%	48%

Power Demand Power demand (X) may be estimated by summing the power cost portions of all operating cost sections and dividing the sum by the power cost per kilowatt hour. As an alternate method, power demand may be estimated using the following equation based upon the Bond Work Index.

Power demand $(X) = (11)(Q)(W)(P^{-0.5})$

where X = power demand, in KV·A (if single phase increase by 73%),

Q = feed rate, in metric tons per hour,

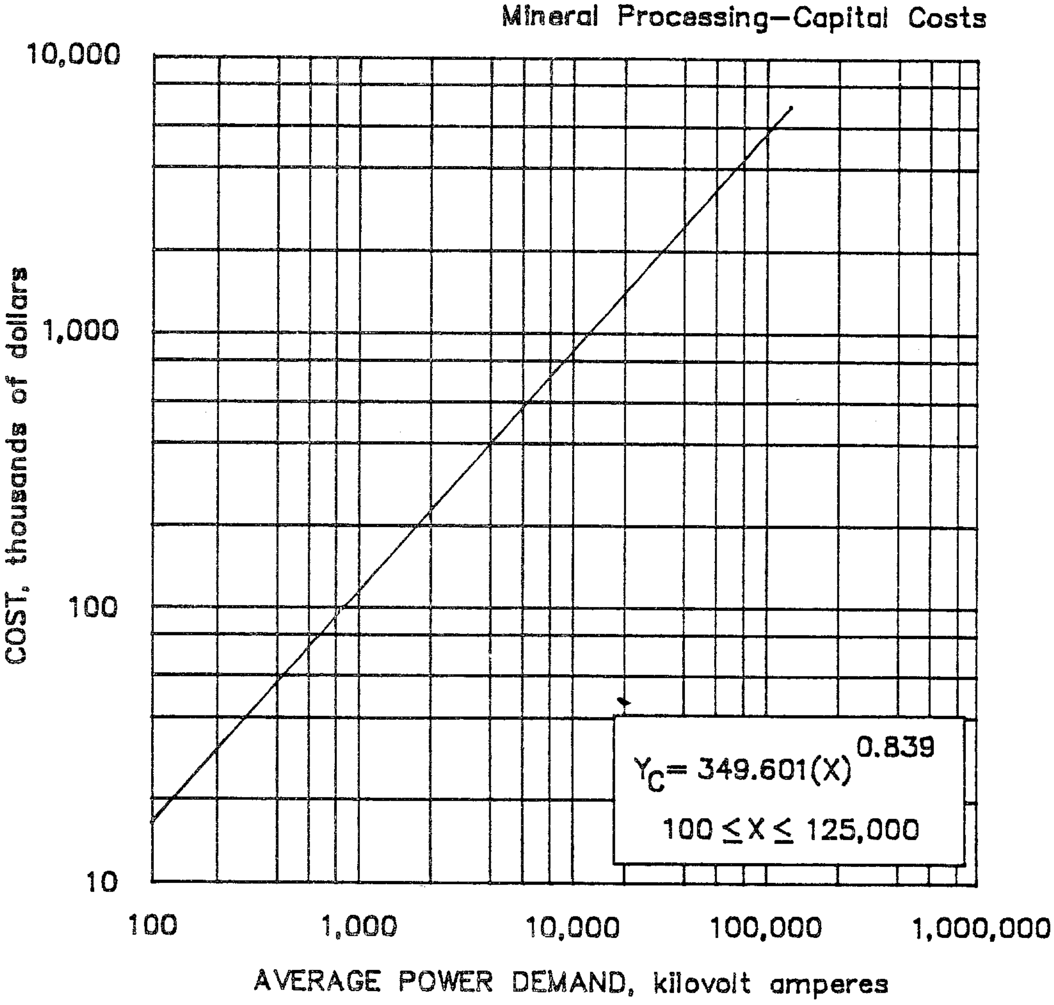
W = Bond Work Index of rock being milled (if dry grinding, increase by 33%),

and P = product size, in microns.

NOTE--kilovolt ampere (kV·A) is equivolent to kilowatt (kW); kV·A is commonly used in the power generation industry to designate power demand.

ADJUSTMENT FACTOR

Multiproduct Operations and Complicated Flotation or Recovery Factor To adjust for multiproduct operations and complicated flotation or recovery processes, the kilowatts must be modified. A factor (W_X) must be used to reflect the change in power needs. This can range from $W_X = 1$ for some single-product copper porphyries with a nearby water source to $W_X = 4$ for multiproduct, complicated-chemistry, recovery circuits. This factor then becomes a multiplier of work index (W) and the product, $W \times W_X$, is then substituted for the original W in the power demand equation. The adjustment for the number of operating shifts per day is implicit in the choice of the hourly mill feed rate (Q) in the power demand equation.



6.1.8.4. Electrical system

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.6.2. LOADING FACILITIES
LOAD-OUT FACILITIES

Load-out facility capital costs are based on equipment needed to transport, store, and load-out for shipment concentrates from a mill via truck or train. Total storage capacity is equal to 2 days production of the concentrate from the mill. The load-out facility capital cost includes all costs associated with acquisition and installation of conveyors, storage bins, and bucket elevators. This curve is primarily applicable to low-grade deposits, such as copper or molybdenum deposits. As such, it will cover operations that mine between 2,000 and 60,000 mt of ore per day. The total capital cost is based on a single curve having a production rate (X), in metric tons of concentrate transferred from the mill to storage bins in a 24 h period. The curve is valid for operations between 150 and 1,500 mtpd, operating one shift per day.

BASE CURVE

The capital cost derived from the curve is a combination of the following costs:

Construction labor cost......	11%
Construction supply cost.....	31%
Purchased equipment cost.....	58%

A typical breakdown of the load-out facility's major cost components is

Bins and activators...........	78%
Bucket elevators.............	7%
Conveyors....................	15%

The total load-out facility capital cost is $(Y_C) = 5{,}923.123(X)^{0.568}$ and is distributed as follows:

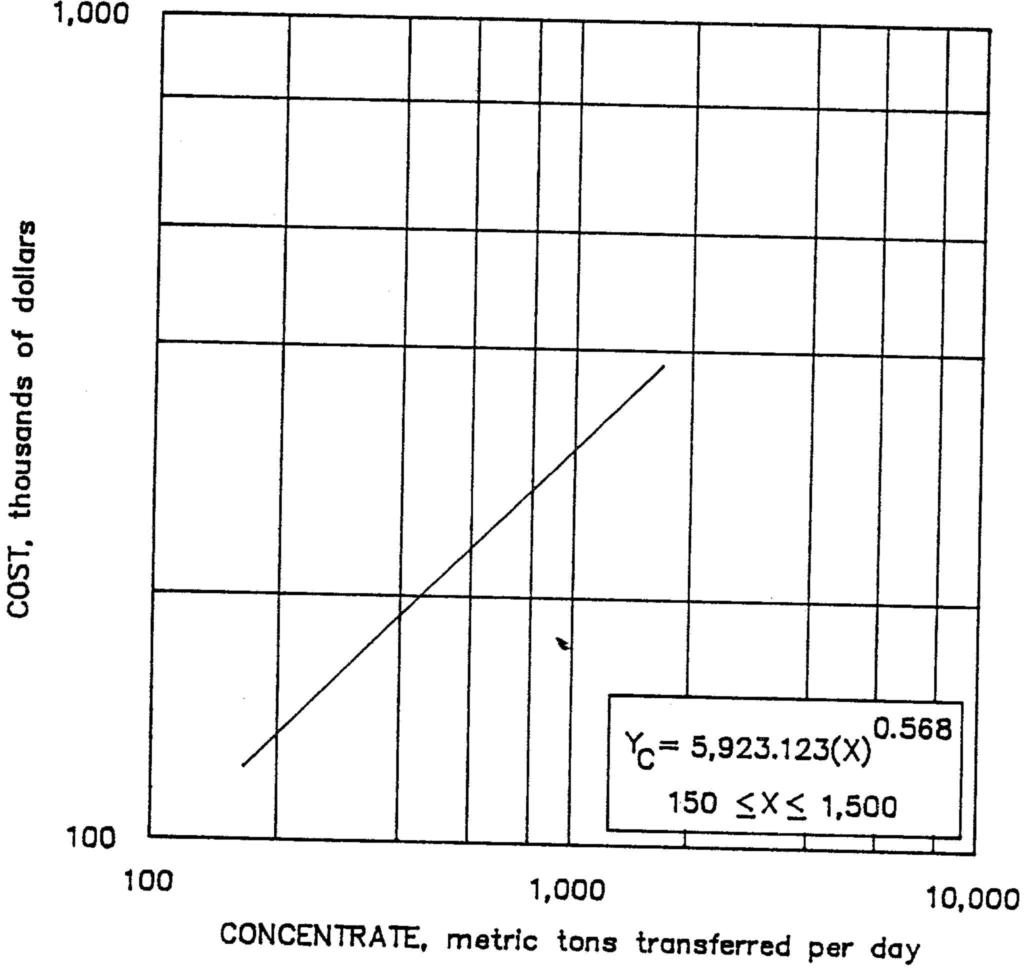
(L) <u>Construction Labor Cost</u> $(Y_L) = 651.543(X)^{0.568}$

(S) <u>Construction Supply Cost</u> $(Y_S) = 1{,}836.168(X)^{0.568}$

(E) <u>Purchased Equipment Cost</u> $(Y_E) = 3{,}435.411(X)^{0.568}$

ADJUSTMENT FACTOR

<u>Secondary Concentrate Loadout</u> Milling operations often recover and concentrate secondary minerals such as molybdenum and uranium. The quantities recovered are seldom large in comparison to the primary mineral, running between less than 1 up to 125 mtpd. The basic facilities used for loading out such material usually consist of a small storage bin, a vibrating conveyor used for filling 37 to 55 gallon drums, a roller conveyor for transporting the drums, and a fork-lift for loading drums into trucks or rail cars. These types of facilities are not included in this cost curve. If such operations occur at the proposed mill, the curve must be adjusted accordingly.



6.1.8.6.1. Loading facilities
LOAD—OUT FACILITIES

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.6.2. LOADING FACILITIES
OFF-LOADING FACILITIES

Off-loading facility capital costs are based on installation of equipment used in transporting ore from a reception point to storage bins adjacent to the mill during a two-shift-per-day operation. Storage capacity is between 800 and 12,000 mt of ore. Examples of the types of material stored would be coarse metallic ore, crushed limestone, and coal. For situations where larger storage facilities are needed, see the section 6.8.1.12., stockpile storage facilities. Off-loading facility capital costs includes all costs associated with acquisition and installation of the conveyors, feeders, and storages bins required for this task.

The total capital cost is based on a single curve having a production rate (X), in metric tons of concentrate off-loaded and stored in bins for use by the mill per day. The curves are valid for operations between 800 and 12,000 mtpd, operating two shifts per day.

BASE CURVE

The off-loading facility capital cost derived from the curve is a combination of the following costs:

Construction labor cost......	43%
Construction supply cost.....	45%
Construction equipment cost..	12%

A typical breakdown of the off-loading facility's major cost components is

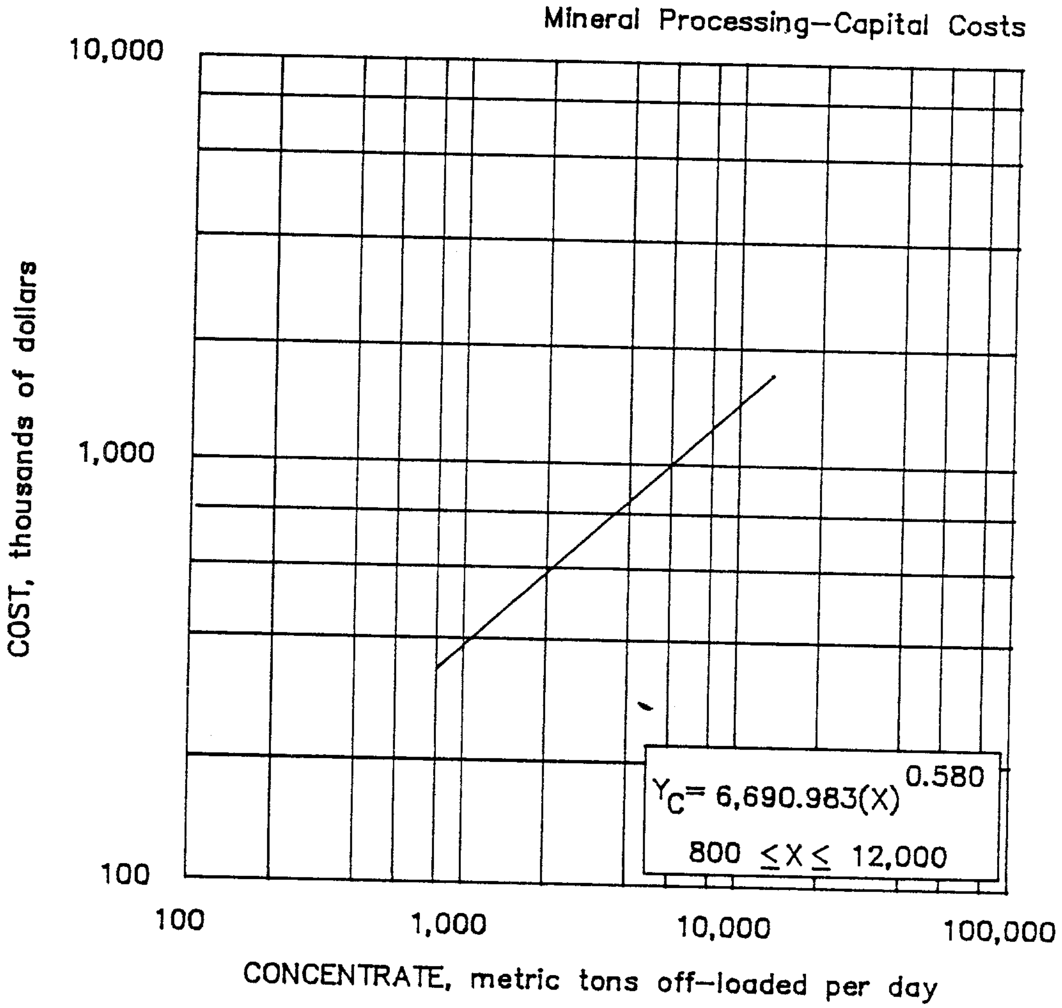
Bins and activators.........	84%
Conveyors and feeders.......	13%
Ramps and retaining walls...	3%

The total off-loading facility capital cost is $(Y_C) = 6{,}690.983(X)^{0.580}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 2{,}877.123(X)^{0.580}$

(S) Construction Supply Cost $(Y_S) = 3{,}010.942(X)^{0.580}$

(E) Purchased Equipment Cost $(Y_E) = 802.918(X)^{0.580}$



6.1.8.6.2. Loading facilities
OFF-LOADING FACILITIES

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.7. MAIN POWER LINES

If power is to be obtained from a local power company, it is generally necessary to construct new facilities to connect the mine site to the existing power line network. This cost is usually borne by the mine company that desires to receive the service. For shorter distances and lower maximum power loads, this may simply entail extending existing, medium voltage (13- to 24-kV) distribution lines. To satisfy greater loads over longer distances, however, it is necessary to construct higher voltage (115-kV) transmission lines as well as substations dedicated to serve the mine solely. The following tabulation will aid the evaluator in determining the appropriateness of the various options to his particular case.

Main power line distribution

Case	Load Range(MV•A)	Maximum distribution line length, km 24 kV	13 kV	Substation costs
1....	2- 4	105-52	38-19	$ 0
2....	4- 8	52-26	19-10	95,000
3....	8-12	26-18	10- 6	289,000
4....	12-20	18-10	6- 4	630,000
5....	20	0[1]	0[1]	630,000

[1] At greater than 20 MV•A it is advisable to have the main substation at the mine site, thus only transmission lines are considered.

Note--MV•A(million volt amperes) = 1000kW; KV•A(thousand volt amperes) = kW Both MV•A and KV•A are commonly used in the power generation industry to designate power demand.

LINE COSTS:

Transmission lines	$59,000/km
Distribution lines	$42,000/km

It is important to understand that there is an inverse relationship between megavolt amperes and maximum distribution line distances. Thus, in case 2, at 24 kV, the first or lowest load figure (4 MV•A) corresponds to the maximum distance figure (52 km) and the highest load to the lowest distance figure.

It is also important to be aware of a few underlying assumptions regarding the five separate cases. Case 1 shows the power requirement range in which it is likely that existing distribution lines could supply the needed power. Thus there is no substation expense. The second and third cases assume that minor and major modifications of an existing substation will be required, respectively. They also assume that new line needed will originate from that modified substation. For cases 4 and 5 the large power requirements necessitate the construction of a completely new, dedicated substation. This facility will thus have to be fed by extending an existing high-voltage, transmission line. In the instance of case 4 the site of the substation is as near the existing transmission line network as practicable; for case 5 the substation is assumed to be at the mine site.

The costs contained in this section assume that the power company that will be supplying the power will design and construct the line. Principal costs categories included are right-of-way purchase and clearing, access road construction, line and substation construction, permitting, and preconstruction design.

The procedure for determining the system cost and requirements are as follows:

1. Estimate the maximum power demand that the mine will require. If not available an estimate of this value may be made by the techniques contained in the appropriate mine and beneficiation electrical system sections contained in this handbook. It is recommended that, for estimating, horsepower and kW (or KV·A) be considered to be equivalent. Motor efficiencies as well as other system power losses generally account for much of the difference between the two units.
2. Contact the probable power supplier to determine the "nearest useable source", or likeliest point from which power may be obtained. Depending upon present loading within the system this may or may not be the nearest transmission or distribution line.
3. Calculate the actual maximum distribution line length on the basis of the projected load using the following equations:

   24 kV load

   Maximum distribution line distance, in kilometers = 210/(P)

   13 kV load

   Maximum distribution line distance, in kilometers = 77/(P)
   where P = power requirements, in megavolt amperes.

4. Determine distribution line costs by multiplying the lesser of either the total length of line required or the maximum length of distribution line as calculated in step 3, by line cost per kilometer ($42,000).
5. Estimate the transmission line cost by multiplying the remaining length of line needed by transmission line cost per kilometer ($59,000). Note that for greater than 20 MV·A it is recommended that transmission lines be installed for the entire distance.
6. Based on megavolt amperes, determine a substation cost from the previous tabulation and add this to the line costs already determined. The combination of line and substation costs is the total main power line cost.

BASE CURVE

System costs have been graphed for three different line distances over the range (X) of 2 to 40 MV·A. These curves are included to aid the manual user who is interested in a very preliminary cost and desires to avoid the procedure outlined above for a more detailed cost determination.

Freight charges from the east coast manufacturing plant to Denver, CO, for the major purchased equipment has been determined to be:

Transformer:	32 mt........................	$7500
Oil breaker:	3 @13 mt each.................	$9600

All other equipment and materials are considered to be locally available in Denver, CO.

The total capital cost is based on single curves having power loads (X), in megavolt amperes. The curves are valid for power loads of 2 to 40 MV·A.

The capital cost derived from the curve is a combination of the following costs:

	Small (2 to 20 MV·A)	Large (20 to 40 MV·A)
Construction labor cost......	50%	47%
Construction supply cost.....	50%	37%
Purchased equipment cost.....	-	16%

The total 10-km main powerline capital cost is
$(Y_C \text{ 10-KM LINE}) = 207{,}826.608(X)^{0.563}$ and is distributed as follows:

(L) Construction Labor Cost
$(Y_L \text{ 10-KM LINE-SMALL}) = 103{,}913.304(X)^{0.563}$
$(Y_L \text{ 10-KM LINE-LARGE}) = 97{,}678.506(X)^{0.563}$

(S) Construction Supply Cost
$(Y_S \text{ 10-KM LINE-SMALL}) = 103{,}913.304(X)^{0.563}$
$(Y_S \text{ 10-KM LINE-LARGE}) = 76{,}895.844(X)^{0.563}$

(E) Purchased Equipment Cost
$(Y_E \text{ 10-KM LINE-LARGE}) = 33{,}252.257(X)^{0.563}$

The total 25-km main powerline capital cost is
$(Y_C \text{ 25-KM LINE}) = 644{,}990.250(X)^{0.370}$ and is distributed as follows:

(L) Construction Labor Cost
$(Y_L \text{ 25-KM LINE-SMALL}) = 322{,}495.125(X)^{0.370}$
$(Y_L \text{ 25-KM LINE-LARGE}) = 303{,}145.418(X)^{0.370}$

(S) Construction Supply Cost
$(Y_S \text{ 25-KM LINE-SMALL}) = 322{,}495.125(X)^{0.370}$
$(Y_S \text{ 25-KM LINE-LARGE}) = 238{,}646.392(X)^{0.370}$

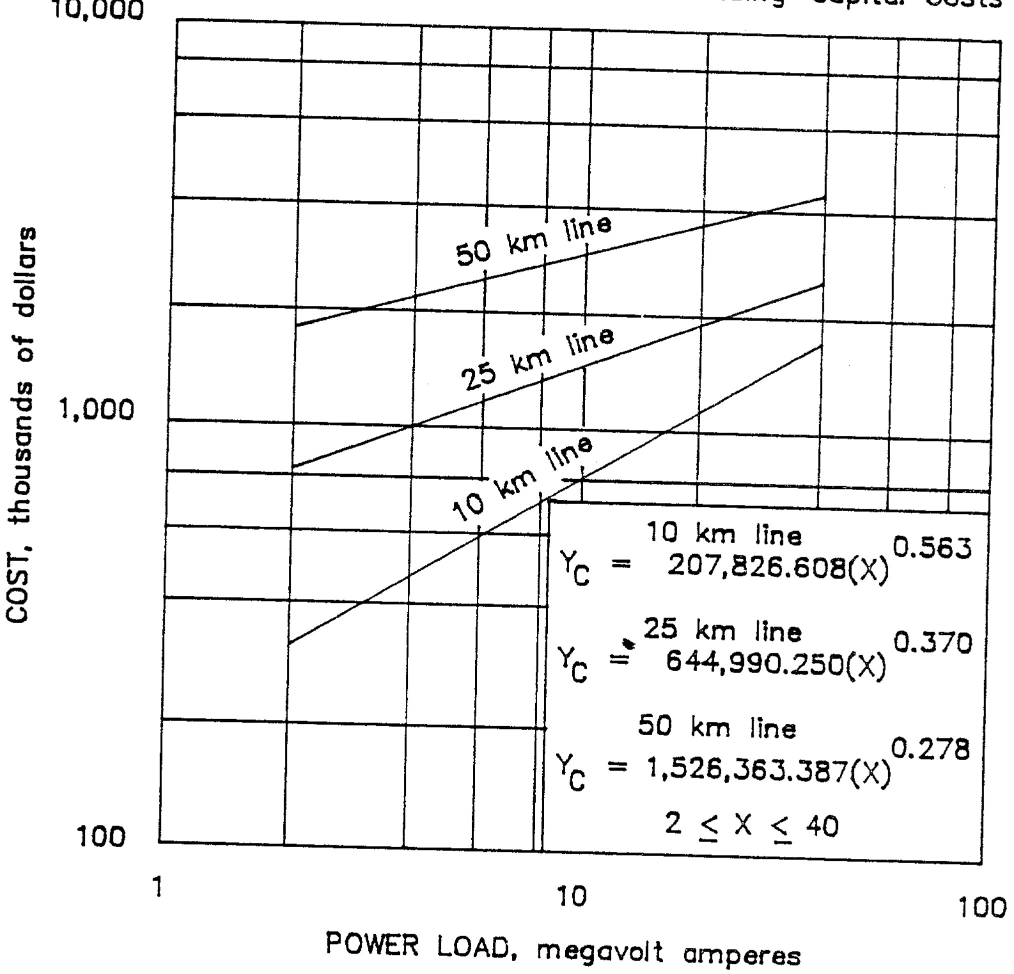
(E) Purchased Equipment Cost
$(Y_E \text{ 25-KM LINE-LARGE}) = 103{,}198.440(X)^{0.370}$

The total 50-km main powerline capital cost is
$(Y_C \text{ 50-KM LINE}) = 1{,}526{,}363.387(X)^{0.278}$ and is distributed as follows:

(L) Construction Labor Cost
$(Y_L \text{ 50-KM LINE-SMALL}) = 763{,}181.694(X)^{0.278}$
$(Y_L \text{ 50-KM LINE-LARGE}) = 717{,}390.792(X)^{0.278}$

(S) Construction Supply Cost
$(Y_S \text{ 50-KM LINE-SMALL}) = 763{,}181.694(X)^{0.278}$
$(Y_S \text{ 50-KM LINE-LARGE}) = 564{,}754.453(X)^{0.278}$

(E) Purchased Equipment Cost
$(Y_E \text{ 50-KM LINE-LARGE}) = 244{,}218.142(X)^{0.278}$



6.1.8.7. Main power lines

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.8. MILL BUILDINGS

The cost shown is for the mineral processing plant building, or buildings, erected on cleared land.

BASE CURVE

This cost curve is based on a conventional, one-product flotation mineral processing plant and includes foundation and floor excavation, concrete floors and footings, a steel superstructure, electrical and mechanical work, interior lighting, floor gratings and supports, insulation, interior control and instrument rooms, and overhead cranes.

The total capital cost is based on a single curve having an area (X), in square meters of mill building area <u>or</u> on a single cost curve having a production rate (T), in metric tons ore processed per day. The curve is valid for areas of 170 to 31,000 m^2, <u>or</u> 100 to 100,000 mtpd, operating three shifts per day.

If building space requirements are known, the capital cost estimate may be made directly by consulting the cost curve. If space requirements are not known, they can be estimated from the following equation:

Square meters of building space $(X) = 9.390(T)^{0.697}$
where T = ore processed, in metric tons per day.

The mill building capital cost distribution is as follows:

Construction labor cost......	49%
Construction supply cost.....	50%
Purchased equipment cost.....	1%

The mill building section should not be used for processes that do not require building closure, such as limestone calcination.

The total capital cost is $(Y_{C\ \text{SQUARE METERS}}) = 3{,}989.552(X)^{0.869}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u> $(Y_{L\ \text{SQUARE METERS}}) = 1{,}954.880(X)^{0.869}$

(S) <u>Construction Supply Cost</u> $(Y_{S\ \text{SQUARE METERS}}) = 1{,}994.776(X)^{0.869}$

(E) <u>Purchased Equipment Cost</u> $(Y_{E\ \text{SQUARE METERS}}) = 39.896(X)^{0.869}$

The total capital cost is $(Y_{C\ MTPD}) = 32{,}407.203(T)^{0.574}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_{L\ MTPD}) = 15{,}879.529(T)^{0.574}$

(S) Construction Supply Cost $(Y_{S\ MTPD}) = 16{,}203.602(T)^{0.574}$

(E) Purchased Equipment Cost $(Y_{E\ MTPD}) = 324.072(T)^{0.574}$

ADJUSTMENT FACTORS

Shift Factor To adjust the capital cost for a different number of daily operating shifts, multiply the actual daily tonnage by the ratio of the base number of shifts (three) divided by the number of desired shifts. Then, use this modified production rate in place of actual daily tonnage in the above tonnage, square-meter equation to obtain the adjusted building area. This factor need not be applied if actual building areas are known.

Weather Factor The buildings are based on weather requirements for the Denver, CO, area. For facilities located in climates that vary from the Denver area, multiply the costs obtained from the curve by the following factors:

Mild areas:
Weather factor $(F_{W\ MILD}) = 0.94$

Severe areas:
Weather factor $(F_{W\ SEVERE}) = 1.08$

Open-Sided Building Factor For buildings with open sides, multiply the cost obtained from the curve by the following factor:

Open-sided building factor $F(O) = 0.82$

The weather factor should not be used in combination with this factor.

Soil Factor The curve costs are based on a soil bearing capacity of 6,000 lb/ft^2, which is the safe bearing capacity of loose, medium, or coarse sand, or fine compact sand. For soil bearing capacities other than 6,000 lb/ft^2, multiply the cost obtained from the curve by the appropriate factor in the table below:

Table 8. Soil factors

Safe bearing capacity (10^3 lb/ft^2)	Type of soil	Factor
3	Fine, loose sand or soft clay	1.14
6	Loose, medium or coarse sand, fine compact sand	1.00
10	Compact sand and gravel, hard clay, gravel, coarse sand	0.92
16	Hardpan, soft rock	0.89
24	Shale, medium-hardness rock	0.87
100	Solid hard rock	0.85

Two-Product Factor To obtain the adjusted number of square meters (X_2) for a two-product flotation mineral processing plant, calculate the square meters of building space with the following equation:

Two-product factor (X_2) = $10.235(T)^{0.697}$
where T = ore processed, in metric tons per day.

Then use the adjusted square meters (X_2) in the square-meter-capital-cost equation.

Three-Product Factor To obtain the adjusted number of square meters (X_3) for a three-product flotation mineral processing plant, calculate the square meters of building space with the following equation:

Three-product factor (X_3) = $10.517(T)^{0.697}$
where T = ore processed, in metric tons per day.

Then use the adjusted square meters (X_3) in the square-meter-capital-cost equation.

Copper-Molybdenum Factor To obtain the adjusted number of square meters (X_C) for a copper-molybdenum flotation mineral processing plant, calculate the square meters of building space with the following equation:

Copper-molybdenum factor (X_C) = $11.080(T)^{0.697}$
where T = ore processed, in metric tons per day.

Then use the adjusted square meters (X_C) in the square-meter-capital-cost equation.

Type of Operation Factors For types of operations differing from a conventional crush-grind-float operation, use the following equations to determine the number of square meters (X_O) required, based on capacities in metric tons per day or liters per minute. Then use the adjusted square meters (X_O) in the square meter capital cost equation.

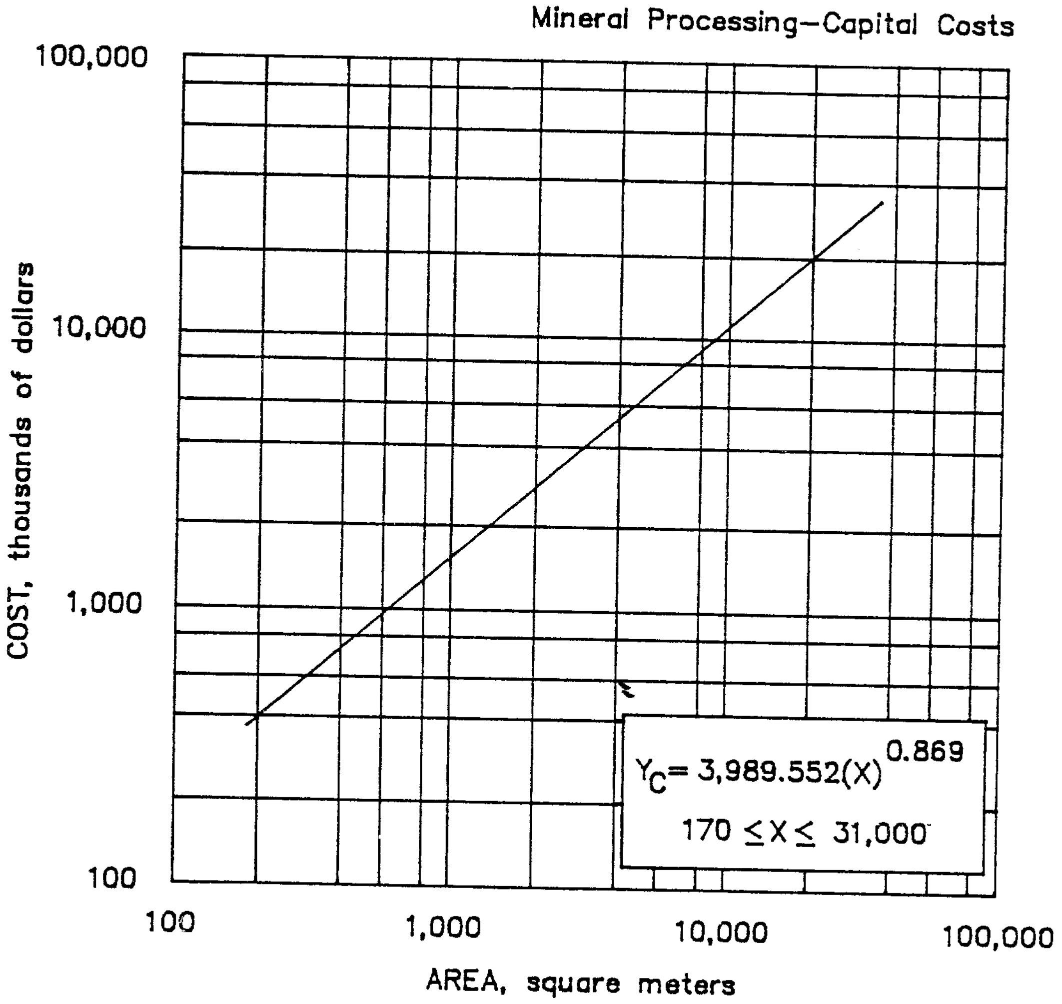
Type of operation	Equation	Range of validity
Concentrator-agglomerating plant..................	$(X_O) = 1.13(\text{mtpd})-8{,}230$	10,000-29,000 mtpd
SX-EW..................	$(X_O) = 1.09(\text{L/min})-9{,}400$	10,000-20,000 L/min
Flotation with tabling...	$(X_O) = 0.267(\text{mtpd})-54.8$	950-1,000 mtpd

Either a number-of-products factor or a type-of-operation factor may be used, but not both. If the user determines that none of the above adjustment factors apply, adjustments should be made to the costs based on the user's knowledge of the building requirements.

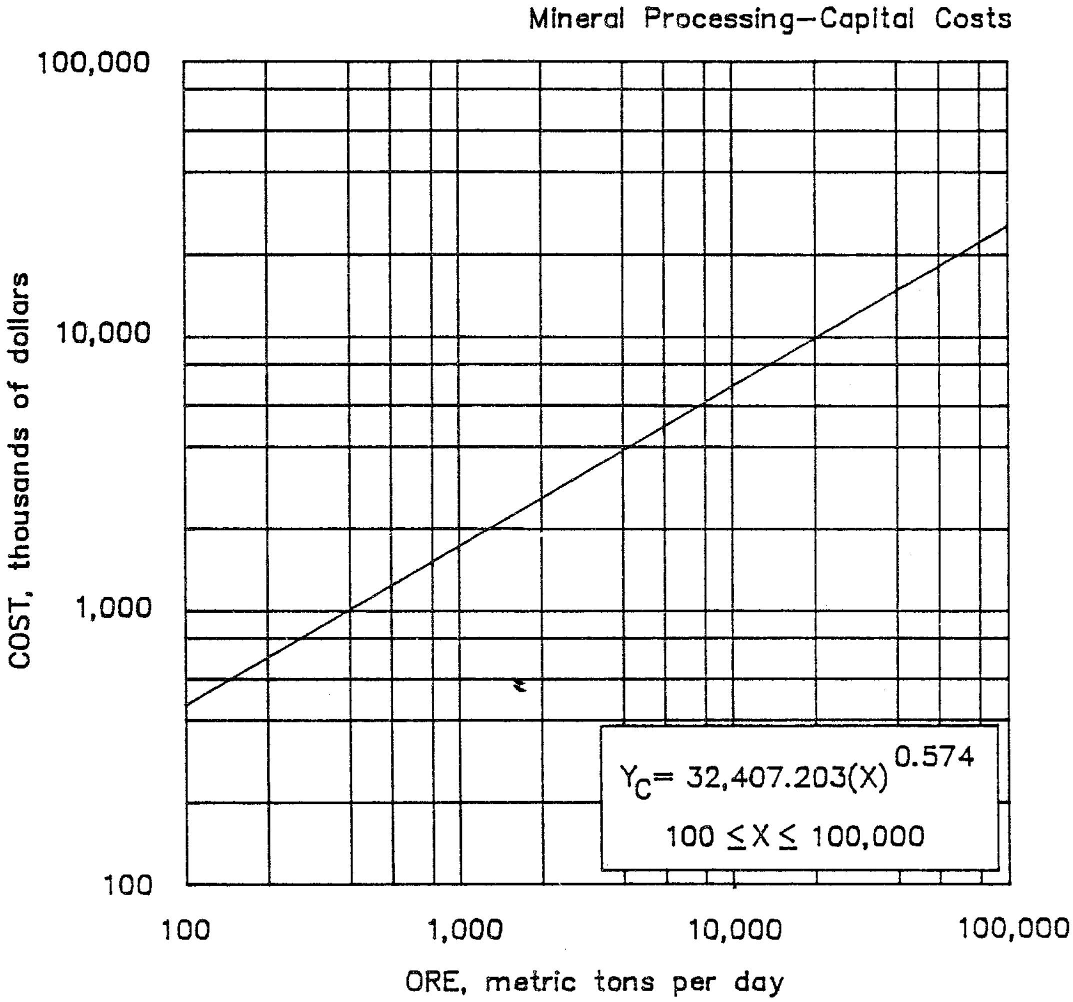
Fine-Ore Bin Factor If fine-ore bins are to be included, add the cost obtained from the curve to the following factor:

Fine-ore bin factor $F(_F) = 402.000(T)^{0.792}$
where T = feed, in metric tons per day.

To insulate fine-ore bins, add an additional $4/mtpd of feed.



6.1.8.8.a Mill buildings



6.1.8.8.b Mill buildings

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.9. MISCELLANEOUS EQUIPMENT

The capital costs are for nondefined equipment that may be included in some operations and excluded in others. Items in this category would be instrumentation, communications, emergency lighting, standby generators, and special purpose equipment.

BASE CURVE

This curve was established as 5% of the cost of utilities and facilities excluding the mill buildings item. The total capital cost is based on a single curve having an adjusted feed rate (X), in metric tons mill feed per day. The curve is valid for operations between 100 and 100,000 mtpd, operating three shifts per day. The curve includes all costs associated with acquisition and installation of any miscellaneous equipment.

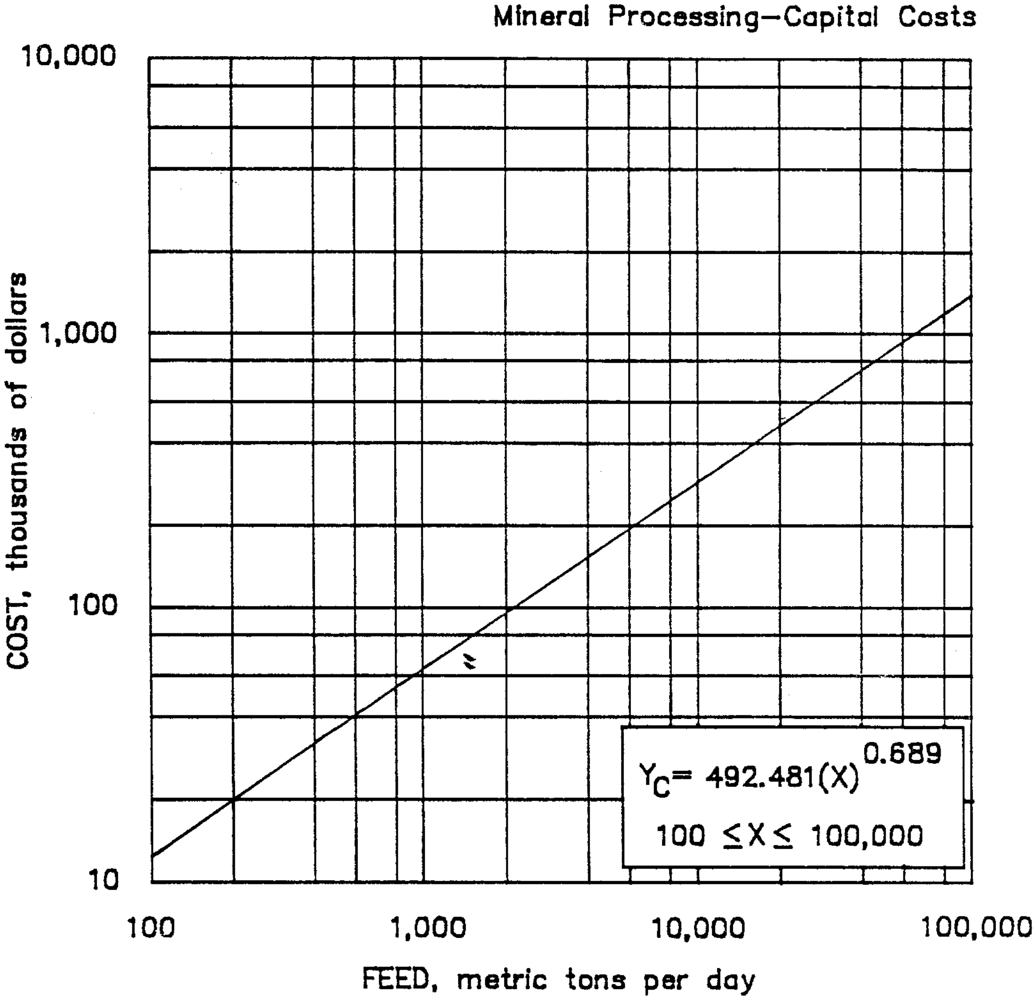
The capital cost derived from the curve is a combination of the following costs:

Construction labor cost......	25%
Purchased equipment cost.....	74%
Transportation cost..........	1%

The total capital cost is $(Y_C) = 492.481(X)^{0.689}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u> $(Y_L) = 124.620(X)^{0.689}$

(E) <u>Purchased Equipment Cost</u> $(Y_E) = 373.861(X)^{0.689}$



6.1.8.9. Miscellaneous equipment

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.10. OFFICES AND LABORATORIES

The cost curve for offices and laboratories includes construction of general offices, engineering and safety offices, and laboratories, including furnishings as well as all necessary assay and metallurgical equipment. Building costs are based on masonry two-story buildings. In this section, office and laboratory capital costs are presented separately.

BASE CURVE

The costs obtained from this curve are based on the assumption that these facilities will be used only for mineral processing operations. If the mineral processing plant and mine are to share the same facilities, the user must determine, using a knowledge of the requirements, what can be jointly used and apportion the resulting costs for the mine and plant.

OFFICES

The total office capital cost is based on a single cost curve having an area (X), in square meters of office space <u>or</u> on a single cost curve having a production rate (T), in metric tons material processed per day. The curve is valid for areas of 8.5 to 4,600 m^2, <u>or</u> 85 to 230,000 mtpd, operating three shifts per day. The capital cost curve for offices includes construction of administrative, engineering, and safety office space, as well as office furnishings.

If office space requirements are known the capital cost estimate may be made directly by consulting the curve; if space requirements are not known they can be estimated from the following equation:

Square meters of office space = $0.206(T)^{0.826}$
where T = material processed, in metric tons per day.

The office capital cost derived from the curve is a combination of the following costs:

Construction labor cost......	38%
Office supply cost...........	14%
Purchased equipment cost.....	48%

The total office capital cost is $(Y_{C\ \text{SQUARE METERS}}) = 591.395(X)^{0.979}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u> $(Y_{L\ \text{OFFICES-SQ M}}) = 224.730(X)^{0.979}$

(S) <u>Office Supply Cost</u> $(Y_{S\ \text{OFFICES-SQ M}}) = 82.795(X)^{0.979}$

(E) <u>Purchased Equipment Cost</u> $(Y_{E\ \text{OFFICES-SQ M}}) = 283.870(X)^{0.979}$

The total office capital cost is $(Y_{C\ MTPD}) = 125.878(T)^{0.809}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_{L\ OFFICES\text{-}MTPD}) = 47.834(T)^{0.809}$

(S) Office Supply Cost $(Y_{S\ OFFICES\text{-}MTPD}) = 17.623(T)^{0.809}$

(E) Purchased Equipment Cost $(Y_{E\ OFFICES\text{-}MTPD}) = 60.421(T)^{0.809}$

LABORATORIES

The total laboratory capital cost is based on a single cost curve having an area (X), in square meters of office space or on a single cost curve having a production rate (T), in metric tons material processed per day. The curve is valid for areas of 51 to 1,725 m^2, or 800 to 230,000 mtpd, operating three mining shifts per day. The capital cost curve for assay laboratories includes construction of sample prepara- tion, analytical, and metallurgical laboratory space as well as crushing, assaying, and metallurgical laboratory equipment. The capital cost is based on steel building construction and is for a lab used only by the mine.

If laboratory space requirements are not known they can be estimated from the following equation:

Square meters of laboratory space $(A) = 8.316(T)^{0.436}$
where T = ore processed, in metric tons per day.

The total laboratory cost derived from the curve is a combination of the following costs:

Construction labor cost......	36%
Laboratory supply cost.......	24%
Purchased equipment cost.....	40%

The total laboratory capital cost is $(Y_{C\ SQUARE\ METERS}) = 1,146.989(X)^{0.909}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_{L\ LABS\text{-}SQ\ M}) = 412.916(X)^{0.909}$

(S) Laboratory Supply Cost $(Y_{S\ LABS\text{-}SQ\ M}) = 275.277(X)^{0.909}$

(E) Purchased Equipment Cost $(Y_{E\ LABS\text{-}SQ\ M}) = 458.796(X)^{0.909}$

The total laboratory capital cost is $(Y_{C\ MTPD}) = 11,670.278(T)^{0.359}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_{L\ LABS\text{-}MTPD}) = 4,201.300(T)^{0.359}$

(S) Laboratory Supply Cost $(Y_{S\ LABS\text{-}MTPD}) = 2,800.867(T)^{0.359}$

(E) Purchased Equipment Cost $(Y_{E\ LABS\text{-}MTPD}) = 4,668.111(T)^{0.359}$

ADJUSTMENT FACTORS

Laboratory Shift Factor The square meters of laboratory space required is based on a three-shift operation. To adjust the capital cost for a different number of daily operating shifts, multiply the actual daily tonnage by the ratio of the base number of shifts (three) divided by the number of desired shifts. Then, use this modified production rate in place of actual daily tonnage in the area versus tonnage equation to obtain the adjusted area. Then, enter the adjusted area in the cost equation to obtain the adjusted capital cost. The square meters of office space is not contingent on the number of shifts and requires no adjustment. If the number of square meters of laboratory space is known, do not use this adjustment factor.

Weather Factor The buildings are based on weather requirements for the Denver. CO, area. For facilities located in climates that vary from the Denver area, multiply the costs obtained from the curve by one the following factors:

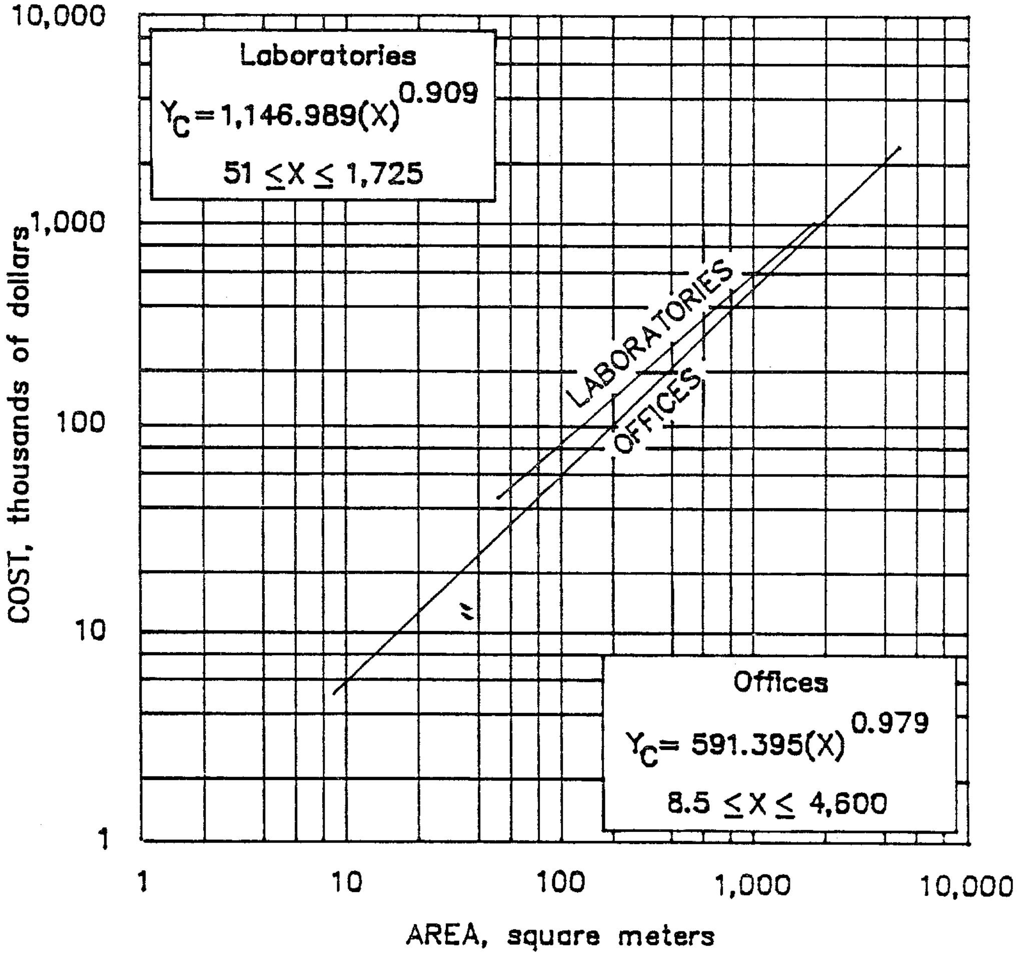
Mild areas:
Weather factor $(F_{W\ MILD}) = 0.94$

Severe areas:
Weather factor $(F_{W\ SEVERE}) = 1.08$

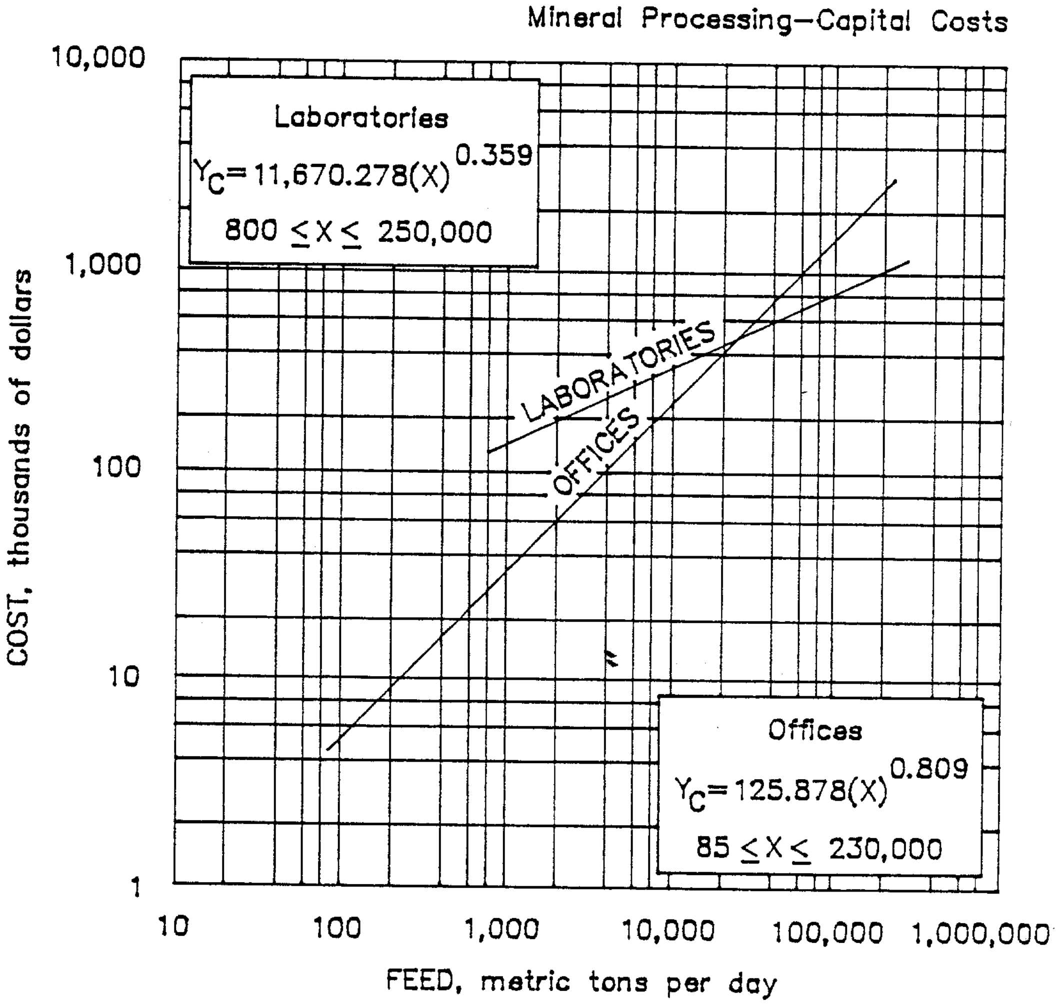
Wind and Snow Load Factor The buildings are based on typical Denver, CO, area requirements for an equivalent combined wind and snow load of 20 lb/ft^2. To adjust the costs for more severe conditions (greater than 40 lb/ft^2), multiply the costs obtained from the curve by the following factor:

Wind and snow load factor $(Y_{W\ SEVERE}) = 1.03$

Mineral Processing—Capital Costs



6.1.8.10.a Offices and laboratories



6.1.8.10.b Offices and laboratories

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.11. PORTABLE POWER GENERATION

This section is to be used in conjunction with section 6.1.8.4. when electrical power is unavailable through a commercial power utility company or when it would be uneconomical to run power distribution facilities to the user. No adjustments are necessary for the mine or mineral processing plant electrical system (sections 2.2.4.2. and 4.2.5.3. (IC 9142), and 6.1.8.4.) because output power matches the power input to the mine/processing plant transformer-switchgear substations.

The cost shown is for acquisition and installation of the primary power source, either a horizontal-diesel or a gas-turbine operated generator. The cost curve is based on a single 60-Hz, three-phase electrical generator providing all power at the rated kilowatt output. This section should be included in the mine and/or mineral processing plant capital cost totals.

BASE CURVE

The total capital cost is based on a single cost curve having an average continuous power output (X), in kilowatts. The curve is valid for generators between 18 to 23,600 kW. The curve includes all costs associated with the acquisition, transportation, and installation of single-unit generators.

To convert from kilovolt amperes (kV•A) demand to kilowatt (kW) power output, estimate power factor (PF). This may vary from 0.80 for electric motor circuits to 1.00 for electric light circuits. The kilowatt power output is then determined by kV•A X PF = kW.

The portable power generation costs derived from the curves are a combination of the following costs::

	Horizontal diesel (18 to 2,900 kW)	Gas turbine (2,900 to 23,600 kW)
Installation labor cost........	21%	21%
Installation materials cost....	20%	20%
Purchased equipment cost.......	58%	59%
Freight cost..................	1%	-

Installation is assumed to be half labor and half materials.

The total diesel-powered portable power generation capital cost is $(Y_{C\ DIESEL}) = 797.574(X)^{0.876}$ and is distributed as follows:

(L) Installation Labor Cost $(Y_{L\ DIESEL}) = 167.491(X)^{0.876}$

(S) Installation Materials Cost $(Y_{S\ DIESEL}) = 159.514(X)^{0.876}$

(E) Purchased Equipment Cost $(Y_{E\ DIESEL}) = 470.568(X)^{0.876}$

The total turbine-powered portable power generation capital cost is ($Y_{C\ TURBINE}$) $=2{,}251.219(X)^{0.872}$ and is distributed as follows:

(L) Installation Labor Cost ($Y_{L\ TURBINE}$) $= 472.756(X)^{0.872}$

(S) Installation Materials Cost ($Y_{S\ TURBINE}$) $= 450.244(X)^{0.872}$

(E) Purchased Equipment Cost ($Y_{E\ TURBINE}$) $= 1{,}328.219(X)^{0.872}$

Power Output Determination For surface mine power output (kW), see Electrical System (section 2.2.4.2., IC 9142). For underground mine and mineral processing plant power demand (kV•A), see Electrical System [sections 4.2.5.3., (IC 9142) and 6.1.8.4.]

ADJUSTMENT FACTORS

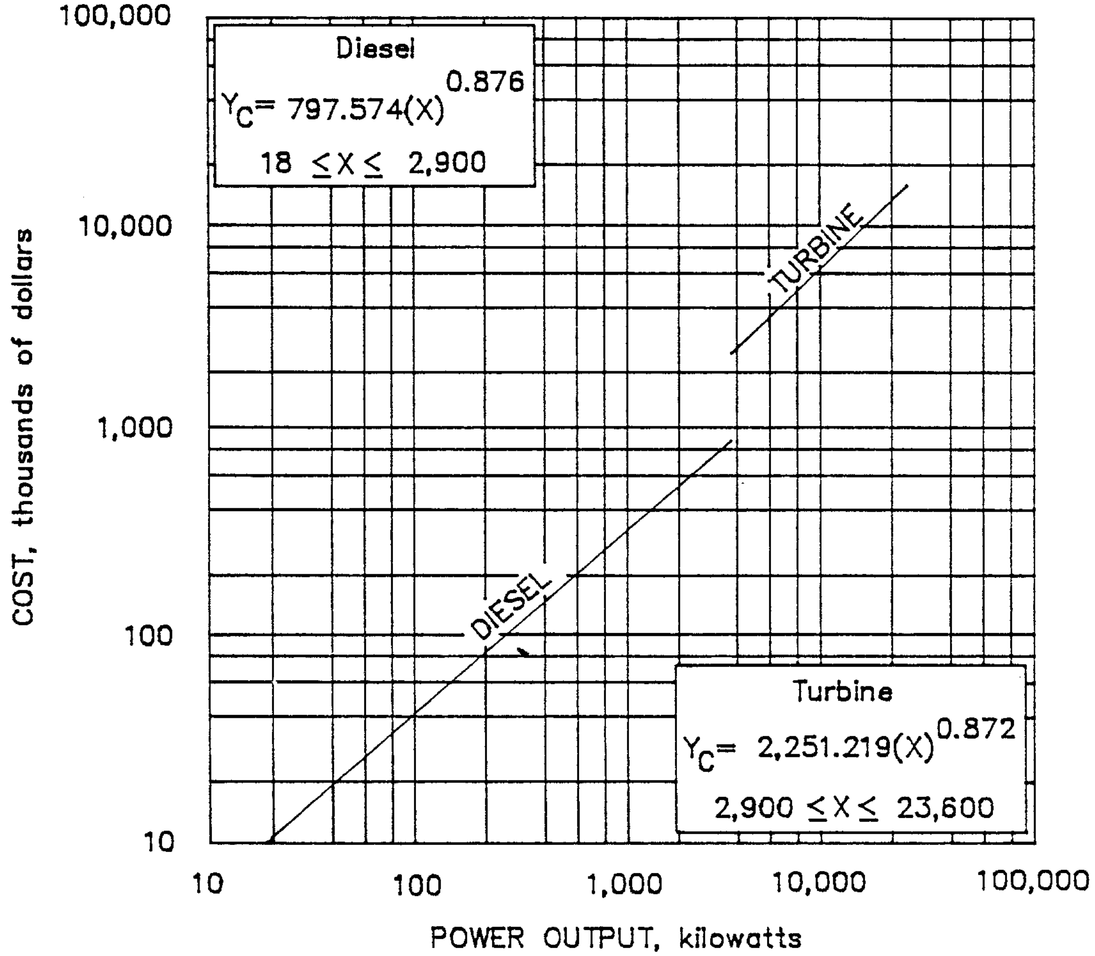
Power Rate If power is to be supplied by more than one unit, the total power output should be divided by the number of required units to obtain the power output per unit (X) needed for entering the curve. After the unit cost has been calculated, the cost must be multiplied by the total number of units used.

Power Source If geography or economics necessitate multiple power sites to support mines and mineral processing plants, portable power cost should be estimated separately for each site using this section.

Economic Life The normal economic life for generators is 25,000 h for units rated at 1,100-kW output or greater and ranges from 11,000 to 17,500 h for units rated at less than 1,100-kW output.

If the units are operated at standby rates, roughly 10% over capacity, the economic life would decrease by 50%.

If high-sulfur fuels are used, the economic life would be decreased by 25%.



6.1.8.11 Portable power generation

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.12. STOCKPILE STORAGE FACILITIES

A stockpile storage facility provides sufficient storage capacity for a material until it can be further processed. A storage facility may also provide adequate reserve material to dampen surges in the material supply. Examples of materials stockpiled are smelter flux, coal, and coarse ore. For this base curve, capital cost is correlated to the live storage capacity of the stockpile facility. Live storage capacity of a stockpile is normally about 25% of the total stockpile capacity and 150% of the daily stockpile reclaim rate. The stockpile storage facility capital cost includes all costs associated with acquisition and installation of stockpiling conveyors, reclaim tunnels, reclaim feeders, and reclaim conveyors.

BASE CURVE

The total capital cost is based on a single curve having a live storage capacity (X), in metric tons material. The curve is valid for 3,000 to 300,000 mt, operating two shifts per day.

The capital cost derived from the curve is a combination of the following costs:

Construction labor cost......	13%
Construction supply cost.....	36%
Purchased equipment cost.....	51%

A typical breakdown of the major cost components is

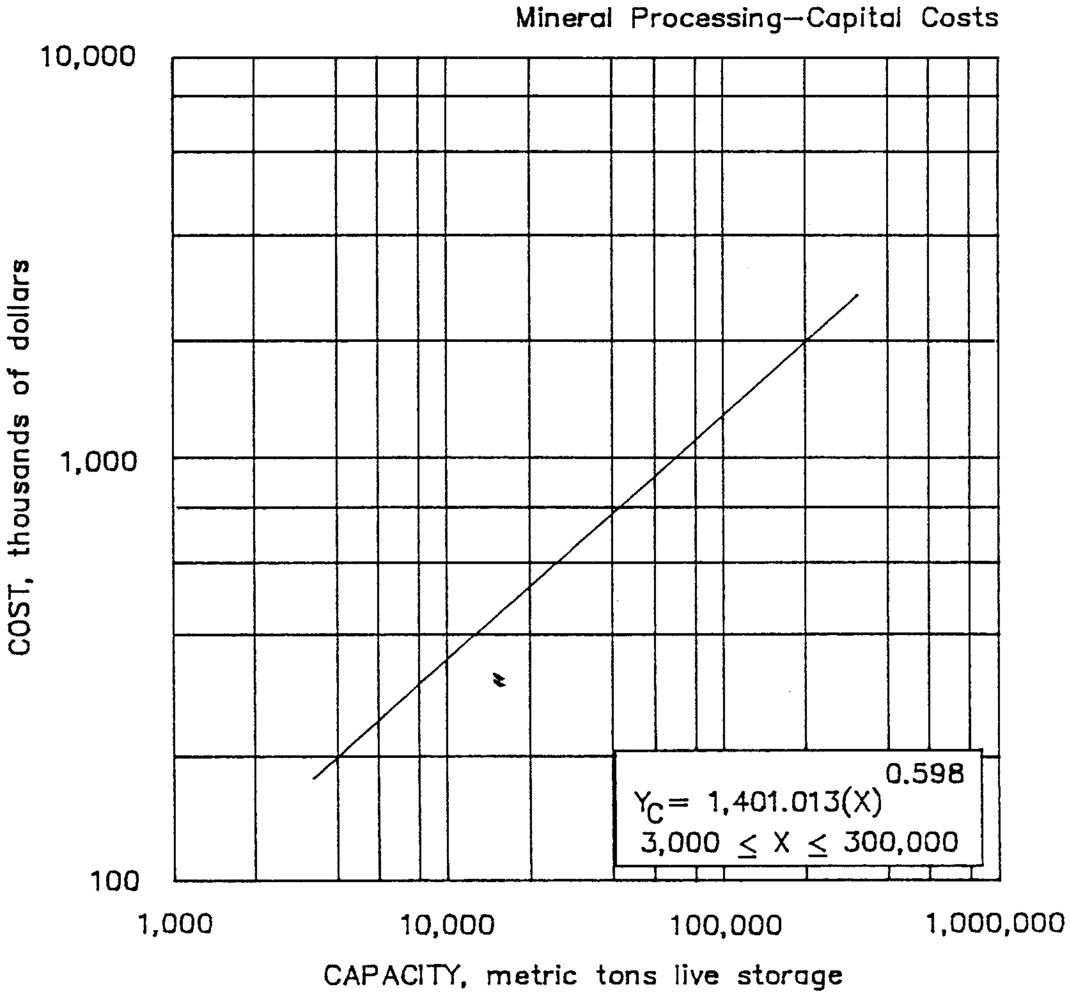
Reclaim feeders.............	14%
Stockpiling conveyor.........	23%
Reclaim tunnels.............	31%
Reclaim conveyors*...........	32%

The total stockpile storage facility capital cost is $(Y_C) = 1,401.013(X)^{0.598}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u> $(Y_L) = 182.132(X)^{0.598}$

(S) <u>Construction Supply Cost</u> $(Y_S) = 504.365(X)^{0.598}$

(E) <u>Purchased Equipment Cost</u> $(Y_E) = 714.516(X)^{0.598}$



6.1.8.12. Stockpile storage facilities

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.13. VEHICLES

The vehicles capital cost is for the acquisition of service vehicles assigned exclusively to the mill.

BASE CURVE

The total capital cost is based on a single curve having an adjusted feed rate (X), in metric tons mill feed per day. The curve is valid for operations between 100 and 100,000 mtpd, operating three shifts per day. The curve includes all costs associated with acquisition of pickup and flatbed trucks, hydraulic cranes, front-end loaders, forklifts, bulldozers, and draglines.

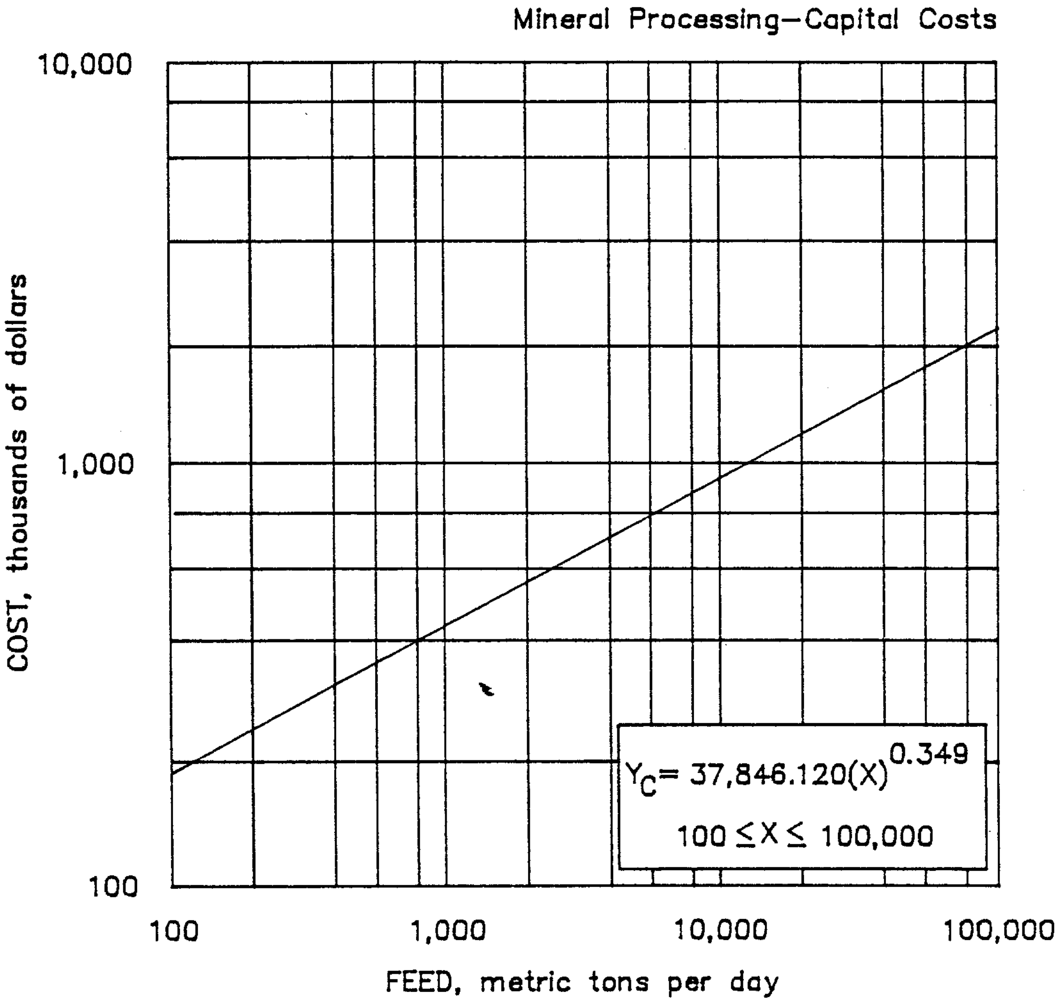
The capital cost derived from the curve is a combination of the following costs:

Purchased equipment cost.....	98%
Transportation cost..........	2%

The total capital cost is $(Y_C) = 37{,}846.120(X)^{0.349}$.

The capital costs consist of the following typical range of equipment costs:

	Small (100 to 3,500 mtpd)	Large (25,000 to 100,000 mtpd)
Pickup & flatbed trucks	3%	4%
Cranes	-	27%
Front-end loaders	44%	19%
Forklifts	16%	2%
Bulldozers	37%	23%
Draglines	-	25%



6.1.8.13. Vehicles

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.8. GENERAL OPERATIONS

6.1.8.14. WATER SUPPLY SYSTEM (MAKEUP WATER)

Water is supplied from aquifers or surface sources to mineral processing plants primarily for ore processing. Depending on the mineral processing method, the water volume required will vary. The water supply system capital cost for a mineral processing plant (and/or a surface mine, section 2.2.4.10.2., IC 9142) is based on daily water consumption.

If total daily volume (mine and mineral processing makeup water) is known, the manual user should enter this volume in the equation given below (unless the mine is supplied with water from an independent source). The total cost may be alloted as follows:

a) 9% to section 2.2.4.10.2. (surface mine, IC 9142).

b) 91% to section 6.1.8.14. (mineral processing)

NOTE--Percentages are derived from the Bu Mines IC 8285 dealing with water consumption for U.S. mines and mineral processing plants. Different percentages may be obtained if an actual breakdown of mine and mineral processing plant is known.

For flotation plants, the total water required varies from 2.5 to 4.5 m^3/mt floated. Ten to 40% of the water required is makeup water. Gravity concentration may require as much as 8 m^3 of water per metric ton of ore feed. About 10% of this figure is new water and the rest reclaimed.

BASE CURVE

The total capital cost is based on a single curve for a water volume (X), in cubic meters per day and is valid for volumes of 1,000 to 150,000 m^3/d, operating three shifts per day. The curve is predicated on an average pumping head of 291 m, and pumping distances ranging from 3 to 53 km, and consists of wells, storage tanks, pipelines, distribution piping, pumps, and fittings.

The capital cost derived from the curve is a combination of the following costs:

Construction labor cost......	54%
Construction supply cost.....	13%
Purchased equipment cost.....	32%
Freight cost.................	1%

A typical breakdown of equipment major cost components is

Pipeline....................	58%
Pumps.......................	26%
Storage tanks...............	16%

The total capital cost is $(Y_C) = 848.677(X)^{0.893}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 458.286(X)^{0.893}$

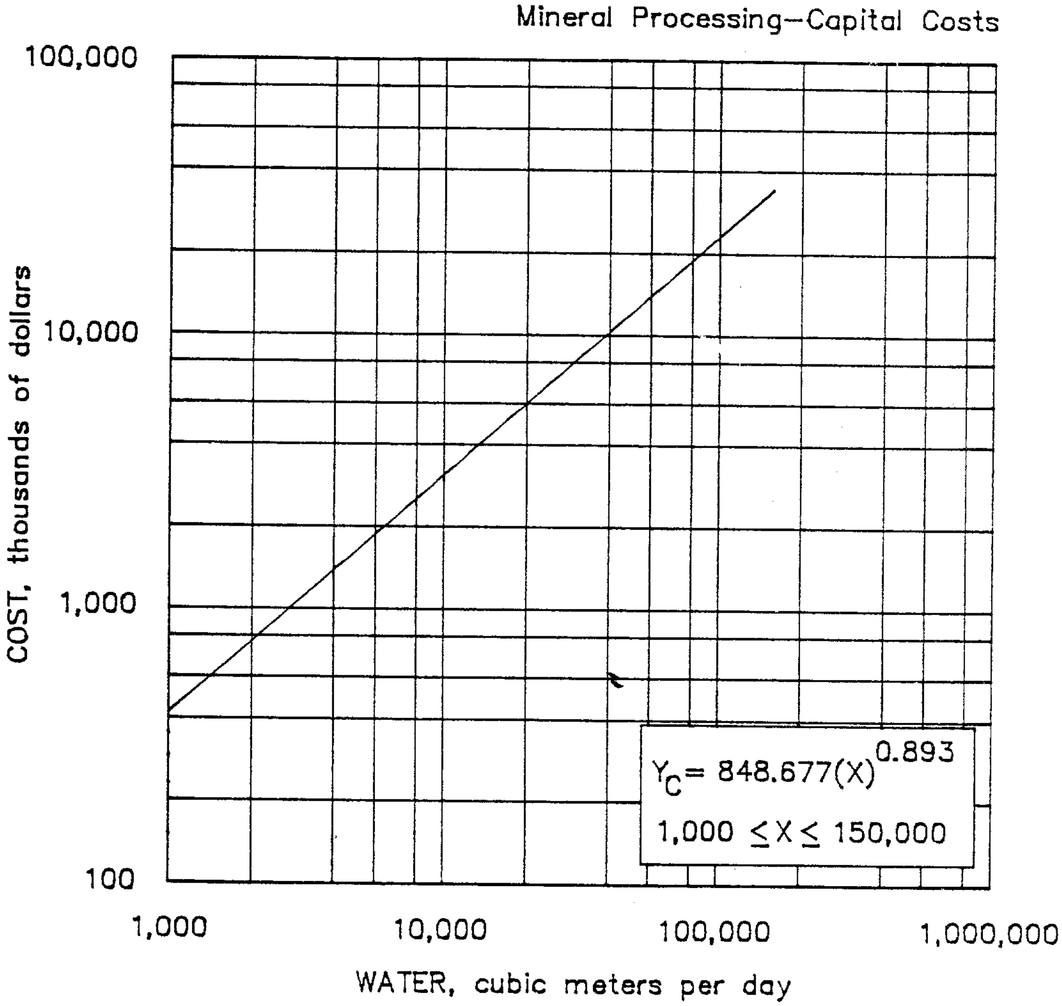
(S) Construction Supply Cost $(Y_S) = 110.328(X)^{0.893}$

(E) Purchased Equipment Cost $(Y_E) = 280.063(X)^{0.893}$

ADJUSTMENT FACTORS

Pumping Distance Factor To adjust the capital cost for actual pumping distances, multiply the cost by the following factor:

Pumping distance factor $(F_D) = 0.03+[12.516(D)(X)^{-0.549}]$
where D = actual distance, in kilometers,
and X = volume, in cubic meters per day.



6.1.8.14. Water and drainage system
WATER SUPPLY SYSTEM (MAKEUP WATER)