6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.1. AMALGAMATION

The capital cost of amalgamation is for the acquisition and installation of equipment needed to process a gravity concentrate for the recovery of gold. The amalgamation circuit includes amalgamators and/or amalgamation plates.

BASE CURVE

The total cost is based on a single cost curve having a feed rate (X), in metric tons of feed material to the amalgamation circuit per day. The curve is valid for operations between 0.4 and 65.0 mtpd, operating one shift per day. The curve includes all costs associated with the acquisition and installation of the amalgamation circuit.

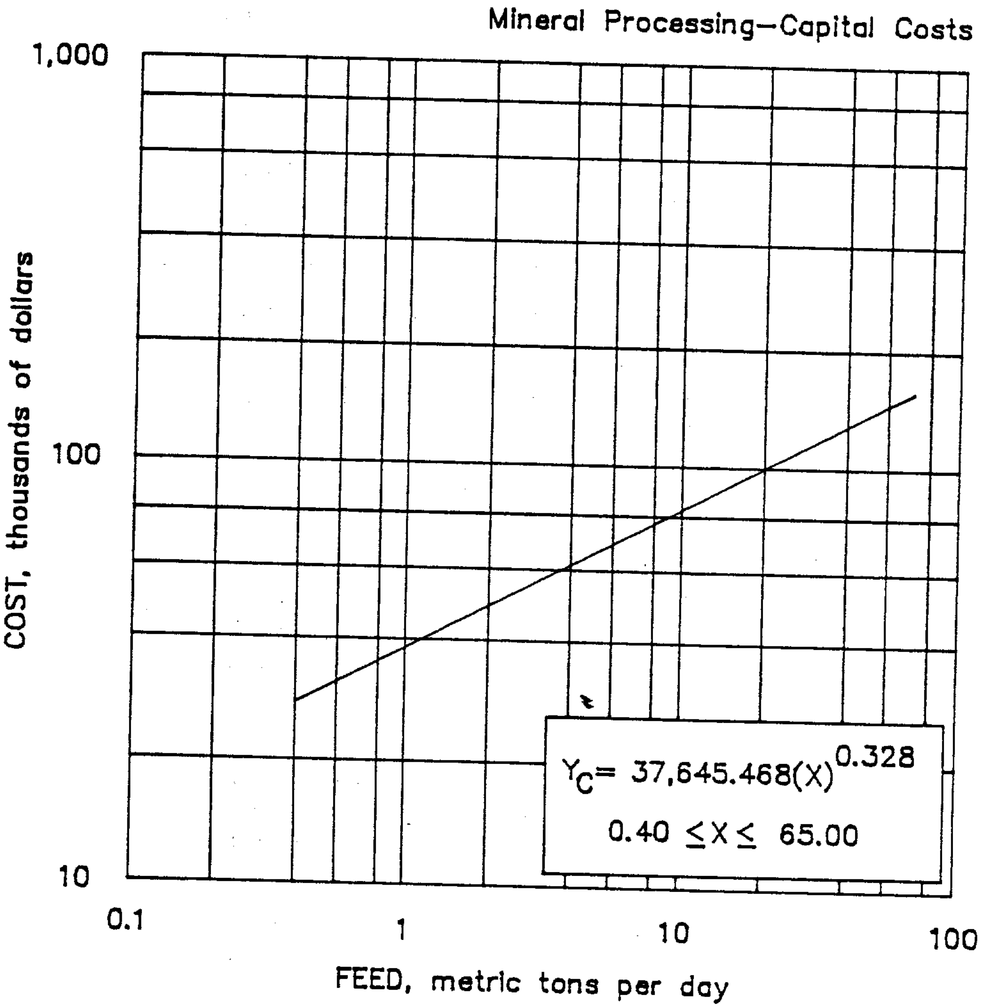
The capital cost derived from the curve is a combination of the following costs:

	Small (0.4 to 1 mtpd)	Large (1 to 65 mtpd)
Construction labor cost.........	3.2%	4.7%
Construction supply cost........	3.3%	3.5%
Purchased equipment cost........	93.5%	91.8%

The total capital cost is $(Y_C) = 37{,}645.468(X)^{0.328}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_{L\ SMALL}) = 1{,}204.655(X)^{0.328}$
(S) Construction Supply Cost $(Y_{S\ SMALL}) = 1{,}242.300(X)^{0.328}$
(E) Purchased Equipment Cost $(Y_{E\ SMALL}) = 35{,}198.513(X)^{0.328}$

(L) Construction Labor Cost $(Y_{L\ LARGE}) = 1{,}769.337(X)^{0.328}$
(S) Construction Supply Cost $(Y_{S\ LARGE}) = 1{,}317.591(X)^{0.328}$
(E) Purchased Equipment Cost $(Y_{E\ LARGE}) = 34{,}558.540(X)^{0.328}$



6.1.6.1. Amalgamation

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.2.1. BRINE RECOVERY
LITHIUM (WELLS)

The capital cost includes the acquisition and installation of equipment items associated with the brine recovery system.

BASE CURVE

The total capital cost for a lithium brine recovery system is based on a single curve having an adjusted feed rate (X), in liters of lithium-bearing solution per minute. The curve is valid for operations between 1,300 and 9,700 L/min of brine solution, operating three shifts per day. The curve is for the acquisition and installation of the purchased equipment items including pumps, solar evaporation ponds, and mobile equipment. The capital cost curve does not include the cost of site preparation for the solar evaporation ponds. This cost should be estimated using clearing (section 6.1.8.1).. The amount of area, in hectares, for site preparation is calculated using the following equation:

Site preparation area $(A) = 19{,}793.209-[83.024(N)]$
where N = net evaporation rate, in centimeters per year.

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

Construction labor cost....	32.8%
Construction supply cost...	55.1%
Purchased equipment cost...	12.0%
Transportation cost........	0.1%

The total capital cost is $(Y_C) = 5{,}696.547(X)^{0.929}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 1{,}868.467(X)^{0.929}$

(S) Construction Supply Cost $(Y_S) = 3{,}138.797(X)^{0.929}$

(E) Purchased Equipment Cost $(Y_E) = 689.283(X)^{0.929}$

ADJUSTMENT FACTORS

Well Depth Factor The base curve is premised on an average well depth of 150 m. To adjust for a different average depth, multiply the cost obtained from the curve by the following factor:

Well depth factor $(F_D) = 0.00250(D)+0.626$
where D = well depth, in meters.

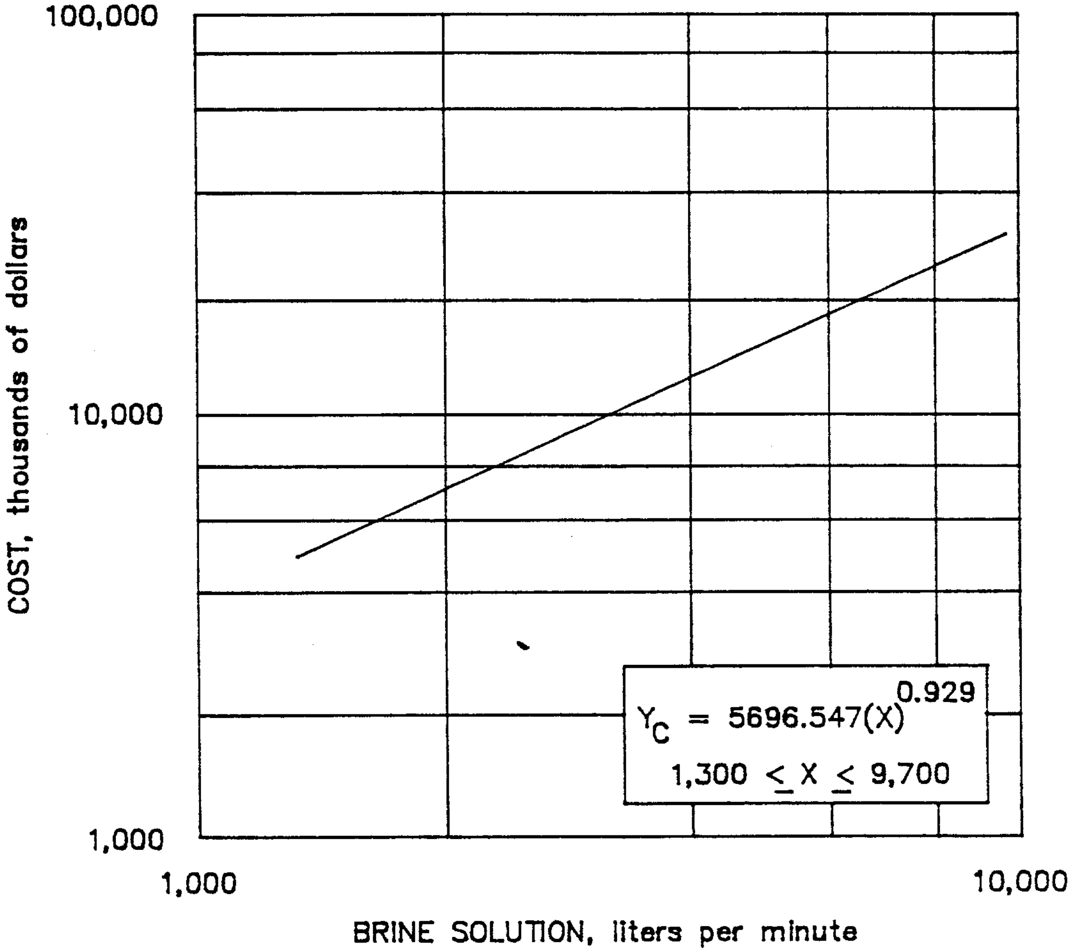
Net Evaporation Rate Factor The base curve is premised on a net evaporation rate of 119.4 cm/yr. To adjust for a different net evaporation rate, multiply the cost obtained from the curve by the following factor:

Net evaporation rate factor $(F_E) = 1.30-[0.00251(E)]$
where E = net evaporation rate in centimeters per year

Solar Evaporation Pond Liner Factor The base curve is premised on the installation of unlined solar evaporation ponds. To adjust the base curve for the installation of a synthetic liner, multiply the cost obtained from the curve by the following factor:

Solar evaporation pond liner factor $(F_L) = 4.6$

Mineral Processing—Capital Costs



6.1.6.2.1. Brine recovery
LITHIUM (WELLS)

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.2.2. BRINE RECOVERY
MAGNESIUM (SEAWATER)

The capital cost includes the acquisition and installation of equipment items associated with the brine recovery system.

BASE CURVE

The total capital cost for a magnesium brine recovery system from seawater is based on a single curve having an adjusted feed rate (X), in liters of magnesium-bearing seawater per minute. The curve is valid for operations between 3,500 and 91,400 L/min, operating three shifts per day. These equipment items include the seawater pumps and pier.

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

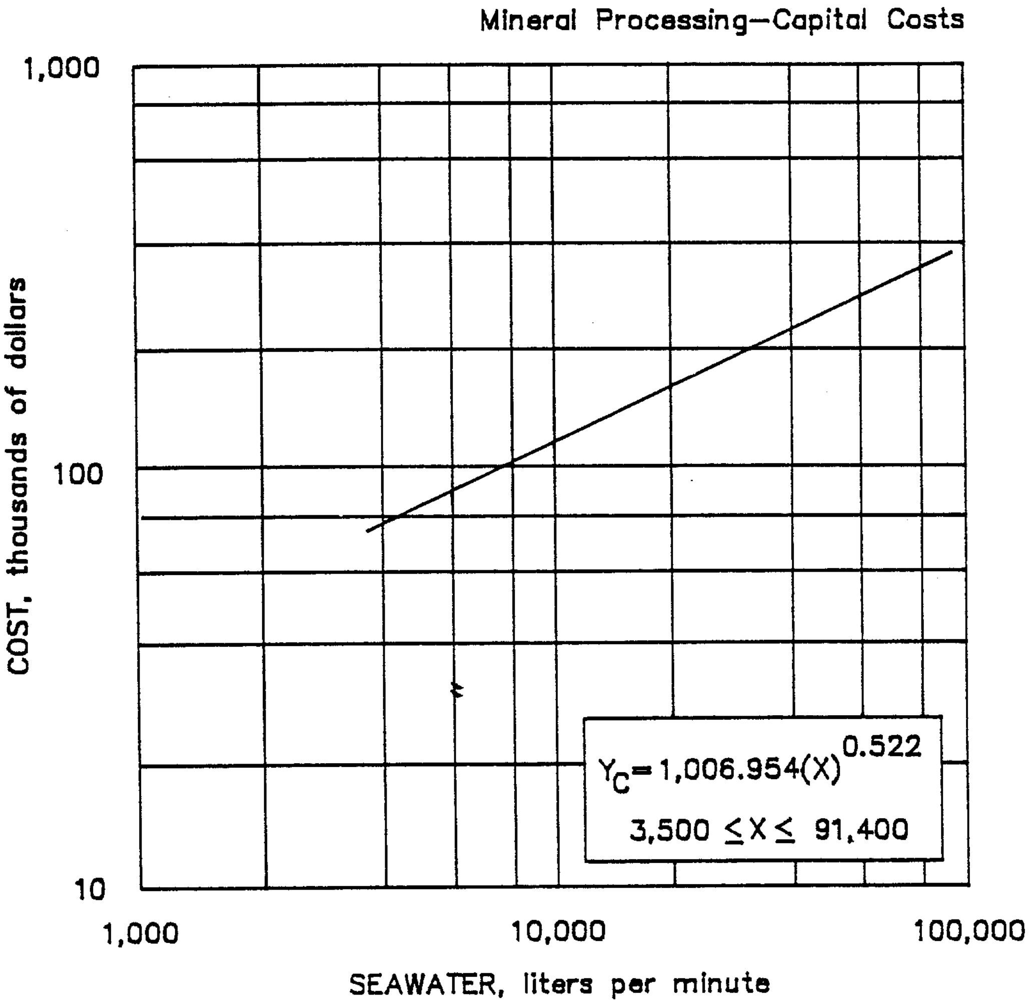
Construction labor cost....	8.3%
Construction supply cost...	10.2%
Purchased equipment cost...	81.4%
Transportation cost........	0.1%

The total capital cost is $(Y_C) = 1{,}006.954(X)^{0.522}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u> $(Y_L) = 83.579(X)^{0.522}$

(S) <u>Construction Supply Cost</u> $(Y_S) = 102.709(X)^{0.522}$

(E) <u>Purchased Equipment Cost</u> $(Y_E) = 820.666(X)^{0.522}$



6.1.6.2.2. Brine recovery
MAGNESIUM (SEAWATER)

6.1.6.2.3. BRINE RECOVERY
MAGNESIUM (WELLS)

The capital cost includes the acquisition and installation of equipment items associated with the brine recovery system.

BASE CURVE

The total capital cost for a magnesium brine recovery system from wells is based on a single curve having an adjusted feed rate (X), in liters of magnesium-bearing brine solution per minute. The curve is valid for operations between 770 and 7,000 L/min, operating three shifts per day. These equipment items include well pumps, storage facility, and mobile equipment.

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

Construction labor cost....	42.2%
Construction supply cost...	49.3%
Purchased equipment cost...	8.5%

The total capital cost is $(Y_C) = 7{,}228.804(X)^{0.950}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u> $(Y_L) = 3{,}050.555(X)^{0.950}$

(S) <u>Construction Supply Cost</u> $(Y_S) = 3{,}563.800(X)^{0.950}$

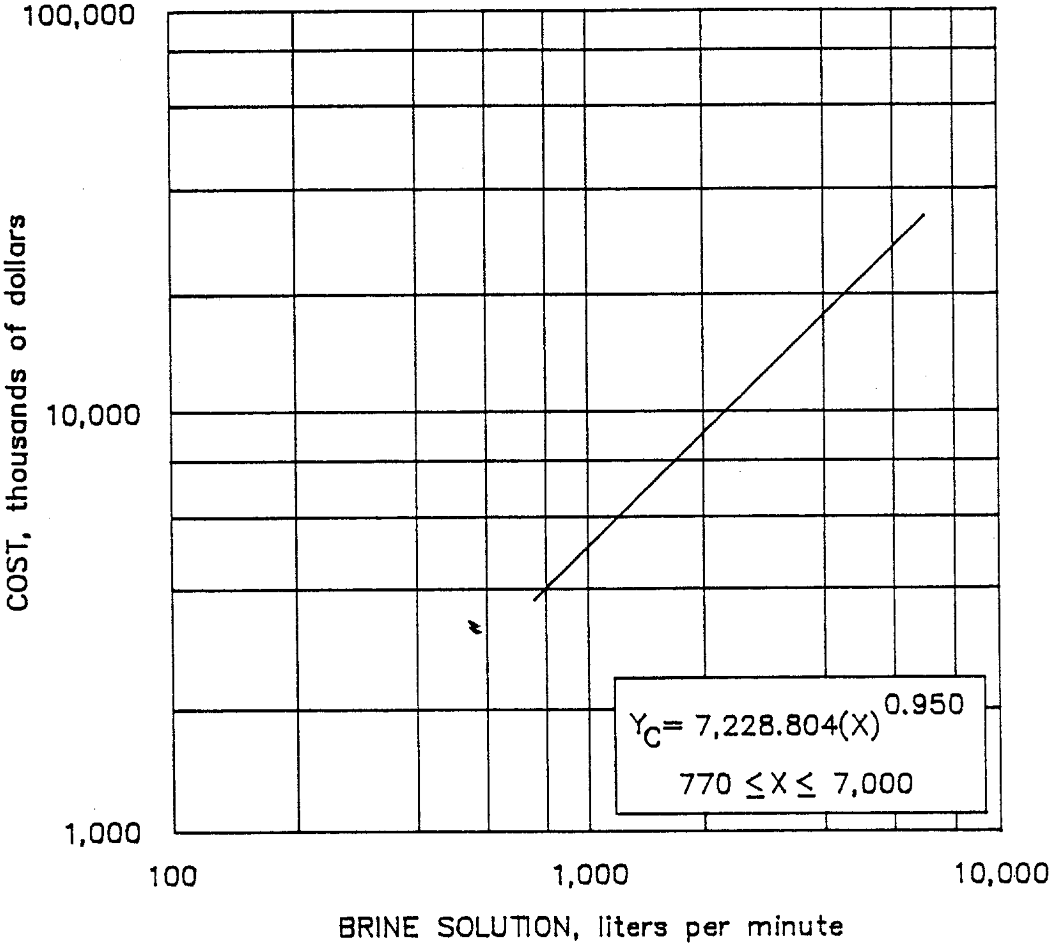
(E) <u>Purchased Equipment Cost</u> $(Y_E) = 614.448(X)^{0.950}$

ADJUSTMENT FACTOR

<u>Well Depth Factor</u> The base curve is premised on an average well depth of 1,400 m. To adjust for a different average depth, multiply the cost obtained from the curve by the following factor:

Well depth factor $(F_D) = 0.02486(D)^{0.510}$
where D = well depth, in meters.

Mineral Processing—Capital Costs



6.1.6.2.3. Brine recovery
MAGNESIUM (WELLS)

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.2.4. BRINE RECOVERY MAGNESIUM/POTASH (LAKES)

The capital cost includes the acquisition and installation of equipment items associated with the brine recovery system.

BASE CURVE

The total capital cost for a magnesium-potash brine recovery system from lakes is based on a single curve having an adjusted feed rate (X), in billions of liters of magnesium-potash lake brine per year. The curve is valid for operations between 50 and 105 billion L, operating three shifts per day. (To convert acre feet to liters, multiply acre feet by 1.23331×10^6. To convert hectare meters to liters, multiply hectare meters by 1×10^7.) The purchased equipment items include pumps, solar evaporation ponds, and mobile and harvesting equipment. The capital cost curve does not include the cost of site preparation for the solar evaporation ponds. The cost for site preparation should be estimated using clearing (section 6.1.8.1.). The area requirement, in hectares, for site preparation for the solar evaporation ponds is calculated using the following equation:

Site preparation area $(A) = 46{,}584.200-[229.253(N)]$
where N = net evaporation rate, in centimeters per year.

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

Construction labor cost....	66.8%
Construction supply cost...	0.4%
Purchased equipment cost...	32.6%
Transportation cost........	0.2%

The total capital cost is $(Y_C) = 281{,}139.945(X)^{0.942}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 187{,}801.483(X)^{0.942}$

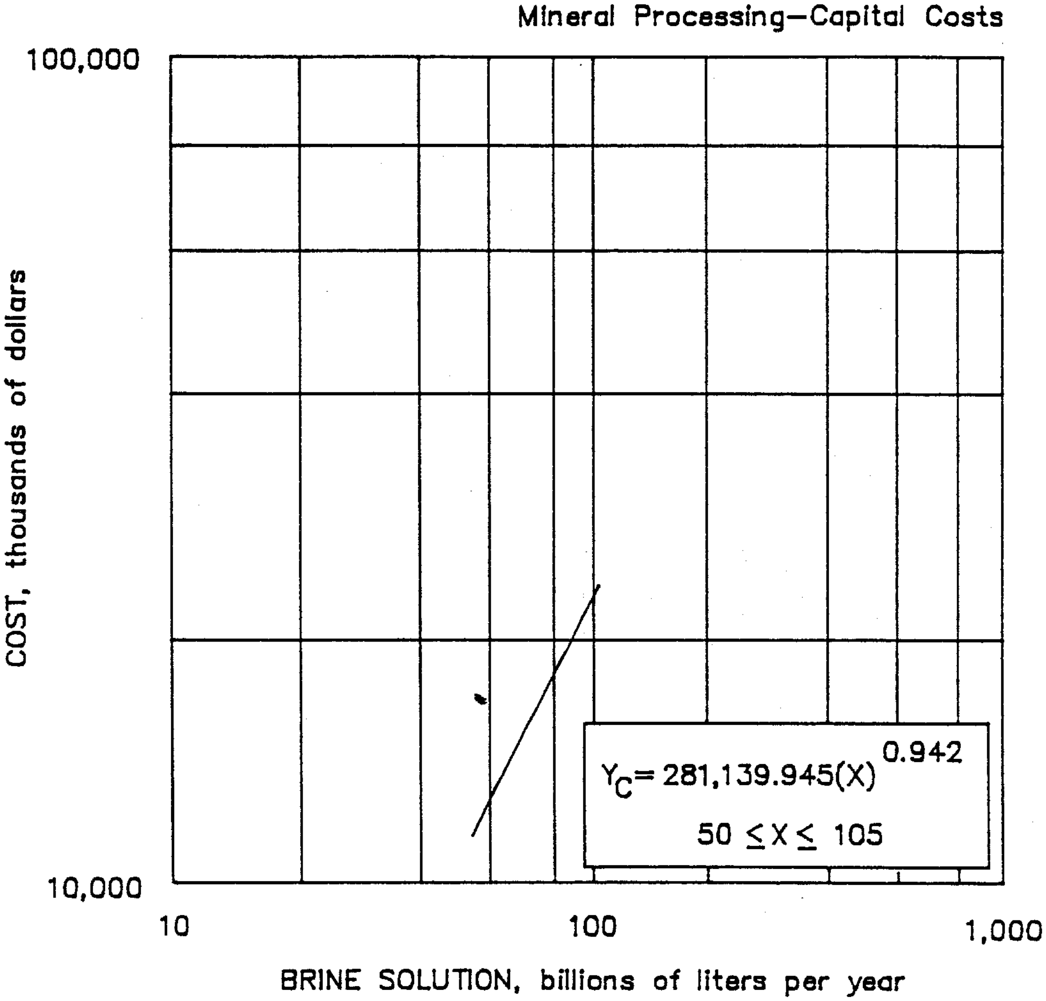
(S) Construction Supply Cost $(Y_S) = 1{,}124.560(X)^{0.942}$

(E) Purchased Equipment Cost $(Y_E) = 92{,}213.902(X)^{0.942}$

ADJUSTMENT FACTOR

Net Evaporation Rate Factor The base curve is premised on a net evaporation rate of 101.6 cm/yr. To adjust for a different net evaporation rate, multiply the cost obtained from the curve by the following factor:

Net evaporation rate factor $(F_E) = 1.676-[0.00665(E)]$
where E = net evaporation rate, in centimeters per year.



6.1.6.2.4. Brine recovery
MAGNESIUM/POTASH (LAKES)

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.2.5. BRINE RECOVERY
POTASH (FLOODED MINE)

The capital cost includes the acquisition and installation of equipment items associated with the brine recovery system.

BASE CURVE

The total capital cost for a potash brine recovery system from flooded mine workings is based on a single curve having an adjusted feed rate (X), in liters of potash-bearing brine per minute. The curve is valid for operations between 3,200 and 13,000 L of brine solution, operating three shifts per day. The equipment items include pumps, storage tanks, evaporation ponds, harvesting equipment, mobile equipment, and slurry tanks. The capital cost curve does not include the cost of site preparation for the solar evaporation ponds. The cost for site preparation should be estimated using clearing (section 6.1.8.1.), and the area requirement, in hectares, for site preparation is calculated using the following equation:

Site preparation area (A) = $1{,}976-[9.724(N)]$
where N = net evaporation rate, in centimeters per year.

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

Construction labor cost....	19.4%
Construction supply cost...	69.3%
Purchased equipment cost...	11.2%
Transportation cost........	0.1%

The total capital cost is $(Y_C) = 2{,}117.440(X)^{0.969}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 410.783(X)^{0.969}$

(S) Construction Supply Cost $(Y_S) = 1{,}467.386(X)^{0.969}$

(E) Purchased Equipment Cost $(Y_E) = 239.271(X)^{0.969}$

ADJUSTMENT FACTORS

Pumping Head Factor The base curve is premised on an average pumping head of 244 m. To adjust for a different average pump head, multiply the cost obtained from the curve by the following factor:

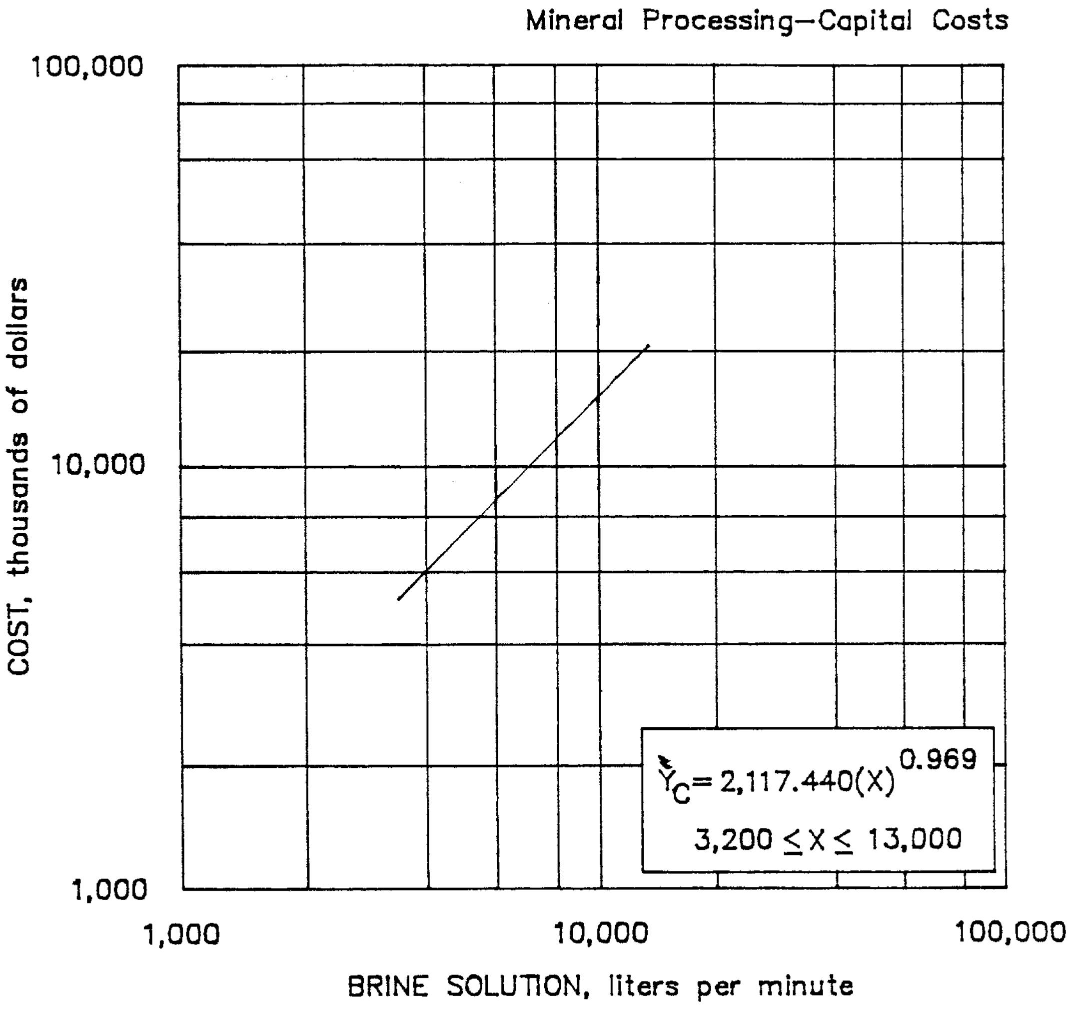
Pumping head factor $(F_H) = 0.0000172(H)+0.996$
where H = pumping head, in meters.

Net Evaporation Rate Factor The base curve is premised on a net evaporation rate of 101.6 cm/yr. To adjust for a different net evaporation rate, multiply the cost obtained from the curve by the following factor:

Net evaporation rate factor $(F_E) = 1.803-[0.0079(E)]$
where E = net evaporation rate, in centimeters per year.

Evaporation Pond Liner Factor The base curve is premised on the installation of a synthetic liner in the solar evaporation ponds. To adjust for no synthetic liner in the solar evaporation ponds, multiply the cost obtained from the curve by the following factor:

Evaporation pond liner factor $(F_L) = 0.206$



6.1.6.2.5. Brine recovery
POTASH (FLOODED MINE)

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.3. CALCINATION (ROTARY KILN)

Capital costs for rotary-kiln operations are for the acquisition and installation of equipment for calcining (or applying high heat to) limestone or other ores or materials, using appropriate adjustment factors. This section starts with conveyance of the crushed limestone or other feed material to the kiln, includes calcination using coal as fuel, and ends after conveyance from the kiln. A special section is included for estimating the cost of storage and load-out of the product. The total capital cost is based on a single curve having an adjusted feed rate (X), in metric tons per day. The curve is valid for operations between 100 and 6,000 mtpd, operating three shifts per day.

BASE CURVE

Major items of equipment are rotary refractory-lined kilns, product cooler, stone and coal weigh belts, coal ball mill, burner, fans, fabric dust collector, belt and screw conveyors, steel storage bins (dust and coal), and coal handling equipment.

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

Construction labor cost......	44%
Construction supply cost.....	22%
Purchased equipment cost.....	34%

The capital cost consists of the following typical range of equipment costs:

	Small (100 to 750 mtpd)	Large (750 to 6,000 mtpd)
Kilns (and related equipment).....	83%	92%
Conveyors and elevators..........	5%	2%
Storage bins.....................	10%	5%
Front-end loader.................	2%	1%

The total capital cost is $(Y_C) = 95{,}349.610(X)^{0.759}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 41{,}953.828(X)^{0.759}$

(S) Construction Supply Cost $(Y_S) = 20{,}976.914(X)^{0.759}$

(E) Purchased Equipment Cost $(Y_E) = 32{,}418.868(X)^{0.759}$

ADJUSTMENT FACTORS

Shift Factor The curve is based on a three shift per day operation. Because it would be impractical to operate less than 24 hours per day (due to the large heat losses connected with starting up and shutting down), no shift adjustment factors should be used.

Fuel Factor If natural gas is used as a fuel instead of coal, multiply the cost obtained from the curve by the following factor:

Fuel factor $(F_{F\ \mathrm{NATURAL\ GAS}}) = 0.949$

If fuel oil is used instead of coal, multiply the cost obtained from the curve by the following factor:

Fuel factor $(F_{F\ \mathrm{FUEL\ OIL}}) = 0.969$

Length-to-Diameter Factor To adjust the capital cost for kiln length-to-diameter (L/D) ratios different than 32, multiply the cost obtained from the curve by the following factor (see the ratio, length-diameter, column of the following tabulation for ratios for various commodities):

Length-to-diameter factor $(F_{L/D}) = 0.696(L/D)^{0.104}$

STORAGE AND LOAD-OUT OF PRODUCT

The capital cost for storage and load-out of the product from the kilns includes the acquisition and installation of equipment to receive, store, and load-out the product. The total cost is based on a single curve having a product storage, load-out rate (X), in metric tons per day. The curve is valid for operations between 100 and 6,000 mtpd, operating three shifts per day.

Major items include belt conveyors, bucket elevators, vibrating screens, product crushers, and steel storage bins. The costs are distributed as follows:

Construction labor cost......	22%
Construction supply cost.....	11%
Purchased equipment cost.....	67%

The capital cost consists of the following typical range of equipment costs:

Conveyors (belt).......	10%
Elevators (bucket).....	2%
Screens................	1%
Crushers (hammermill)..	4%
Bins (steel)...........	83%

The total capital cost is $(Y_C) = 147{,}957.493(X)^{0.368}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 32{,}550.649(X)^{0.368}$

(S) Construction Supply Cost $(Y_S) = 16{,}275.324(X)^{0.368}$

(E) Purchased Equipment Cost $(Y_E) = 99{,}131.520(X)^{0.368}$

Rotary kiln calcination - Feed and product characteristics and cost factors

Product and feed or reaction	Normal moisture in feed, %	Fuel rate[1] Btu/mt product	Fuel cost multiplier[2]	Length diameter ratio[3] (L/D)	Specific gravity[4]
Lime (CaO): Limestone......................	0- 3	7.44	1.00	32	1.18
Lime, magnesia: Dolomite....................	0- 3	7.55	1.01	35	1.18
Alumina: Aluminum hydroxide.................	15	5.40	0.73	30	1.04
Light weight aggregate: Clay, shale.........	3- 7	2.54	0.34	18	0.56
Petroleum coke: Burn off volatiles..........	6-14	1.65	0.22	20	0.69
Clay: Evaporate H_2O and densifier...........	0-24	5.62	0.76	24	0.85
Periclase: Brucite, magnesiz................	50	12.68	1.70	30	1.93
Phosphate:					
Nodulize..................................	15-30	3.31	0.44	22	1.28
Calcine $CaCO_3$.............................	0- 1	4.32	0.58	36	1.28
Burn off carbonaceous material.............	10-15	2.04	0.27	20	1.28
Diatomaceous earth: Burn off carbonaceous material.........................	0- 5	4.8	0.63	15	0.52
Manganese oxide: Manganese carbonate........	3-10	4.5	0.60	28	1.90

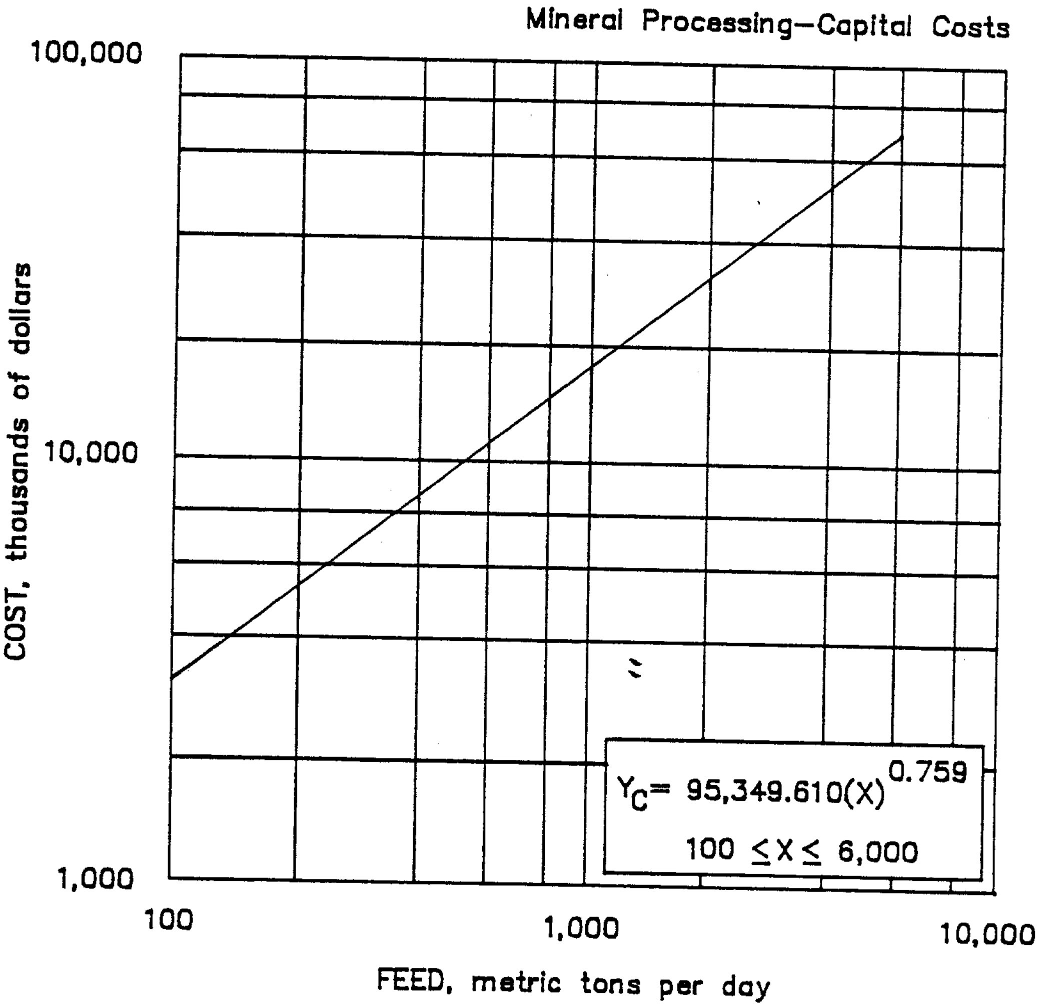
[1] Lime value is from kiln manufacturer; others are averages from Engineering and Mining Journal, June 1980, page 139.

[2] To determine cost of coal burned to calcine a particular material, multiply the fuel portion of the supplies curve by the appropriate multiplier.

[3] Averages for kiln: from Engineering and Mining Journal, June 1980, page 139.

[4] Approximate average values (bulk form, i.e., including voids) of materials during processing in the kiln; values from various sources: KVS Handbook, Perry's Engineering Manual, CRC Handbook.

NOTE.—No sulfides are considered because: 1) sulfides are not usually roasted in a rotary kiln (multiple-hearth vertical furnaces are frequently used), 2) the varying amounts of sulfur (oxidation of which is exothermic) would make fuel adjustment factors cumbersome, and 3) a flue gas scrubber (with lime addition) is probably necessary to meet environmental requirements (unless the SO_2 is used for acid manufacturing, which is not infrequently the case).



6.1.6.3. Calcination (rotary kiln)

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.4. CALCINING (DEAD-BURN MAGNESIUM)

The capital cost for calcining is for the acquisition and installation of equipment needed to process dead-burned dolomite. The calcining circuit consists of kilns, coolers, scrubbers, and related equipment such as conveyors.

BASE CURVE

The total cost is based on a single cost curve having a capacity rate (X), in metric tons of feed material to the kiln per day. The curve is valid for capacities between 60 and 910 mtpd, operating on a continuous basis. The curve includes all costs associated with the acquisition and installation of the calcining circuit.

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

Construction labor cost....	12.3%
Construction supply cost...	1.9%
Purchased equipment cost...	81.5%
Transportation cost........	4.3%

The total capital cost is $(Y_C) = 88{,}034.896(X)^{0.728}$ and is distributed as follows:

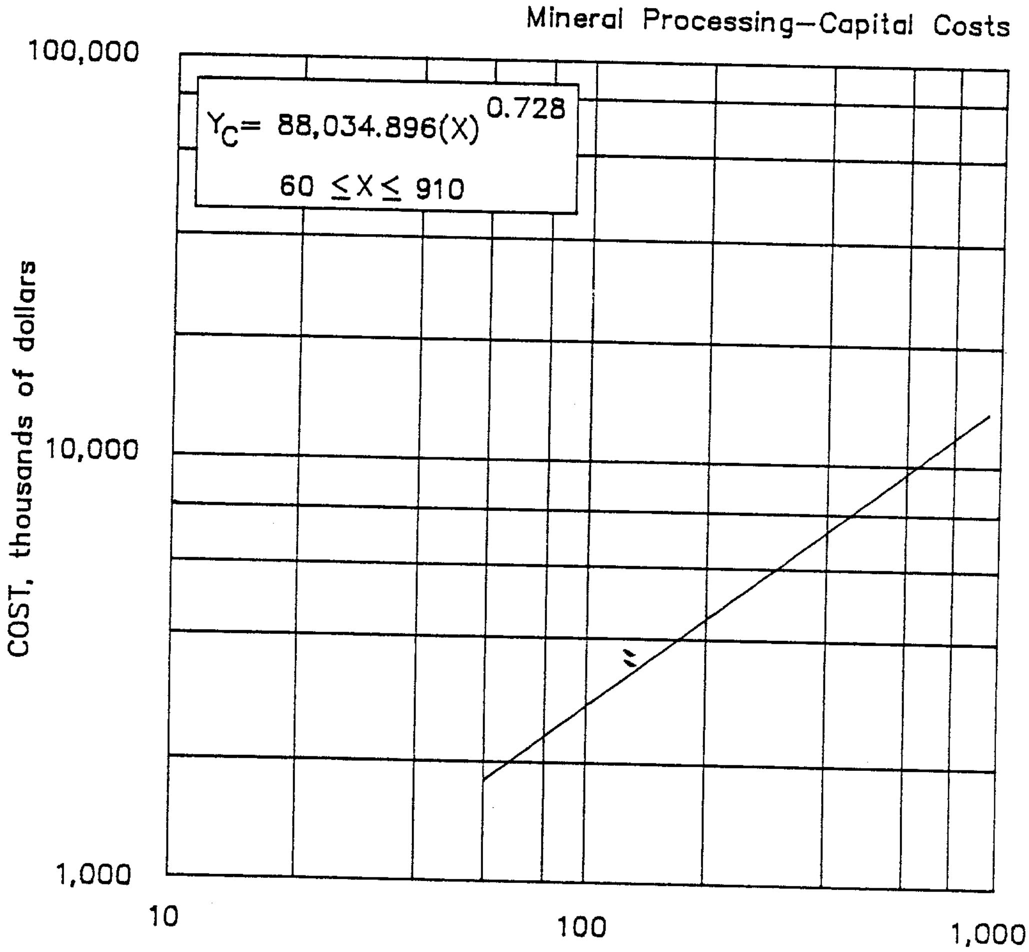
(L) Construction Labor Cost $(Y_L) = 10{,}828.292(X)^{0.728}$

(S) Construction Supply Cost $(Y_S) = 1{,}672.663(X)^{0.728}$

(E) Purchased Equipment Cost $(Y_E) = 75{,}533.941(X)^{0.728}$

ADJUSTMENT FACTOR

Shift Factor The base curve is premised on a three-shift-per-day operation. Based on industry practice, it is desirable to operate a calcining operation for dead-burn magnesium on a continuous basis. Therefore, no adjustment factor for the number of operating shifts is recommended.



6.1.6.4. Calcining (deadburned magnesium)

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.5. COMPACTION

The capital cost for compaction is for the acquisition and installation of equipment needed to compact potash crystals to a final product. The compaction circuit includes impactors, screw conveyors, belt conveyors, bucket elevators, screens, and impactors. The total capital cost is based on a single curve having an adjusted feed rate (X), in metric tons of final compacted product per day. The curve is valid for operations between 220 and 3,150 mtpd, operating three shifts per day.

BASE CURVE

The base curve is predicated on processing potash crystals to a final product. The base curve assumes that 50% of the compactor feed will report as final product. The remaining feed recycles back to the compactor as fines.

The total cost includes the costs associated with the acquisition and installation of the screw conveyors, compactors, screens and impactors.

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

Installation labor cost......	3.0%
Installation materials cost..	4.6%
Purchased equipment cost.....	91.8%
Transportation cost..........	0.6%

The total compaction capital cost is $(Y_C) = 6{,}954.771(X)^{0.837}$ and is distributed as follows:

(L) Installation Labor Cost $(Y_L) = 208.643(X)^{0.837}$

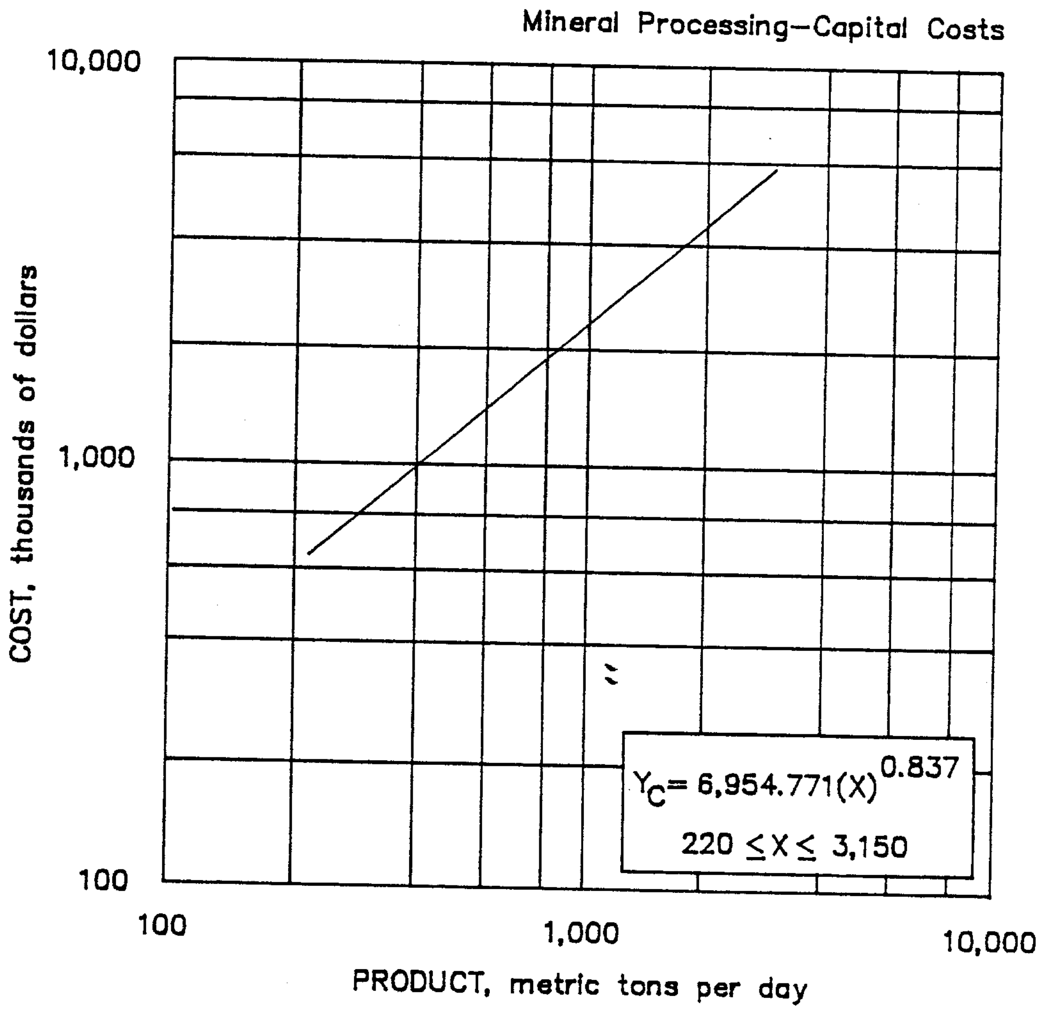
(S) Installation Materials Cost $(Y_S) = 319.919(X)^{0.837}$

(E) Purchased Equipment Cost $(Y_E) = 6{,}426.208(X)^{0.837}$

ADJUSTMENT FACTORS

Compactor Feed Product Factor The dominant factor in compaction is the percent of compactor feed which reports as final product. The base curve is predicated on 50% of the compactor feed reporting as final product. The normal range of this vari- able is 25% to 75% of the feed reporting as product. To adjust for varying quan- tities of product in the compactor feed, multiply the cost obtained from the curve by the following factor:

Compactor feed product factor $(F_P) = 0.967[50/(P)]^{0.831}$
where P = feed reporting as product, in percent.



6.1.6.5. Compaction

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.6. CRYSTALLIZATION

The capital cost includes the acquisition and installation of equipment items associated with the crystallization circuit for potash. Major equipment items include dissolving (leaching) tanks, hot thickener, pumps, crystallizers, cyclones, heat exchangers, and centrifuges. The total capital cost for the potash crystallization circuit is based on a single curve having an adjusted feed rate (X), in metric tons of crystallized product per day. The curve is valid for operations between 50 and 4,350 mtpd, operating three shifts per day.

BASE CURVE

The curve includes all costs associated with the acquisition and installation of the purchased equipment items.

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

Construction labor cost....	2.6%
Construction supply cost...	17.8%
Purchased equipment cost...	78.5%
Transportation cost........	1.1%

The total capital cost is $(Y_C) = 56{,}341.633(X)^{0.655}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 1{,}464.882(X)^{0.655}$

(S) Construction Supply Cost $(Y_S) = 10{,}028.811(X)^{0.655}$

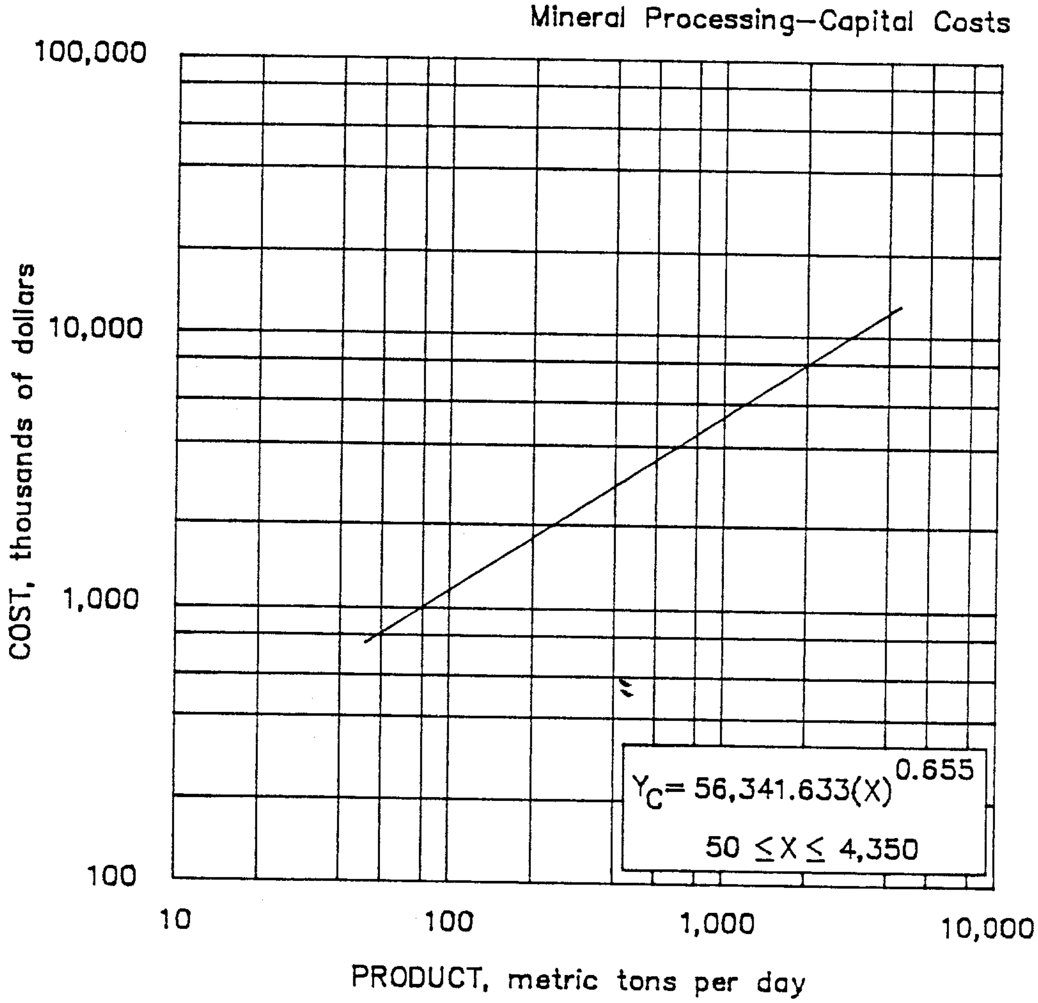
(E) Purchased Equipment Cost $(Y_E) = 44{,}847.940(X)^{0.655}$

ADJUSTMENT FACTORS

Shift Factor The capital cost curve is based on a three shift per day operation. The operating schedule for the crystallization circuit is a function of the previous operating circuits (crushing, grinding, flotation, etc.). Typically, these circuits in the potash industry are operated on a continuous basis. Accordingly, no adjustment factor for a one- or two-shift operation is recommended.

Leaching Factor The base curve is premised on feed sources from effluents, baghouses, and dust collectors to the crystallizer circuit for the recovery of crystallized potash. To adjust for the leaching of tailings or ore, multiply the cost obtained from the curve by the following factor:

Leaching factor $(F_L) = 1.46$



6.1.6.6. Crystallization

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.7. FRASCH PROCESS

The capital cost includes the acquisition and installation of equipment items associated with the Frasch process. Major equipment items include the sulfur wells, mine water heaters, hot process water softeners, air compressors, reagent handling system, sulfur relay stations, storage tanks, sulfur loading facilities, and pumps. The total capital cost is based on a single cost curve having an adjusted feed rate (X), in metric tons of sulfur per day. The curve is valid for operations between 1,150 and 7,900 mtpd, operating three shifts per day.

BASE CURVE

The total capital cost is based on a single curve at an adjusted feed rate (X) for the acquisition and installation of the purchased equipment items.

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

Construction labor cost......	25.6%
Construction supply cost.....	39.3%
Purchased equipment cost.....	34.7%
Transportation cost..........	0.4%

The total Frasch process capital cost is $(Y_C) = 24{,}851.517(X)^{0.991}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 6{,}361.988(X)^{0.991}$

(S) Construction Supply Cost $(Y_S) = 9{,}766.646(X)^{0.991}$

(E) Purchased Equipment Cost $(Y_E) = 8{,}722.882(X)^{0.991}$

ADJUSTMENT FACTOR

Shift Factor The base curve is based on a three-shift-per-day operation. Frasch process is typically operated on a continuous basis to maintain a steady production rate of molten sulfur. Therefore, no adjustment factor for a one or two-shift operation is recommended for Frasch processing.

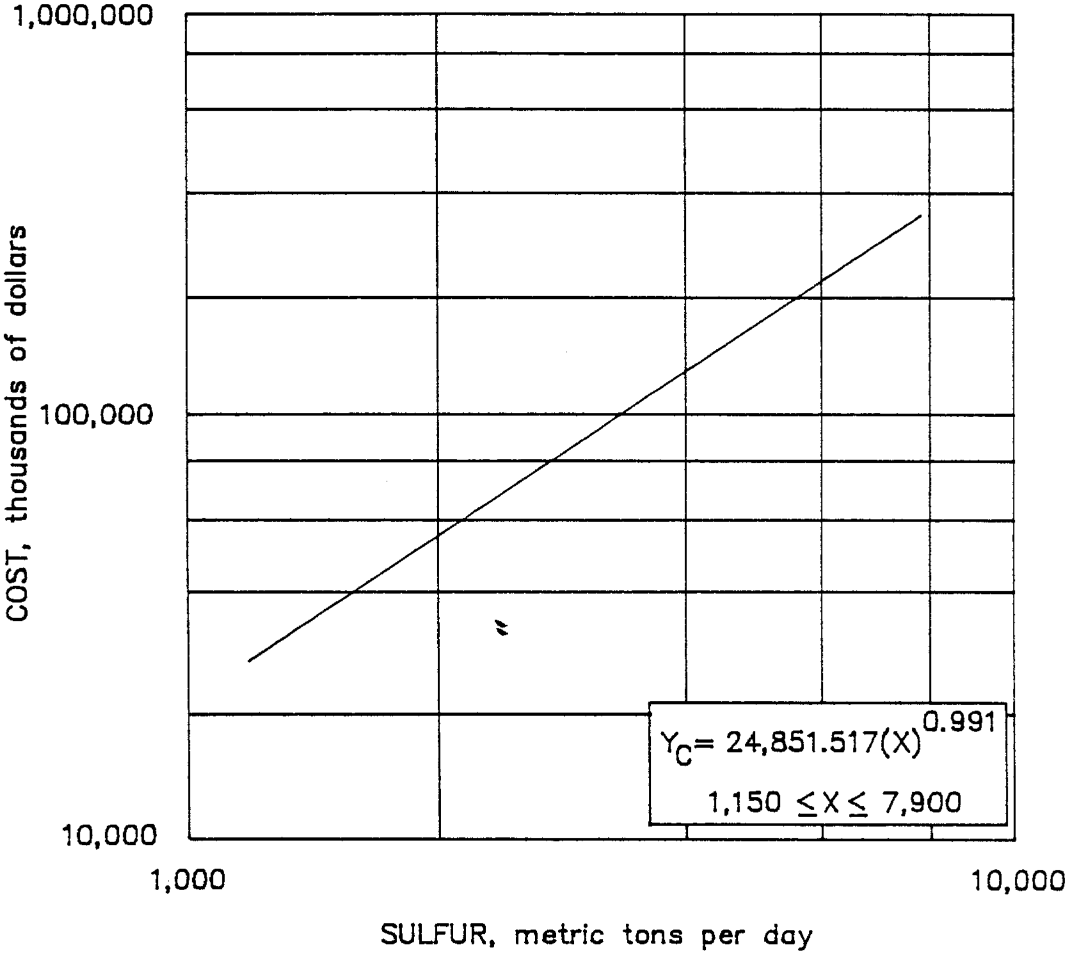
Water-Sulfur Ratio Factor The base curve is based on a water-sulfur ratio of 3,000 gal of water per metric ton of sulfur produced. To adjust the base curve for other ratios, the multiply the cost obtained from the curve by the following factor:

Water-sulfur ratio factor $(F_R) = 0.00652(R)^{0.629}$

where R = water-sulfur ratio, in gallons of water per metric ton of sulfur produced, (to convert liters to gallons multiply liters by 0.2642).

Water Quality Factor The curve is based on a raw water quality as total hardness of 100 mg of $CaCO_3$ per milliliter. To adjust the base curve for other water qualities, the multiply the cost obtained from the curve by the following factor:

Water quality factor $(F_W) = 0.975(W)^{0.0056}$
where W = water quality as total hardness of $CaCO_3$, in milligrams per milliliter.



6.1.6.7. Frasch process

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.8. HANDSORTING

The handsorting capital cost is for acquisition and installation of auxiliary equipment for sorting ore by hand.

BASE CURVE

The total capital cost is based on a single cost curve having an adjusted feed rate to the picking belt (X), in metric tons material sorted per day. The curve is valid for operations between 40 and 2,000 mtpd, operating one shift per day. Costs as- sociated with acquisition and installation of the sorting surface may include tables, fixed chutes and grizzlies, belt conveyors, pan conveyors, revolving tables, or shaking surfaces. The costs in this section are based on belt conveyors as the sorting surface.

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

Construction labor cost......	14%
Construction supply cost.....	15%
Purchased equipment cost.....	68%
Transportation cost..........	3%

The capital cost consists of the following typical range of major equipment costs:

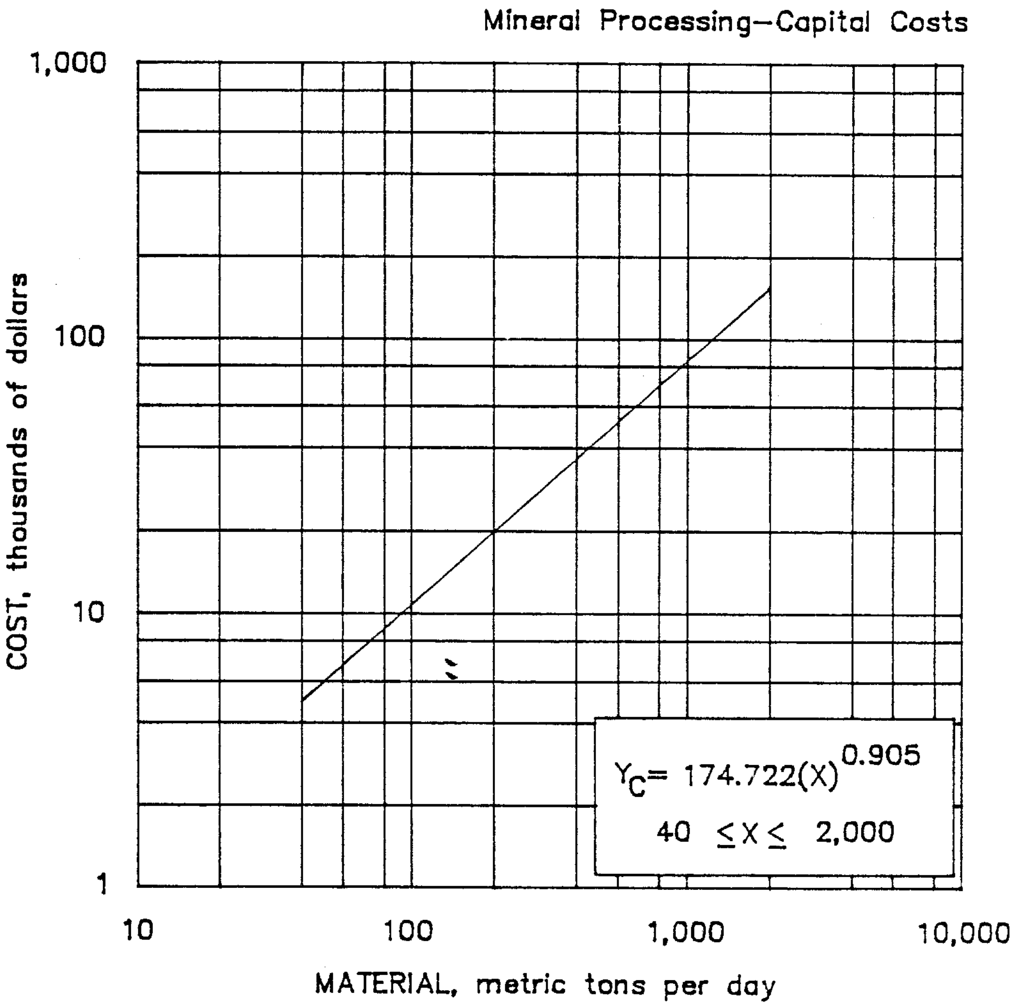
Belt conveyors.............	100%

The total capital cost is $(Y_C) = 174.722(X)^{0.905}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u> $(Y_L) = 24.461(X)^{0.905}$

(S) <u>Construction Supply Cost</u> $(Y_S) = 26.208(X)^{0.905}$

(E) <u>Purchased Equipment Cost</u> $(Y_E) = 124.053(X)^{0.905}$



6.1.6.8. Handsorting

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.9. LIME SLAKING

The capital cost for lime slaking is for the acquisition and installation of equipment needed to process pebble lime to a lime slurry. The lime slaking circuit includes dry storage, ball-mill slaking, cyclone classification, and slurry storage. The circuit can process pebble lime with a maximum size of 3 in delivered by bottom-dump truck.

BASE CURVE

The total cost is based on a single cost curve having a feed rate (X), in metric tons lime per shift. The curve is valid for operations between 20 and 125 mt/shift, operating one shift per day. The curve includes all costs associated with the acquisition and installation of the necessary bins, tanks, sumps, pumps, conveyors, and ball mill.

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

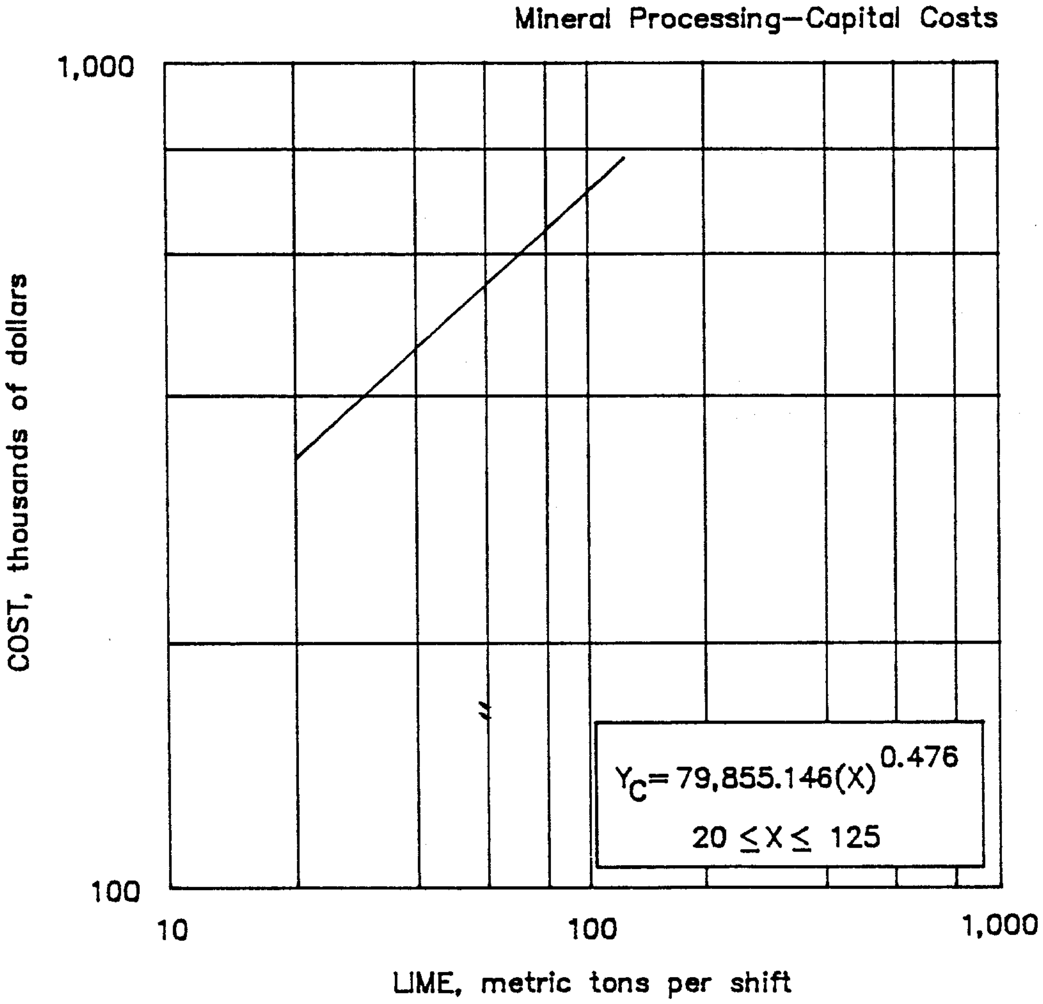
Construction labor cost....	23.4%
Construction supply cost...	25.0%
Purchased equipment cost...	51.0%
Transportation cost........	0.6%

The total capital cost is $(Y_C) = 79{,}855.146(X)^{0.476}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 19{,}165.235(X)^{0.476}$

(S) Construction Supply Cost $(Y_S) = 19{,}963.787(X)^{0.476}$

(E) Purchased Equipment Cost $(Y_E) = 40{,}726.124(X)^{0.476}$



6.1.6.9. Lime slaking

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.10.1. MERCURY APPLICATIONS
MERCURY CONDENSERS

The capital cost for mercury condensers is for the acquisition and installation of equipment needed to process furnace gases from primary mercury operations for the recovery of mercury or retort gases from gold-silver operations for the removal of mercury. The mercury condenser circuit consists of the condenser tubes or pipes and pollution equipment including scrubbers, fan, pumps, and exhaust stack.

BASE CURVE

The total cost is based on a single cost curve having a capacity rate (X), in metric tons of feed material to the furnace per day. The curve is valid for operations between 0.15 and 115 mtpd. For small operations (0.15 to 7 mtpd), the mercury condenser is normally operated on a one batch per day cycle. For large operations (7 to 115 mtpd), the operation is assumed to be on a continuous basis. The curve includes all costs associated with the acquisition and installation of the mercury condenser circuit.

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

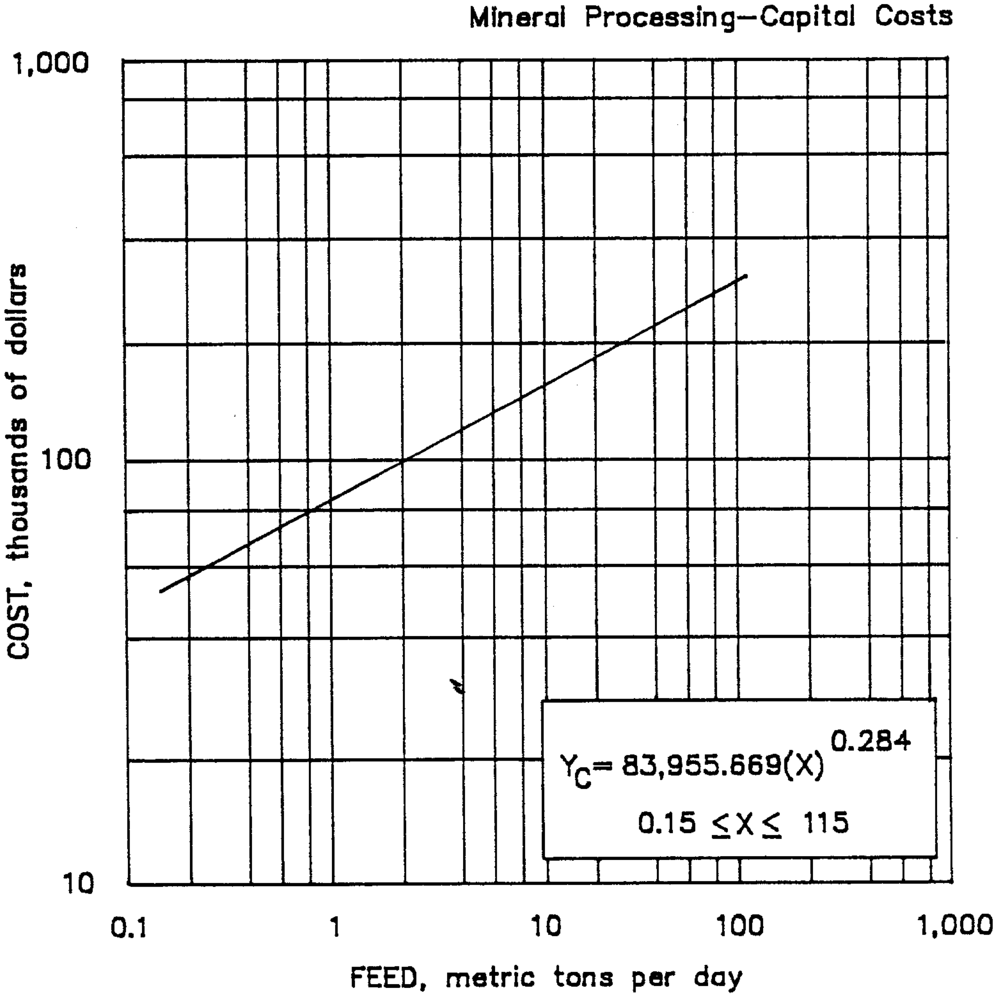
Construction labor cost....	2.2%
Construction supply cost...	1.8%
Purchased equipment cost...	96.0%

The total capital cost is $(Y_C) = 83{,}955.669(X)^{0.284}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u> $(Y_L) = 1{,}847.025(X)^{0.284}$

(S) <u>Construction Supply Cost</u> $(Y_S) = 1{,}511.202(X)^{0.284}$

(E) <u>Purchased Equipment Cost</u> $(Y_E) = 80{,}597.442(X)^{0.284}$



6.1.6.10.1. Mercury applications
MERCURY CONDENSERS

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.10.2. MERCURY APPLICATIONS
MERCURY RETORTS

The capital cost for mercury retorts is for acquisition and installation of equipment needed to process steel-wool cathodes or precipitates from gold-silver operations for the removal of mercury. The mercury retort circuit consists of the mercury retort furnace including the retort, furnace lining, boats, resistance heaters, and controllers.

BASE CURVE

The total cost is based on a single cost curve having a feed rate (X), in kilograms per day. The curve is valid for operations between 40 and 1,100 kg/d, operating on a one-batch-per-day cycle. The curve includes all costs associated with the acquisition and installation of the mercury retort.

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

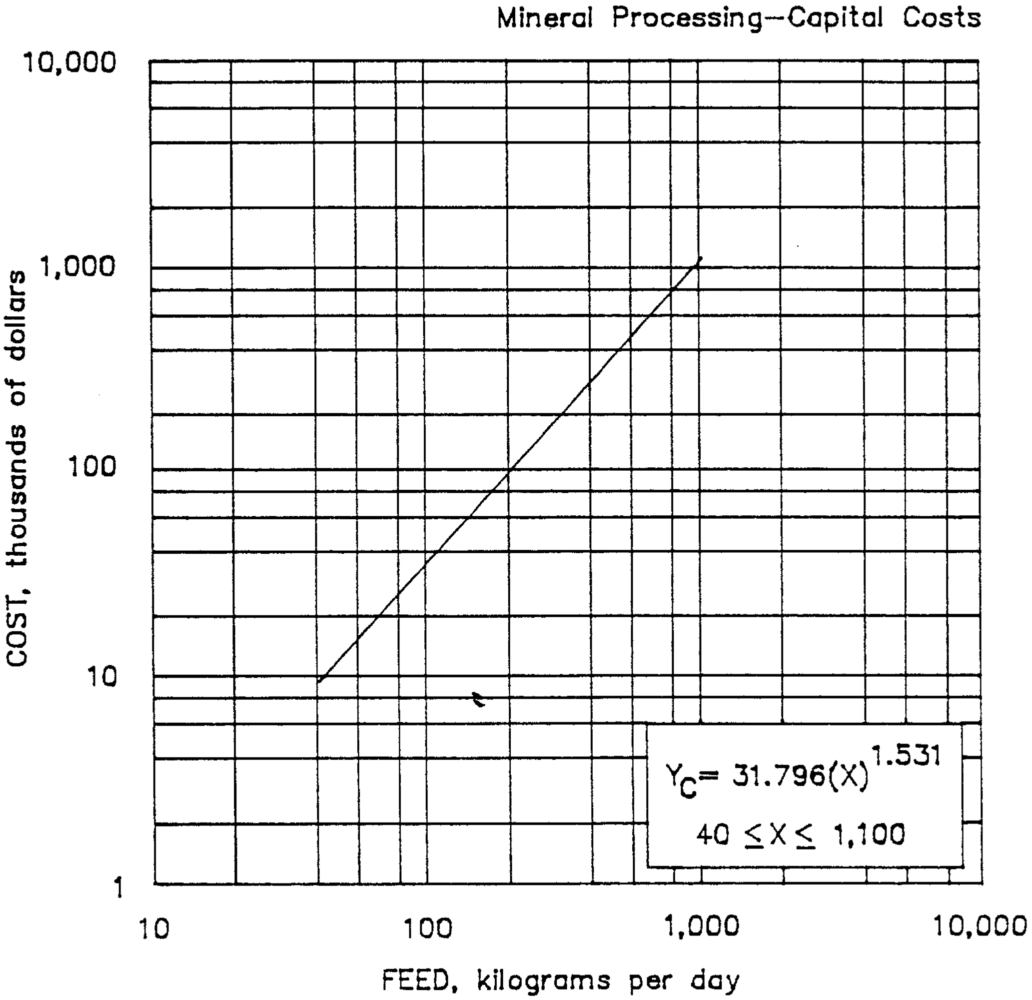
Construction labor cost....	2.3%
Construction supply cost...	11.9%
Purchased equipment cost...	85.8%

The total capital cost is $(Y_C) = 31.796(X)^{1.531}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 0.731(X)^{1.531}$

(S) Construction Supply Cost $(Y_S) = 3.784(X)^{1.531}$

(E) Purchased Equipment Cost $(Y_E) = 27.281(X)^{1.531}$



6.1.6.10.2. Mercury applications
MERCURY RETORTS

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.11. PELLETIZING

The capital cost for pelletizing is for the acquisition and installation of equipment needed to produce pellets from an iron ore concentrate. The pelletizing plant consists of balling drums, induration furnace, and related equipment such as conveyors, mixers, fans, and scrubbers. The base curve is predicated on the pelletizing treatment of an iron concentrate processed from magnetic ore. The pelletizing plant does not include the cost of a filter plant. The total cost is based on a single cost curve having a capacity rate (X), in metric tons of pellets produced per day. The curve is valid for operations between 6,400 and 28,000 mtpd, operating three shifts per day.

BASE CURVE

The base case includes all costs associated with the acquisition and installation of the pelletizing circuit.

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

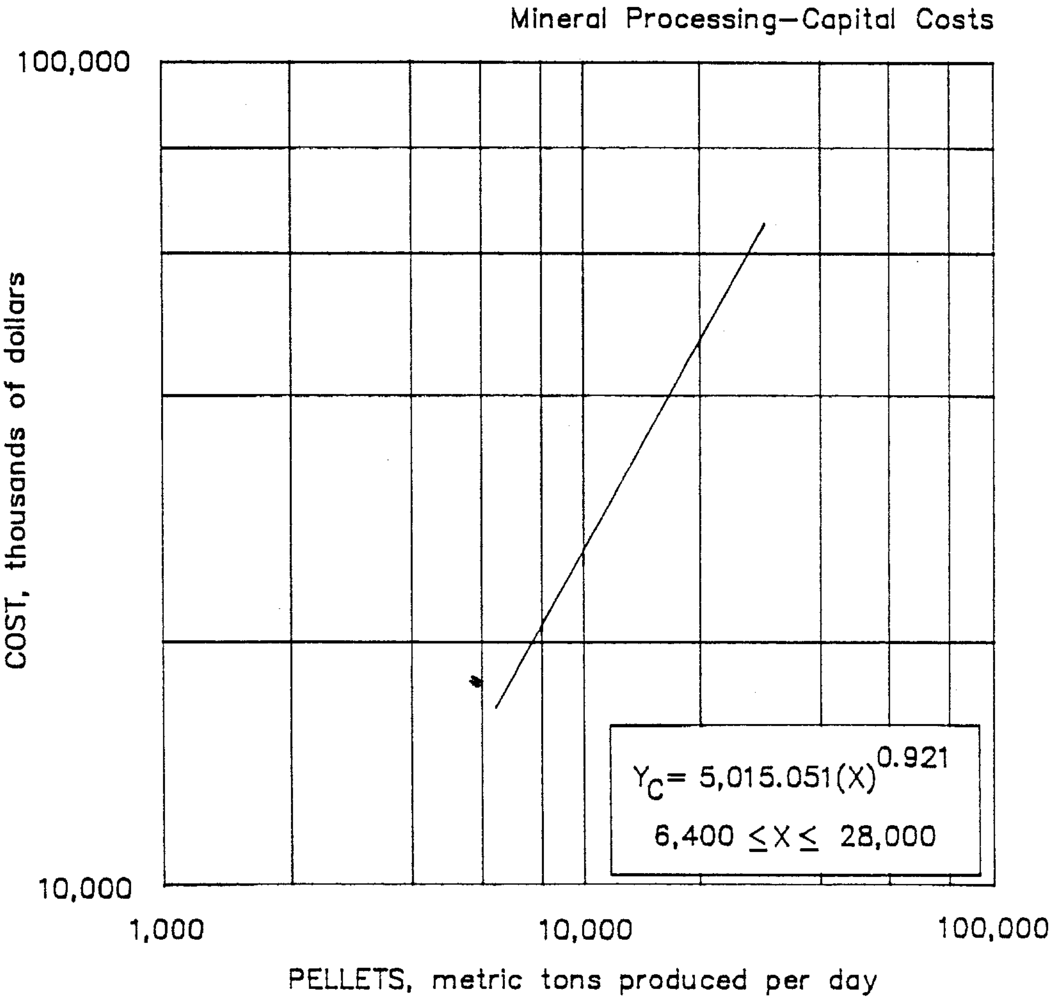
Construction labor cost....	16.5%
Construction supply cost...	5.2%
Purchased equipment cost...	75.7%
Transportation cost........	2.6%

The total capital cost is $(Y_C) = 5{,}015.051(X)^{0.921}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u> $(Y_L) = 827.483(X)^{0.921}$

(S) <u>Construction Supply Cost</u> $(Y_S) = 260.783(X)^{0.921}$

(E) <u>Purchased Equipment Cost</u> $(Y_E) = 3{,}926.785(X)^{0.921}$



6.1.6.11. Pelletizing

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.12.1. WASHING AND SCREENING

The washing and screening capital cost is for acquisition and installation of equipment to wash and screen loosely consolidated ores such as barite. Washing separates the gangue from the ore and screening separates the ore into two or more sizes. The sized ore is then usually processed further by various means. Washing is usually the first step as the ore enters the processing plant. Screening may be combined with crushing and grinding in various combinations depending on plant design, or may be a completely independent operation.

BASE CURVE

The total capital cost is based on a single curve having an adjusted feed rate (X), in metric tons material per day. The curve is valid for operations between 100 and 10,000 mtpd, operating two shifts per day. The curve includes all costs associated with acquisition and installation of trommel screens, log washers, vibrating screens, water guns, and pumps.

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

Installation labor cost.........	3.4%
Installation materials cost.....	10.3%
Purchased equipment cost........	82.2%
Transportation cost.............	4.1%

The capital cost consists of the following typical range of equipment costs:

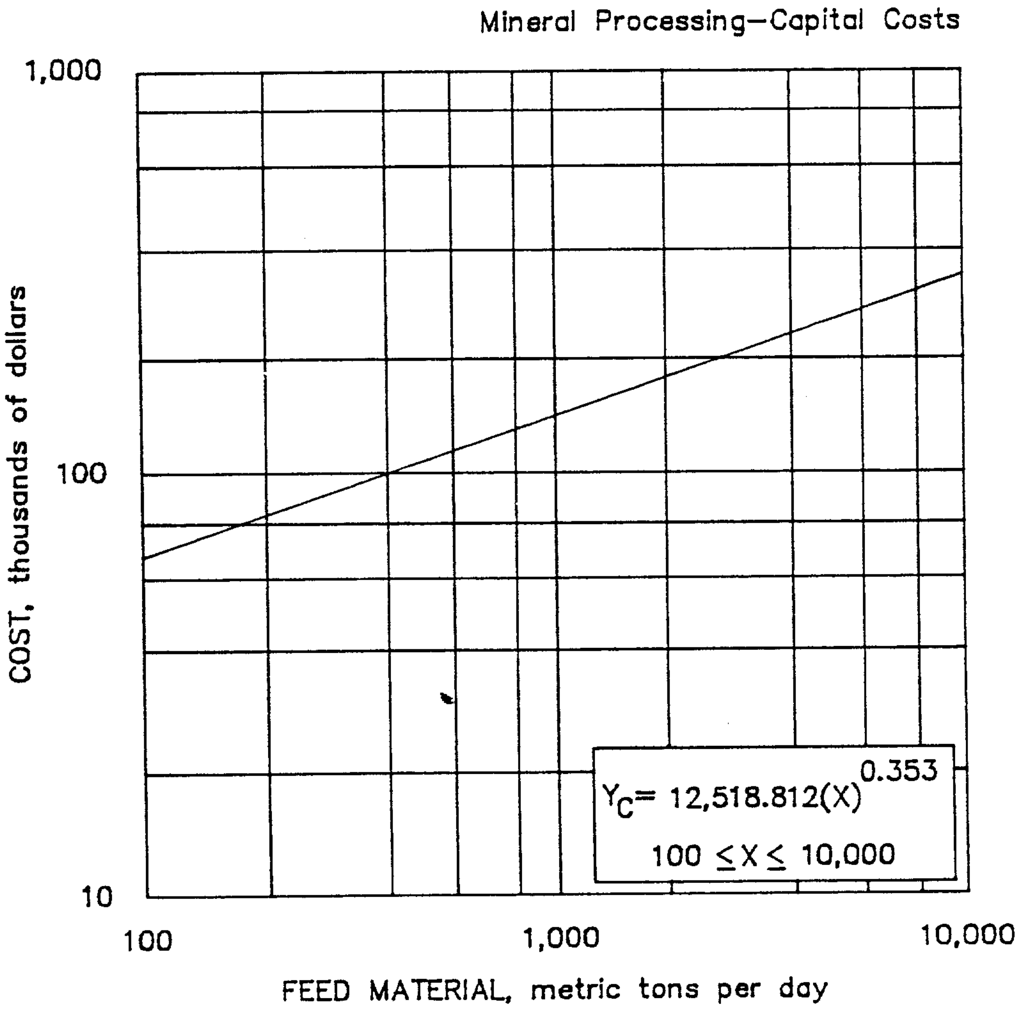
	Small (100 to 2,000 mtpd)	Large (2,000 to 10,000 mtpd)
Pumps..................	10%	9%
Washing equipment......	45%	10%
Screening equipment....	45%	35%
Miscellaneous (hoppers, conveyors, etc.)......	-	46%

The total capital cost is $(Y_C) = 12{,}518.812(X)^{0.353}$ and is distributed as follows:

(L) Installation Labor Cost $(Y_L) = 425.640(X)^{0.353}$

(S) Installation Materials Cost $(Y_S) = 1{,}289.438(X)^{0.353}$

(E) Purchased Equipment Cost $(Y_E) = 10{,}803.735(X)^{0.353}$



6.1.6.12.1. Washing and screening

6.1. MINERAL PROCESSING--CAPITAL COSTS

6.1.6. SPECIAL APPLICATIONS

6.1.6.12.2. WASHING AND SCREENING--PHOSPHATE

The washing and screening capital cost is for acquisition and installation of equipment to wash and screen (including ore feed preparation for flotation) of loosely consolidated phosphate ores. Washing and screening separates the minus 1.91-cm (0.75-in), plus 14- or 16-mesh phosphate material (called pebble concentrate) from the finer material. The finer material containing phosphate is then processed in the feed preparation circuit where the clay fraction is removed from the plus 150-mesh material consisting of phosphate and silica sands. This plus 150-mesh material goes to the flotation circuit.

BASE CURVE

The total capital cost is based on a single curve having an adjusted feed rate (X), in metric tons material per day. The curve is valid for operations between 5,000 and 70,000 mtpd, operating three shifts per day. The curve includes all costs associated with acquisition and installation of trommel screens, hammermills, log washers, flume and vibrating screens, classifiers, and cyclones.

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

Construction labor cost......	35%
Construction supply cost.....	43%
Purchased equipment cost.....	20%
Transportation cost..........	2%

The capital cost consists of the following typical range of equipment costs.

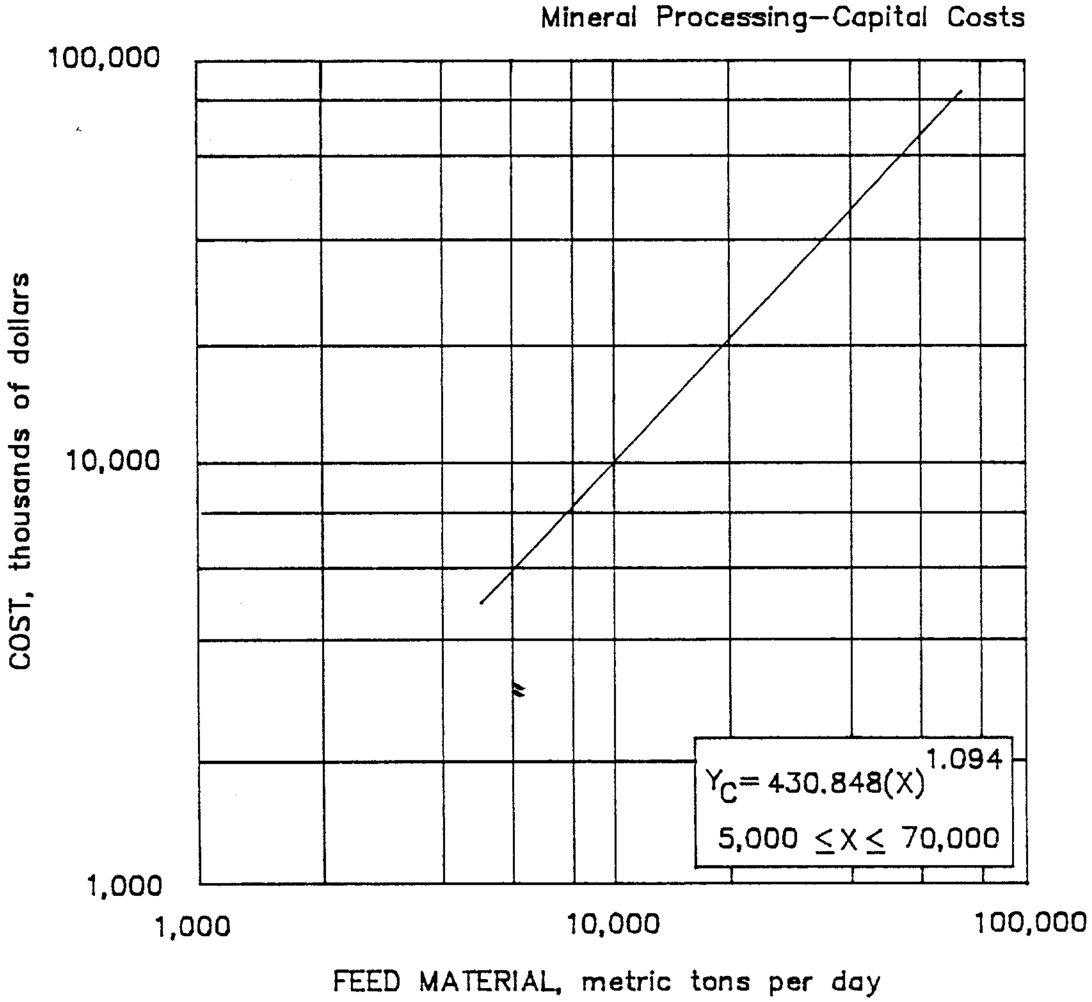
	Small (5,000 to 22,000 mtpd)	Large (22,000 to 70,000 mtpd)
Pumps......................	5%	20%
Trommels and screens........	15%	19%
Washers and classifiers.....	43%	11%
Miscellaneous (conveyor belts, hammermills, etc.).........	37%	50%

The total capital cost is $(Y_C) = 430.848(X)^{1.094}$ and is distributed as follows:

(L) Construction Labor Cost $(Y_L) = 150.797(X)^{1.094}$

(S) Construction Supply Cost $(Y_S) = 185.265(X)^{1.094}$

(E) Purchased Equipment Cost $(Y_E) = 94.786(X)^{1.094}$



6.1.6.12.2. Washing and screening
PHOSPHATE