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**Comparative Porphyry Copper Mining
and Processing Costs—Alaska
and Arizona**



UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 8656

Comparative Porphyry Copper Mining and Processing Costs—Alaska and Arizona

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Juneau, Alaska**



**UNITED STATES DEPARTMENT OF THE INTERIOR
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COMPARATIVE PORPHYRY COPPER MINING AND PROCESSING COSTS—ALASKA AND ARIZONA

by

R. G. Bottge¹

ABSTRACT

To better understand those factors which increase mining costs in Alaska, a Bureau of Mines study was conducted to compare the estimated costs of operating a 100,000-tpd open pit copper mine located on a hypothetical ore body in the Lake Clark area, Alaska, with the costs of mining a similarly sized hypothetical copper ore body near Tucson, Ariz. The information derived should be beneficial to the State and Federal governments in appraising the potential for development of large, low-grade porphyry copper deposits in south-central Alaska. Conventional mining and concentrating methods were assumed, and capital and operating costs were derived using flowsheets and standard costing methods.

The total price required for copper mined in Alaska and Arizona was \$1.12 and \$0.63 per pound, respectively, plus or minus 20 percent. These values were obtained assuming no leaching of low-grade copper, recovery of gold, silver, and molybdenum as byproducts, 100-percent equity financing, and a 12 percent discounted cash flow rate of return. The average domestic and international prices for copper in July 1973 were \$0.60 and \$0.916 per pound, respectively. The existence of a developed transportation and power system in Alaska would have reduced capital and operating costs substantially. The required price for copper would have declined from \$1.12 to \$1.05 per pound, plus or minus 20 percent.

INTRODUCTION

This is the second in a series of publications planned by the Bureau of Mines to show estimates of mining and processing costs for developing various types of mineral deposits in Alaska. These reports are meant to provide State and Federal governments with information to appraise the potential for development of Alaska's mineral deposits. The detailed cost tables may be useful to industry in assessing those factors which raise mining and processing costs in Alaska over those in the 48 contiguous states.

¹Mining engineer.

In this report, two identical porphyry copper ore bodies are assumed to exist--one approximately 10 miles north of Lake Clark in the Alaska Range to the West of Cook Inlet, and one approximately 45 miles northwest of Tucson, Ariz. (fig. 1). Both deposits are assumed to contain 714 million tons of copper ore averaging 0.5 percent copper with associated gold, silver, and molybdenum. Deposits of this type occur throughout Arizona, and the Lake Clark area is considered to be one of high potential for this type of deposit in Alaska (4, 7).²

The Alaska setting for the townsite would be near the north end of Lake Clark. The mine and concentrator would be 12 miles to the north of the townsite. The site is situated in the Alaska Range approximately 145 air miles southwest of Anchorage. No roads lead to the area, but the site is on a proposed highway corridor extending along the west side of Cook Inlet to a point west of West Forelands where it goes inland and down the west side of Lake Clark. The climate at the site is alpine with cool summers and cold winters; precipitation is likely to be about 25 to 30 inches per year. Maximum high temperatures may reach 85 to 90 degrees and the minimum lows would likely be 40 to 45 degrees below zero (5). The probable number of heating degree days is 11,000 to 12,000 (10).

The setting for the Arizona townsite would be approximately 45 miles northwest of Tucson, 10 miles southwest from a present highway system. The climate is desert with maximum daily highs of plus 100 degrees and minimum lows of plus 15 to 20 degrees. Annual precipitation is less than 10 inches (8). The number of heating degree days per year is approximately 2,000 (10).

For this study, the Arizona mine and processing facilities were adopted from a model prepared by the Intermountain Field Operation Center, Denver, Colo., in 1970 and updated to July 1973 (1). The same data was used as the basis for an Alaska model with additional or larger sized equipment added where needed. The capital and operating costs were determined using standard costing techniques. This type of cost estimate, prepared from flowsheets with a minimum of equipment data, can be expected to be within 20 percent of actual costs.

ACKNOWLEDGMENTS

Acknowledgment is made to the Intermountain Field Operation Center, Denver, Colo., for sharing their copper mine and processing models, and to Harold Bennett for his help in clarifying the fine points of those models.

OPERATION DESCRIPTION

Geology and Ore Body

The mine model is based on a currently operating property in Arizona. The deposit consists of several porphyry copper ore bodies in a zone 5 miles

²Underlined numbers in parentheses refer to items in the list of references preceding the appendixes.

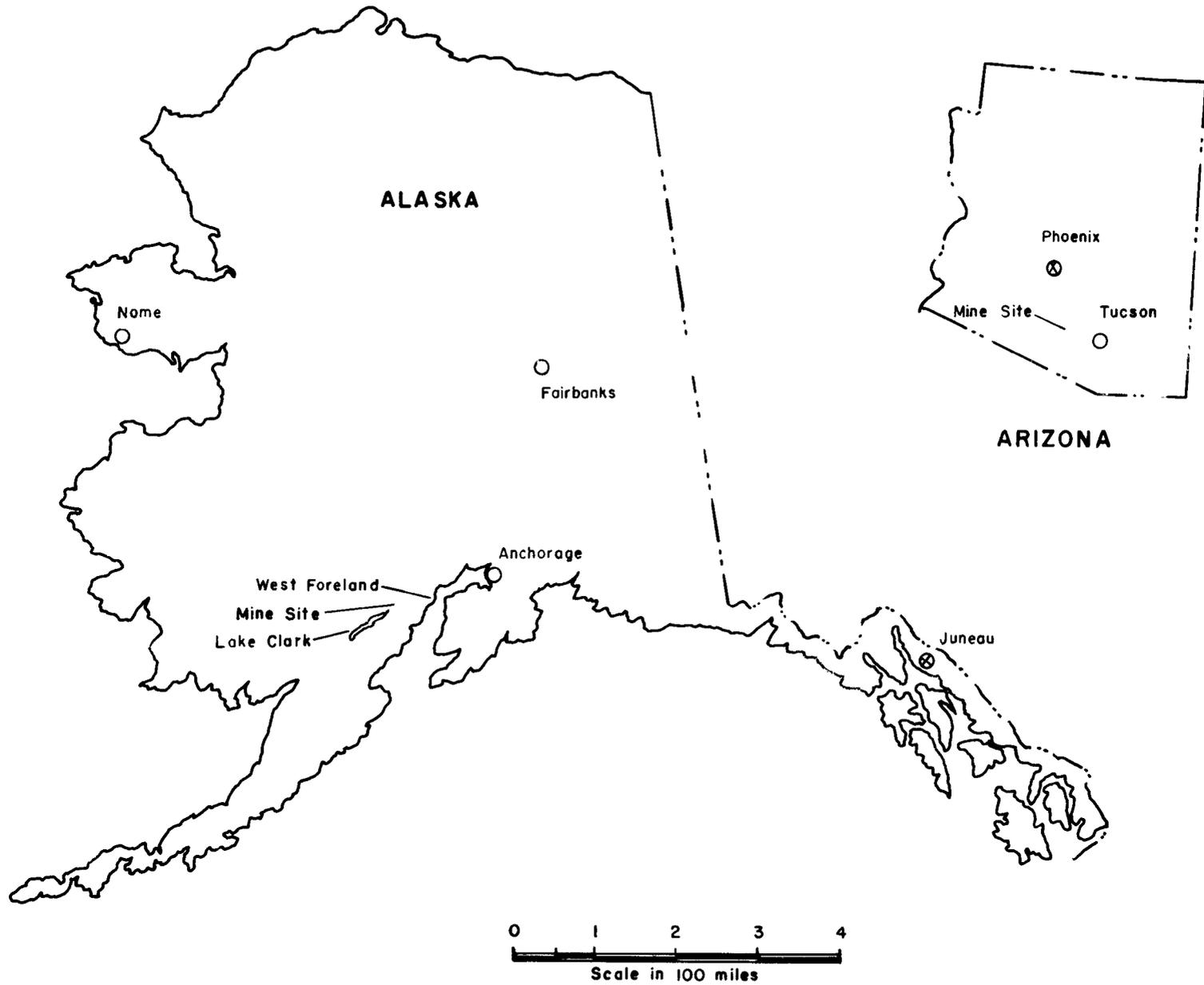


FIGURE 1. - Index maps of Alaska and Arizona.

long and 1 mile wide. Disseminated copper occurs both in monzonite porphyry stocks and in the surrounding sedimentary rocks. Chalcopyrite is the primary copper mineral but chalcocite enrichment also occurs.

Mining

For this report, 100,000 tons of ore and waste are assumed to be mined daily by drilling 9-inch holes at a rate of 430 feet per shift on a 23- by 26-foot spacing for 40-foot benches. Blasting requires an average of 0.17 pounds of ammonium nitrate-fuel oil (AN-FO) per ton of rock broken.

Fifteen-yard shovels load the broken rock into 150-ton trucks at a rate of 10,000 tons per shovel shift. Ore is hauled an average of 7,000 feet from the pit to the mill with a climb of 400 feet. Waste is hauled an average of 10,000 feet with a climb of 300 feet. The average tonnage hauled per truck shift is 3,000.

For the sake of comparison, no leaching facility was included although leaching of the lower grades of copper ore would probably occur at the Arizona facility. The profitability of the Arizona operation would be enhanced over that in Alaska where the ground and climate mitigate against leaching.

The estimated cost to develop the mine near Lake Clark, Alaska, before credits from minerals mined during preproduction stripping was \$50.0 million versus \$35.9 million for a mine near Tucson, Ariz., (table 1). Mobile equipment was 10 percent greater in cost in Alaska owing to transportation charges and erection costs, since most of the large mining equipment must be partially assembled at the mine site. Transportation charges from Seattle, Wash., in general, added from 5 to 10 percent to the factory price of the equipment and erection costs added from zero to 23 percent to the factory price. Erection costs in Arizona were estimated to add from zero to 13 percent to the factory price. Details of the mine are shown in appendixes A and B.

TABLE 1. - Estimated capital requirements for a 100,000-tpd open pit mine, dollars

Item	Alaska	Arizona
Mobile equipment.....	13,705,000	12,371,100
Plant and buildings.....	6,085,500	3,059,600
Property acquisition cost.....	300,000	300,000
Exploration, development and feasibility study.....	4,000,000	3,000,000
Environmental studies and hearings.....	3,000,000	2,250,000
Preproduction stripping, 36 million tons.....	16,200,000	10,080,000
Subtotal.....	43,290,500	31,060,700
Contingencies and interest during construction.....	6,710,000	4,814,400
Total.....	50,000,500	35,875,100

Plant and building costs in Alaska were nearly double those in Arizona, \$6.1 million versus \$3.1 million (table 1). A factor of 1.93 times the Arizona cost was used for all Alaskan buildings. However, the difference between the two localities was reduced by the addition of mechanical and

electrical items which bore only the cost of transportation. This factor was derived by consulting publications which gave comparative building factors for various Alaskan locations and contiguous U.S. cities (3, 9). Since no construction project has been built in the Lake Clark area, the factor chosen may be considerably in error. Additional costs occur in Alaska owing to the need for larger facilities; for example, fuel tanks in Alaska were designed to hold 2 months' supply instead of the 1-month's supply required in Arizona, and the inventory of parts in a remote Alaskan location must be substantially larger than that in Arizona.

The cost for exploration, development, and feasibility and environmental studies was arbitrarily chosen as \$5.25 million for Arizona and \$7.0 million for Alaska. Preproduction costs of \$16.2 million and \$10.1 million for Alaska and Arizona, respectively, were based on operating costs. This one item accounted for nearly 50 percent of the total increase in Alaskan mine capital costs over those in Arizona.

Concentrating

Forty thousand tons of ore were processed each day, 357 days each year. The concentrating followed conventional procedures with primary and secondary crushing, grinding, flotation, and filtering and the waste going to tailings. Details of the flowsheet are given in appendix C.

The total cost of a 40,000-tpd copper concentrator near Lake Clark, Alaska, was slightly more than double the cost of a similar concentrator near Tucson, Ariz. (table 2). Although the cost to construct a building in Alaska was taken at 1.93 times that in Arizona, the addition of the electrical and mechanical equipment lowered the cost differences to an average of 1.73 times Arizona costs, excluding the copper filter and tailings disposal sections which are not comparable between sites. Detailed costs of the concentrator are shown in appendixes A and B.

TABLE 2. - Estimated capital requirements for a 40,000-tpd copper concentrator, dollars

Item	Alaska	Arizona
Crushing section:		
Primary crushing.....	7,799,200	4,444,200
Secondary and tertiary crushing.....	22,556,500	13,250,000
Grinding section.....	55,048,700	31,189,600
Flotation section.....	28,123,900	16,102,600
Byproduct molybdenum recovery section.....	2,875,300	1,643,200
Copper filter section.....	6,483,300	1,079,400
Lime preparation section.....	1,855,900	1,105,600
Tailings disposal section.....	28,015,900	5,402,900
General facilities.....	2,268,000	1,970,700
Subtotal.....	155,026,700	76,188,200
Contingencies and interest during construction.....	23,192,900	11,403,000
Total.....	178,219,600	87,591,200

Modifications in the copper filter and tailings disposal sections in Alaska added substantially to the cost of the concentrator. The Alaskan concentrator required the addition of four 80-inch by 40-foot dryers and related equipment to remove all but 1 percent of the moisture from the filter cake to facilitate shipment to the coast and to the smelter. A higher moisture content would cause the concentrate to freeze in the cars during the winter months. The Alaskan concentrator had two 260-foot by 22-foot and one 300-foot by 26-foot thickener tanks inside the concentrator building where the water could be kept from freezing. In Arizona, the same thickener tanks were outside. Had the copper filter and tailings disposal sections been identical in Alaska and Arizona, the difference in the cost of the two sites would have been about 1.73 times \$7.4 million or \$12.9 million. The larger drying section and the cost to enclose the tailings disposal section added \$26.8 million more to the Alaskan site in addition to the \$12.9 million.

General facilities in Alaska cost only 15 percent more than in Arizona because the repair and service shop was placed inside the mill building and the cost was shared with the support facilities. In Arizona, this item was a separate building charged totally to the mill. No heating plant was installed in either concentrator. In Arizona, the heat given off by the motors and equipment exceeded the heat required at zero degrees by a factor of three to one. Using one air change per hour in Alaska for the concentrator and two air changes per hour for other facilities, 68.6 million Btu's per hour would be required at minus 40 degrees. Heat from the motors and related equipment plus the dryers amounted to 102.0 million Btu's per hour (6). No heat from the generators was considered in these calculations.

Support Facilities

The cost for support facilities in Alaska was \$100.1 million versus \$19.5 million in Arizona (table 3). The reason for the wide disparity was the remote location of the Alaskan plant necessitating construction of power and transportation facilities.

TABLE 3. - Estimated capital requirements for support facilities, dollars

Item	Alaska	Arizona
Electrical generators.....	6,750,000	0
Gas pipeline.....	5,229,000	0
Road.....	1,389,600	1,200,000
Railroad.....	25,979,400	1,000,000
Railroad equipment and related facilities.....	4,164,000	0
Barge dock and related facilities.....	2,407,500	0
General facilities and air strips.....	2,193,400	113,600
Townsite.....	38,567,900	14,560,000
Subtotal.....	86,680,800	16,873,600
Contingencies and interest during construction.....	13,435,500	2,615,400
Total.....	100,116,300	19,489,000

Power for utilities was assumed available in Alaska from the West Forelands natural gas field in Cook Inlet (fig. 1). A 6-inch buried pipeline was deemed sufficient to carry the necessary natural gas to the mine-concentrator-townsite complex. Natural gas was also assumed available in Arizona, with the utility extending service to the operation and townsite.

Electricity in Alaska was generated by two gas turbines of 25 megawatt capacity each. Electricity in Arizona was assumed available from a utility with electrical lines extended by the utility to the operation and townsite.

The townsite in Alaska was located on a proposed transportation corridor running along the west side of Cook Inlet, turning inland near West Forelands and proceeding along the west side of Lake Clark. Twelve miles of roads were required to connect the town with the mine and concentrator. In Arizona, 10 miles of roads were assumed necessary to connect the operation to the present highway system, and an additional 10 miles were required to connect the townsite with the mine and concentrator.

In Alaska, a railroad connected the concentrator to the dock facilities at West Forelands. Electric locomotives pulled 20 50-ton hopper cars from the concentrator to the dock warehouse 5 days each week returning with empty concentrate cars and loaded box, flat, and tank cars. Concentrate was dumped via bottom doors into hoppers, conveyed to an unheated warehouse, and stacked over an underground conveyor.

General cargo barges arrived at the dock facility in Alaska once each month year-round with supplies for the operation. Barges were beached at high tide thus eliminating costly docking facilities. Concentrate was loaded onto barges via a 48-inch covered conveyor passing under the warehouse and fed by a front-end loader and a crawler tractor.

In Arizona, a railroad was built to carry the concentrate from the operation to the mainline and thence to a smelter in El Paso, Tex. Fifty 100-ton capacity cars departed the concentrator each week. The company bore the cost of the track installation and the railroad company provided the rail cars.

Townsites were required in both mining locations. The cost in Alaska for a townsite for 833 employees was \$38.6 million, and in Arizona the cost for a townsite for 728 employees was \$14.6 million (table 3). The greater cost in Alaska was due to the greater number of employees, a larger commercial center, a school, and a hospital instead of a clinic. Construction costs were greater because the colder climate required more substantial structures. The possible existance of permafrost could require the placing of all water, sewer, steam, and auxiliary lines aboveground in insulated thermadores, thus increasing those costs given in this report.

Operating Costs

Operating costs per ton of ore was \$5.40 in Alaska and \$2.80 in Arizona (tables 4-5). Part of the nearly double cost in Alaska was due to a greater number of employees and pay rates 58 percent greater than those in Arizona. In addition to the usual fringe benefits, Alaskan employees received taxable subsidies equal to approximately 15 percent of their salaries. These taxable subsidies included partial payment by the company of utilities, rent for house and apartment dwellers, and room and board for single employees. Travel allowances were granted for an annual trip to Anchorage for all employees and their families plus air fare to Seattle, Wash. The larger work force required in Alaska was due to the increased number of maintenance personnel, a factor which reflected the colder climate and the larger staff required for supporting facilities. Details of the direct costs are given in appendix D.

TABLE 4. - Estimated annual cost in Alaska, dollars

Item	Mine		Mill		Support facilities		Total	
	Annual cost	Cost per ton	Annual cost	Cost per ton	Annual cost	Cost per ton	Annual cost	Cost per ton
Direct cost:								
Production:								
Labor.....	2,246,200	0.16	3,106,300	0.22	553,300	0.04	5,905,800	0.42
Supervision.....	336,900	0.02	465,900	0.03	83,000	0.01	885,800	0.06
Subtotal.....	2,583,100	0.18	3,572,200	0.25	636,300	0.05	6,791,600	0.48
Maintenance:								
Labor.....	2,255,800	0.16	2,345,500	0.16	390,000	0.03	4,991,300	0.35
Supervision.....	451,200	0.03	469,100	0.03	78,000	0.01	998,300	0.07
Maintenance supplies and parts.....	3,248,000	0.23	1,926,300	0.13	727,900	0.05	5,902,200	0.41
Subtotal.....	5,955,000	0.42	4,740,900	0.32	1,195,900	0.09	11,891,800	0.83
Operating supplies.....	3,372,400	0.24	6,047,600	0.42	-	-	9,420,000	0.66
Power.....	520,200	0.04	5,502,000	0.39	63,100	Nil	6,085,300	0.43
Water.....	5,100	Nil	483,200	0.03	5,100	Nil	493,400	0.03
Natural gas.....	35,100	Nil	275,900	0.02	11,100	Nil	322,100	0.02
Payroll overhead - 25 percent of payroll...	1,322,500	0.09	1,596,700	0.11	276,100	0.02	3,195,300	0.22
Taxable subsidies - 15 percent of payroll..	793,500	0.06	958,000	0.07	165,600	0.01	1,917,100	0.14
Total direct cost.....	14,586,900	1.03	23,176,500	1.61	2,353,200	0.17	40,116,600	2.81
Indirect cost:								
Administrative technical and clerical labor.....	1,375,500	0.10	928,500	0.07	576,000	0.04	2,880,000	0.21
Payroll overhead - 25 percent of payroll.	343,900	0.02	232,100	0.02	144,000	0.01	720,000	0.05
Taxable subsidies - 15 percent of payroll	206,300	0.01	139,300	0.01	86,400	0.01	432,000	0.03
Facilities maintenance and supplies - 0.25 percent of plant cost.....	99,800	0.01	424,300	0.03	238,400	0.02	762,500	0.06
General overhead including head office charges, exploration and research - 5 percent of direct costs.....	729,300	0.05	1,158,800	0.08	117,700	0.01	2,005,800	0.14
Total indirect cost.....	2,754,800	0.19	2,883,000	0.21	1,162,500	0.09	6,800,300	0.49
Fixed cost:								
Taxes and insurance - 2 percent of plant cost.....	798,200	0.06	3,394,700	0.24	1,907,000	0.13	6,099,900	0.43
Depreciation.....	3,544,400	0.25	8,996,700	0.63	5,095,800	0.36	17,636,900	1.24
Property taxes - 2 percent of plant cost.	798,200	0.06	3,394,700	0.24	1,907,000	0.13	6,099,900	0.43
Total fixed cost.....	5,140,800	0.37	15,786,100	1.11	8,909,800	0.62	29,836,700	2.10
Total operating cost.....	22,482,500	1.59	41,845,600	2.93	12,425,500	0.88	76,753,600	5.40

TABLE 5. - Estimated annual cost in Arizona, dollars

Item	Mine		Mill		Support facilities		Total	
	Annual cost	Cost per ton	Annual cost	Cost per ton	Annual cost	Cost per ton	Annual cost	Cost per ton
Direct cost:								
Production:								
Labor.....	1,413,700	0.10	1,952,500	0.14	274,600	0.02	3,640,800	0.26
Supervision.....	212,100	0.01	292,900	0.02	41,200	Nil	546,200	0.03
Subtotal.....	1,625,800	0.11	2,245,400	0.16	315,800	0.02	4,187,000	0.29
Maintenance:								
Labor.....	1,053,200	0.07	1,460,700	0.10	101,900	0.01	2,615,800	0.18
Supervision.....	210,600	0.01	292,100	0.02	20,400	Nil	523,100	0.03
Maintenance supplies and parts.....	2,840,100	0.20	1,267,200	0.09	80,100	0.01	4,187,400	0.30
Subtotal.....	4,103,900	0.28	3,020,000	0.21	202,400	0.02	7,326,300	0.51
Operating supplies.....	2,729,900	0.19	4,005,500	0.28	-	-	6,735,400	0.47
Power.....	218,500	0.02	2,527,100	0.18	-	-	2,745,600	0.20
Water.....	2,600	Nil	241,600	0.02	-	-	244,200	0.02
Natural gas.....	5,300	Nil	8,500	Nil	-	-	13,800	Nil
Payroll overhead - 25 percent of payroll...	722,400	0.05	999,600	0.07	109,500	0.01	1,831,500	0.13
Total direct cost.....	9,408,400	0.65	13,047,700	0.92	627,700	0.05	23,083,800	1.62
Indirect cost:								
Administrative, technical and clerical labor.....	907,900	0.06	613,100	0.04	169,000	0.01	1,690,000	0.11
Payroll overhead - 25 percent of payroll.	227,000	0.02	153,300	0.01	42,200	Nil	422,500	0.03
Facilities maintenance and supplies - 0.25 percent of plant cost.....	66,100	Nil	208,600	0.01	46,400	Nil	321,100	0.01
General overhead includes head office charges and research - 5 percent of direct costs.....	470,400	0.03	652,400	0.05	31,400	Nil	1,154,200	0.08
Total indirect cost.....	1,671,400	0.11	1,627,400	0.11	289,000	0.01	3,587,800	0.23
Fixed cost:								
Taxes and insurance - 2 percent of plant cost.....	529,100	0.04	1,668,400	0.12	371,200	0.03	2,568,700	0.19
Depreciation.....	2,659,700	0.19	4,454,600	0.31	981,500	0.07	8,095,800	0.57
Property taxes - 2 percent of plant cost.	529,100	0.04	1,668,400	0.12	371,200	0.03	2,568,700	0.19
Total fixed cost.....	3,717,900	0.27	7,791,400	0.55	1,723,900	0.13	13,233,200	0.95
Total operating cost.....	14,797,700	1.03	22,466,500	1.58	2,640,600	0.19	39,904,800	2.80

The greater cost for maintenance supplies and parts and operating supplies in Alaska reflected longer supply lines and the necessary rehandling. Mill items, in particular, were quite bulky which further added to transportation costs. The higher power costs reflected the higher natural gas cost, estimated at \$1 per thousand cubic feet at the wellhead. Higher natural gas costs in Alaska reflected the greater quantity required to dry the concentrate.

Higher indirect costs in Alaska arose from the greater number of staff employees required, their relatively higher salaries, and their taxable subsidies. Costs for maintenance and supplies were somewhat higher in Alaska. Fixed costs in Alaska were greater than in Arizona owing to the higher cost of capital equipment and buildings.

FINANCIAL ANALYSIS

The total cost for all facilities in Alaska and Arizona was \$346.6 million and \$152.6 million, respectively (tables 6-7). These capital costs required annual sales of \$150.2 million and \$87.3 million for Alaska and Arizona operations, respectively. These figures include all costs, 100-percent equity financing, and a 12 percent discounted cash flow rate of return. To sustain these sales volumes would require copper prices of \$1.12 per pound in Alaska and \$0.63 per pound in Arizona, plus or minus 20 percent, assuming the following byproduct prices: gold at \$120 per ounce, silver at \$2.70 per ounce, and molybdenum at \$1.60 per pound of concentrate (2). Neither operation would have been able to meet the required profitability of the 12 percent discounted cash flow since copper was selling at 60.0 cents per pound in the United States in July 1973. The leaching of the low-grade ore in Arizona would undoubtedly have increased copper production and thus lowered the price required to meet the profitability standards. Internationally, copper was selling at 91.6 cents per pound in July 1973, just 20 cents below the required Alaskan price.

One advantage the Arizona operation had over the Alaskan operation was access to a developed transportation and power systems. Were the Alaskan operation able to purchase these services instead of having to install them, the capital costs for support facilities would have declined from \$100.1 million to \$52.1 million. Total capital requirements for the Alaskan venture would have declined from \$346.6 to \$298.2 million. Total operating costs for Alaskan operation would drop to \$107.7 to reflect the reduction in depreciation costs. Reductions in personnel, supplies, and fuel costs would have been offset by freight and electrical rate charges from companies supplying these services. Sales would decline to \$140.7 from \$150.2 million reducing the price per ton of ore to \$9.86. The sales price per pound of copper would decline from \$1.12 to \$1.05.

TABLE 6. - Financial analysis for the Alaskan operation

Total original capital requirements.....	\$335,439,400
5-year equipment cost at present worth value.....	4,635,100
10-year equipment cost at present worth value.....	5,081,400
15-year equipment cost at present worth value.....	1,492,500
Total capital requirements.....	<u>\$346,648,400</u>

12 percent discounted cash flow--20-year life

i = interest rate, n = 20 year, P = capital investment
R = positive cash flow using the present worth formula

$$\frac{P}{R} = \frac{(1+i)^n - 1}{i (1+i)^n}$$

$$\frac{\$346,648,400}{R} = \frac{(1+0.12)^{20} - 1}{0.12 (1+0.12)^{20}} = \frac{8.6463}{1.1576} = 7.469$$

$$R = \$346,648,400 \div 7.469 = \$46,411,600$$

Positive cash flow.....	\$ 46,411,600
Less depreciation.....	<u>17,636,900</u>
Depletion plus net profit.....	<u>28,774,700</u>
Sales.....	\$150,230,800
Operating costs ¹	<u>110,199,200</u>
Gross profit.....	40,031,600
Depletion ²	<u>17,517,800</u>
Taxable income.....	22,513,800
Income tax ³	<u>11,256,900</u>
Net profit.....	<u>\$ 11,256,900</u>

Positive cash flow = Net profit + depletion + depreciation
= \$11,256,900 + \$17,517,800 + \$17,636,900
= \$46,411,600

Sales price per ton of ore = \$150,230,800 ÷ 14,280,000 tons = \$10.52

Sales price per pound of copper⁴ = \$143,936,000 ÷ 128,520,000 lb = \$1.12

¹Includes operating costs (\$76,753,600) + transportation costs (\$7,736,900) + smelting and refining charges (\$25,708,700).

²15 percent of concentrate value minus transportation, smelting and refining cost (\$150,230,800 - \$33,445,600 = \$116,785,200 × .15 = \$17,517,800).

³Federal and State income taxes.

⁴Sales minus byproduct credits (\$150,230,800 - \$6,294,800 = \$143,936,000).

TABLE 7. - Financial analysis for the Arizona operation

Total original capital requirements.....	\$143,233,600
5-year equipment cost at present worth value.....	4,274,900
10-year equipment cost at present worth value.....	3,735,000
15-year equipment cost at present worth value.....	<u>1,376,500</u>
Total capital requirements.....	\$152,620,000

12 percent discounted cash flow - 20-year life

i = interest rate, n = 20 years, P = capital investment
R = positive cash flow using the present worth formula

$$\frac{P}{R} = \frac{(1+i)^n - 1}{i (1+i)^n}$$

$$\frac{\$152,620,000}{R} = \frac{(1+0.12)^{20} - 1}{0.12 (1+0.12)^{20}} = \frac{8.6463}{1.1576} = 7.469$$

$$R = \$152,620,000 \div 7.469 = \$20,433,800$$

Positive cash flow.....	\$ 20,433,800
Less depreciation.....	<u>8,095,800</u>
Depletion plus net profit.....	\$ 12,338,000
Sales.....	\$ 87,328,500
Operating costs ¹	<u>70,877,700</u>
Gross profit.....	16,450,800
Depletion ²	<u>8,225,400</u>
Taxable income.....	8,225,400
Income tax ³	<u>4,112,700</u>
Net profit.....	\$ 4,112,700

$$\begin{aligned} \text{Positive cash flow} &= \text{Net profit} + \text{depletion} + \text{depreciation} \\ &= \$4,112,700 + \$8,225,400 + \$8,095,800 \\ &= \$20,433,900 \end{aligned}$$

Sales price per ton of ore = $\$87,328,500 \div 14,280,000$ tons = \$6.12

Sales price per pound of copper⁴ = $\$81,033,700 \div 128,520,000$ lb = \$0.63

¹Includes operating costs (\$39,904,800) + transportation costs (5,264,200) + smelting and refining charges (\$25,708,700).

²50 percent of gross profit.

³Federal and State income taxes.

⁴Sales minus byproduct credits ($\$87,328,500 - \$6,294,800 = \$81,033,700$).

CONCLUSION

Two hypothetical identical ore bodies were assumed, one near Lake Clark in Alaska, and one near Tucson, Ariz. It was assumed that operations would be mining 100,000 tons per day of ore and waste and concentrating 40,000 tons of ore per day averaging 0.5 percent copper plus minor amounts of gold, silver,

and molybdenum. The total capital cost in Alaska and Arizona was \$346.6 million and \$152.6 million, respectively.

Total mining capital requirements in Alaska were 39 percent greater than those in Arizona. Part of the reason for the greater costs was the need for larger fuel storage facilities and other inventories which added to the construction costs estimated to be 1.73 times the cost in Arizona. The major cause of the higher capital costs was preproduction stripping, an item which reflected the higher operating costs in Alaska. This item accounted for nearly 50 percent of the difference in Alaskan mine capital costs and those in Arizona.

The total capital costs for the concentrator in Alaska was slightly more than double the Arizona costs. Although total Alaskan building costs were assumed to be 1.93 times the Arizona costs, the cost and installation of mechanical and electrical equipment lowered the factor to a range of 1.69 to 1.76 times Arizona costs. The inclusion of four dryers and related equipment and the placing of the three thickeners inside the concentrator building added nearly \$27 million to the concentrator costs, or about one-third of the increased capital costs for the concentrator in Alaska versus the one in Arizona.

The total capital costs for the support facilities in Alaska were \$80 million greater than those in Arizona. This difference was due to the necessity to construct complete power and transportation facilities in Alaska plus a larger and somewhat more complete townsite for 833 employees versus 728 employees in Arizona. The support facilities cost of \$100.1 million in Alaska was 70 percent of the total plant cost of \$143 million of the Arizona mine, concentrator, and support facilities.

Total annual operating costs were \$76.8 million in Alaska and \$39.9 million in Arizona. The greater operating costs in Alaska were due to the higher wages paid, the corresponding higher payroll costs, plus the addition of 15 percent in taxable subsidies. The greater number of people required for maintenance, support facilities, and administration magnified the impact that wages had on the overall operation. The higher cost for natural gas in Alaska resulted in higher power costs and additional quantities consumed drying the concentrates in Alaska. Nearly \$10 million more, a substantial share of the \$37 million increase in total operating costs of Alaska over Arizona, was needed annually to operate the support facilities in Alaska than in Arizona. The higher fixed operating costs for depreciation, taxes, and insurance reflect the more than double capital requirements.

The total price required in Alaska and Arizona to maintain a 12 percent discounted cash flow rate of return was \$1.12 and \$0.63 pound, respectively, plus or minus 20 percent. These prices assumed no leaching of the lower grade ore and recovery of gold, silver, and molybdenum as byproducts, 100-percent equity financing, and a 12 percent discounted cash flow rate of return. Had the Alaskan operation been situated near developed transportation and power systems, capital costs would have declined \$48.4 million and operating costs \$2.2 million. The price required for the copper recovered would have declined from \$1.12 to \$1.05 per pound, plus or minus 20 percent.

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APPENDIX A.--COST TABLES FOR ALASKAN COPPER OPERATION

TABLE A-1. - Total capital requirement

	Investment, dollars
Mine.....	39,908,200
Mill.....	169,733,000
Support facilities.....	95,348,900
Total plant cost (insurance, tax base).....	304,990,100
Interest during construction.....	15,635,000
Subtotal for depreciation.....	320,625,100
Working capital.....	14,814,300
Total investment.....	335,439,400

TABLE A-2. - Working Capital

	Cost, dollars
Direct labor.....3 months..	3,195,300
Payroll overhead and subsidies.....do.....	1,566,100
Operating supplies.....do.....	4,080,200
Indirect cost.....4 months..	2,266,700
Fixed cost.....0.5 percent of insurance base..	1,525,000
Spare parts.....	1,475,600
Miscellaneous expense.....	705,400
Total.....	14,814,300

TABLE A-3. - Mine pit equipment cost summary, 100,000-tpd open pit mining operation

Item No.	Item	Quantity	Size	Unit hp	Total hp	Total cost
01100	Drill, primary....	4	Rotary, electric-powered quarry drill, 70,000-lb bit load.	500	2,000	998,200
01101	Drill, secondary..	2	Track mounted, with gasoline powered compressor.	100	200	59,700
01102	Powder truck.....	2	15-ton capacity, pneumatic AN-FO loading, gasoline powered.	120	240	51,300
01103	Shovel.....	5	15-cu yd, electric-powered.....	700	3,500	4,532,900
01104	Truck.....	16	150-ton, rear dump, diesel powered..	1,600	25,600	6,060,300
01105	Front-end loader..	3	Diesel powered, rubber tired, 6-cu-yd bucket.	325	975	295,000
01106	Dozer.....	3	Diesel powered, rubber tired, 76,000-lb draw bar pull.	400	1,200	331,700
01107	Dozer.....	5	Diesel powered, crawler tractor, 50,000-lb draw bar pull.	270	1,350	411,000
01108	Motor grader.....	4	Diesel powered, 14 ft blade, 40,000-lb draw bar pull.	230	920	270,800
01109	Water truck.....	3	Diesel powered, 5,000-gal capacity..	300	900	137,900
01110	Service vehicle...	15	Gasoline powered maintenance trucks, cranes, and miscellaneous vehicles.	80	1,200	344,600
01111	Utility vehicle...	50	Forty-five 3/4-ton pickups, 4 sedans,	80	4,000	211,600
-	Subtotal.....	-	-	-	-	13,705,000
-	Contingency.....	-	-	-	-	1,370,500
-	Subtotal.....	-	-	-	-	15,075,500
-	Interest during construction.	-	-	-	-	753,800
-	Total.....	-	-	-	-	15,829,300

TABLE A-4. - Plant and buildings cost summary, 100,000-tpd open pit mining operation

Item No.	Item	Quantity	Size	Total cost
02100	Transformer station.....	2	3,200 kV-A 69,000-v to 4,160-volt transformer with semipermanent building.	\$56,600
02101	Switch.....	2	Main disconnect, 4,160 v.....	16,700
02102	Distribution wire.....	100,000 ft	Main distribution overhead line, 4 single size 1-0 wires.....	107,500
02103	Circuit breaker.....	10	Weatherproof, portable oil circuit breakers.....	76,000
02104	Portable cable.....	7,000 ft	Three conductor extra-heavy-duty insulation, size 1-0 wire....	29,800
02105	Coupler.....	10	Heavy-duty electric couplers for portable cable.....	4,400
02106	Pole.....	104	Poles for overhead distribution system, includes installation.	61,000
02107	Accessories for distribution line.	1	Cross arms, insulators, and accessories at \$4,100 per mile....	19,300
02108	Primer and cap houses....	2	20-ft x 20-ft concrete building at \$21.00/sq ft.....	16,800
02109	Ammonium nitrate bin....	1	1,000,000-lb capacity steel tank.....	77,400
02110	Blasting equipment.....	1	Galvanometer and generator in a shack on skids.....	1,800
02111	Mine office and change building.	1	60 ft x 100 ft with 15 ft eave including utilities at \$64.00/sq ft.	384,000
02112	Office furniture and equipment.	1	60 ft x 100 ft at \$20.00/sq ft.....	120,000
02113	Mine service building....	1	80 ft x 125 ft with 36-ft eave including utilities at \$46.00/sq ft.	460,000
02114	Repair and service shop..	1	120 ft x 250 ft with 36-ft eave including utilities at \$50.00/sq ft.	1,500,000
02115	Shop equipment and tools.	1	Includes hoists, welders, and general shop tools.....	210,000
02116	Warehouse.....	1	60 ft x 100 ft with 20-ft eave including utilities at \$31.00/sq ft, 1/2 charged to mine.	93,000
02117	-	-	Parts inventory and maintenance supplies.....	2,500,000
02118	Administration building..	1	40 ft x 80 ft with 10-ft eave including utilities at \$71.00/sq ft, 1/2 charged to mine.	113,600
02119	Fuel tank, gasoline.....	1	20,000-gal horizontal steel tank.....	26,400
02120	Fuel tank, diesel fuel...	1	15,000-bbl cone-roof steel tank.....	188,100
02121	Lube tank, hydraulic and crank case.	2	5,000- and 8,000-gal horizontal steel tanks.....	23,100
02122	-	-	Property acquisition cost.....	300,000
02123	-	-	Exploration, development, and feasibility study.....	4,000,000
02124	-	-	Environmental studies and hearings.....	3,000,000
02125	-	-	Preproduction stripping, 36,000,000 tons at \$0.45 per ton....	16,200,000
-	Subtotal.....	-	-	29,585,500
-	Contingency.....	-	-	2,958,500
-	Interest during development.	-	-	1,627,200
-	Subtotal.....	-	-	34,171,200
-	Credit for copper mined during development.	-	-	7,711,300
-	Total.....	-	-	26,459,900

TABLE A-6. - Cost summary, secondary and tertiary crushing section, 40,000-tpd copper concentrator

Item No.	Item	Quantity	Size	Unit hp	Total hp	Cost		Total cost
						Material	Labor	
04100	Vibrating feeder.....	3	60 in x 6.5 ft.....	15	45	\$31,800	\$7,300	\$39,100
04101	Screen.....	3	60 in x 14 ft, double deck.....	25	75	59,200	14,700	73,900
04102	Cone crusher.....	3	7 ft standard.....	-	-	379,300	86,100	465,400
04103	Crusher motor.....	3	-	300	900	56,300	14,600	70,900
04104	Belt conveyor.....	1	42 in x 40 ft.....	20	20	12,200	3,000	15,200
04105	Belt conveyor.....	1	42 in x 85 ft.....	60	60	17,500	4,300	21,800
04106	Belt conveyor.....	1	42 in x 56 ft.....	30	30	14,400	3,400	17,800
04107	Belt conveyor.....	1	54 in x 386 ft.....	300	300	73,200	18,700	91,900
04108	Magnet.....	1	54 in x 60 in.....	7.5	7.5	10,300	2,400	12,700
04109	Belt conveyor.....	1	54 in x 336 ft.....	300	300	63,900	16,300	80,200
04110	Belt conveyor.....	1	60 in x 185 ft.....	150	150	40,200	10,200	50,400
04111	Tripper.....	1	60 in.....	7.5	7.5	24,800	6,300	31,100
04112	Surge bin.....	1	200-ton.....	-	-	37,600	40,600	78,200
04113	Vibrating feeder.....	7	48 in x 6 ft.....	12	84	61,200	14,300	75,500
04114	Screen.....	7	72 in x 14 ft double deck.....	25	175	141,500	34,600	176,100
04115	Cone crusher.....	7	7-ft shorthead.....	-	-	945,000	215,800	1,160,800
04116	Crusher motor.....	7	-	300	2,100	131,200	34,000	165,200
04117	Belt conveyor.....	1	42 in x 185 ft.....	75	75	33,100	8,400	41,500
04118	Belt conveyor.....	1	48 in x 300 ft.....	300	300	54,100	14,000	68,100
04119	Belt conveyor.....	1	36 in x 90 ft.....	10	10	14,300	3,400	17,700
04120	Belt conveyor.....	1	48 in x 1,375 ft.....	500	500	218,900	56,500	275,400
04121	Belt conveyor.....	1	48 in x 1,700 ft.....	250	250	250,400	64,400	314,800
04122	Tripper.....	2	48 in.....	3	6	31,300	7,000	38,300
04123	Fine ore bin.....	1	38,000-ton.....	-	-	462,600	921,600	1,384,200
04124	Dust collector.....	1	34,000 cfm, wet type.....	200	200	31,600	7,700	39,300
04125	Dust collector.....	3	34,000 cfm, wet type.....	125	375	85,800	20,700	106,500
04126	Dust collector.....	1	12,000 cfm, wet type.....	20	20	11,500	2,700	14,200
04127	Pump.....	4	2 in x 2 in rubber-lined, centrifugal.....	5	20	6,300	1,400	7,700
04128	Pump.....	2	6 in x 6 in rubber-lined, centrifugal.....	25	50	8,700	2,000	10,700
04129	Bridge crane.....	2	30-ton, 48-ft span.....	25	50	124,800	30,600	155,400
04130	Passenger elevator.....	1	2,500-lb capacity.....	25	25	33,800	8,400	42,200
-	Subtotal.....	-	-	-	6,135	3,466,800	1,675,400	5,142,200
-	Excavation.....	-	-	-	-	124,000	1,450,200	1,574,200
-	Concrete.....	-	-	-	-	751,900	1,677,400	2,429,300
-	Buildings.....	-	-	-	-	1,459,400	847,400	2,306,800
-	Piping.....	-	-	-	-	834,100	701,400	1,535,500
-	Electrical.....	-	-	-	-	877,200	1,419,400	2,296,600
-	Painting.....	-	-	-	-	36,600	59,800	96,400
-	Instrumentation.....	-	-	-	-	58,800	40,500	99,300
-	Insulation.....	-	-	-	-	15,700	3,500	19,200
-	Subtotal.....	-	-	-	-	4,157,700	6,199,600	10,357,300
-	Total direct costs.....	-	-	-	-	7,624,500	7,875,000	15,499,500
-	Field indirect.....	-	-	-	-	-	-	3,937,500
-	Total construction.....	-	-	-	-	-	-	19,437,000
-	Engineering.....	-	-	-	-	-	-	971,800
-	Administration and overhead.....	-	-	-	-	-	-	971,800
-	Subtotal.....	-	-	-	-	-	-	21,380,600
-	Contingency.....	-	-	-	-	-	-	2,138,100
-	Subtotal.....	-	-	-	-	-	-	23,518,700
-	Fee.....	-	-	-	-	-	-	1,175,900
-	Subtotal.....	-	-	-	-	-	-	24,694,600
-	Interest during construction.....	-	-	-	-	-	-	1,234,700
-	Total.....	-	-	-	-	-	-	25,929,300

TABLE A-7. - Cost summary, grinding section, 40,000-tpd copper concentrator

Item No.	Item	Quantity	Size	Unit hp	Total hp	Cost		Total cost
						Material	Labor	
05100	Belt feeder.....	32	30 in x 11 ft.....	3	96	\$492,800	\$148,600	\$641,400
05101	Belt conveyor.....	14	30 in x 143 ft.....	7.5	105	253,700	76,500	330,200
05102	Belt scale.....	10	30 in.....	0.5	5	57,000	15,000	72,000
05103	Rod mill.....	10	10 ft x 16 ft.....	-	-	1,877,200	666,400	2,543,600
05104	Rod mill motor.....	10	-	800	8,000	352,100	114,100	466,200
05105	Rod mill splitter.....	10	-	-	-	61,600	14,400	76,000
05106	Rod mill charger.....	10	-	-	-	85,800	23,400	109,200
05107	Rod mill, rod storage rack..	10	-	-	-	10,100	2,300	12,400
05108	Rod charge.....	900 tons	-	-	-	350,000	-	350,000
05109	Pump.....	40	10 in x 8 in rubber-lined, centrifugal.	75	3,000	279,700	76,300	356,000
05110	Hydrocyclone.....	60	20 in.....	-	-	193,200	48,800	242,000
05111	Ball mill.....	20	10.5 ft x 13 ft.....	-	-	3,697,300	1,323,700	5,021,000
05112	Ball mill motor.....	20	-	800	16,000	704,100	228,200	932,300
05113	Ball mill charge.....	1,340 tons	-	-	-	649,000	-	649,000
05114	Sampler.....	10	-	0.5	5	18,900	5,800	24,700
05115	Sump pump.....	3	2.5 in rubber-lined, centrifugal.	7.5	22.5	4,600	1,400	6,000
05116	Bridge crane.....	1	30-ton, 5-ton auxiliary, 43-ft span.	25	25	61,900	18,700	80,600
-	Subtotal.....	-	-	-	27,259	9,149,000	2,763,600	11,912,600
-	Excavation.....	-	-	-	-	314,600	3,679,200	3,993,800
-	Concrete.....	-	-	-	-	1,907,600	4,255,700	6,163,300
-	Buildings.....	-	-	-	-	3,702,700	2,150,000	5,852,700
-	Piping.....	-	-	-	-	2,116,300	1,779,500	3,895,800
-	Electrical.....	-	-	-	-	2,225,500	3,601,000	5,826,500
-	Painting.....	-	-	-	-	92,700	151,400	244,100
-	Instrumentation.....	-	-	-	-	149,000	102,700	251,700
-	Insulation.....	-	-	-	-	39,800	9,000	48,800
-	Subtotal.....	-	-	-	-	10,548,200	15,728,500	26,276,700
-	Total direct costs.....	-	-	-	-	19,697,200	18,492,100	38,189,300
-	Field indirect.....	-	-	-	-	-	-	9,246,000
-	Total construction.....	-	-	-	-	-	-	47,435,300
-	Engineering.....	-	-	-	-	-	-	2,371,800
-	Administration and overhead.	-	-	-	-	-	-	2,371,800
-	Subtotal.....	-	-	-	-	-	-	52,178,900
-	Contingency.....	-	-	-	-	-	-	5,217,900
-	Subtotal.....	-	-	-	-	-	-	57,396,800
-	Fee.....	-	-	-	-	-	-	2,869,800
-	Subtotal.....	-	-	-	-	-	-	60,266,600
-	Interest during construction	-	-	-	-	-	-	3,013,300
-	Total.....	-	-	-	-	-	-	63,279,900

TABLE A-8. - Cost summary, flotation section, 40,000-tpd copper concentrator

Item No.	Item	Quantity	Size	Unit hp	Total hp	Cost		Total cost
						Material	Labor	
06100	Pulp distributor.....	13	6-ft-diam.....	1	13	\$72,900	\$22,000	\$94,900
06101	Rougher flotation unit.....	100	10 banks of 10 cells, 61 cu ft.....	7.5	750	393,600	117,100	510,700
	Do.....do.....	400	40 banks of 10 cells, 61 cu ft.....	10	4,000	1,607,000	479,300	2,086,300
06102	Laundrer.....	5,000 ft	12 in.....	-	-	272,900	75,600	348,500
06103	Pump.....	4	10 in x 8 in rubber-lined, centrifugal.....	25	100	21,400	5,400	26,800
06104	Sampler.....	3	-	0.75	2.25	5,600	1,800	7,400
06105	Pump.....	2	12 in x 10 in rubber-lined, centrifugal.....	75	150	14,300	3,700	18,000
06106	Hydrocyclone.....	8	10 in.....	-	-	23,900	6,100	30,000
06107	Regrind ball mill.....	1	7 ft x 12 ft.....	-	-	83,000	30,100	113,100
06108	Regrind ball mill motor.....	1	-	300	300	18,800	5,800	24,600
06109	Regrind ball mill charge.....	1	35 tons.....	-	-	16,400	-	16,400
06110	Sampler.....	1	-	0.25	0.25	1,800	700	2,500
06111	Splitter.....	1	-	-	-	6,200	1,400	7,600
06112	Pump.....	4	10 in x 8 in rubber-lined, centrifugal.....	30	120	22,400	5,800	28,200
06113	Pulp distributor.....	2	8-ft-diam.....	1	2	24,500	7,700	32,200
06114	Cleaner flotation unit.....	120	12 blanks of 10 cells, 50 cu ft.....	7.5	900	245,600	68,400	314,000
06115	Laundrer.....	960 ft	12 in.....	-	-	52,400	14,700	67,100
06116	Pump.....	4	5 in x 5 in rubber-lined centrifugal.....	15	60	14,500	4,200	18,700
06117	Pulp distributor.....	1	8-ft-diam.....	1	1	10,300	3,200	13,500
06118	Recleaner flotation unit.....	40	4 banks of 10 cells, 50 cu ft.....	7.5	300	81,800	22,800	104,600
06119	Laundrer.....	320 ft	12 in.....	-	-	17,400	4,700	22,100
06120	Thickener.....	2	150 ft x 20 ft.....	10	20	462,000	139,600	601,600
06121	Pump.....	4	6 in x 6 in rubber-lined, centrifugal.....	25	100	17,400	4,900	22,300
06122	Sampler.....	1	-	0.25	0.25	1,800	700	2,500
06123	Pump.....	4	10 in x 8 in rubber-lined, centrifugal.....	75	300	27,900	7,700	35,600
06124	Hydrocyclone.....	16	10 in.....	-	-	47,800	12,100	59,900
06125	Sampler.....	2	-	0.25	0.50	3,800	1,400	5,200
06126	Regrind ball mill.....	2	9 ft x 18 ft.....	-	-	350,700	104,500	455,200
06127	Regrind ball mill motor.....	2	-	800	1,600	70,400	22,800	93,200
06128	Regrind ball mill, ball charges.....	134 tons	-	-	-	63,000	-	63,000
06129	Pump.....	4	10 in x 8 in rubber-lined, centrifugal.....	30	120	22,400	5,800	28,200
06130	Pulp distributor.....	2	5-ft-diam.....	1	2	9,000	2,600	11,600
06131	Scavenger flotation unit.....	80	8 banks of 10 cells, 61 cu ft.....	20	1,600	321,400	95,900	417,300
06132	Laundrer.....	800 ft	12 in.....	-	-	43,600	12,100	55,700
06133	Pump.....	9	2 in x 2.5 in rubber-lined, centrifugal.....	7.5	67.5	13,500	3,800	17,300
06134	Bridge crane.....	2	10-ton, 60-ft span.....	20	40	45,600	13,500	59,100
-	Subtotal.....	-	-	-	10,549	4,507,000	1,307,900	5,814,900
-	Excavation.....	-	-	-	-	163,700	1,914,500	2,078,200
-	Concrete.....	-	-	-	-	992,700	2,214,600	3,207,300
-	Buildings.....	-	-	-	-	1,926,800	1,118,800	3,045,600
-	Piping.....	-	-	-	-	1,101,200	926,000	2,027,200
-	Electrical.....	-	-	-	-	1,158,200	1,874,000	3,032,200
-	Painting.....	-	-	-	-	48,200	78,700	126,900
-	Instrumentation.....	-	-	-	-	77,500	53,400	130,900
-	Insulation.....	-	-	-	-	20,300	4,600	24,900
-	Subtotal.....	-	-	-	-	5,488,600	8,184,600	13,673,200
-	Total direct costs.....	-	-	-	-	9,995,600	9,492,500	19,488,100
-	Field indirect.....	-	-	-	-	-	-	4,746,200
-	Total construction.....	-	-	-	-	-	-	24,234,300
-	Engineering.....	-	-	-	-	-	-	1,211,700
-	Administration and overhead.....	-	-	-	-	-	-	1,211,700
-	Subtotal.....	-	-	-	-	-	-	26,657,700
-	Contingency.....	-	-	-	-	-	-	2,665,800
-	Subtotal.....	-	-	-	-	-	-	29,323,500
-	Fee.....	-	-	-	-	-	-	1,466,200
-	Subtotal.....	-	-	-	-	-	-	30,789,700
-	Interest during construction.....	-	-	-	-	-	-	1,539,500
-	Total.....	-	-	-	-	-	-	32,329,200

TABLE A-10. - Cost summary, copper filter section, 40,000-tpd copper concentrator

Item No.	Item	Quantity	Size	Unit hp	Total hp	Cost		Total Cost
						Material	Labor	
08100	Thickener.....	2	75 ft x 12 ft.....	2	4	\$127,500	\$37,600	\$165,100
08101	Pump.....	2	5 in x 5 in rubber-lined, centrifugal..	15	30	7,200	2,300	9,500
08102	Filter.....	4	6 ft x 7 ft.....	8	32	41,800	10,200	52,000
08103	Filter.....	1	8 ft x 10 ft.....	10	10	14,300	3,800	18,100
08104	Belt conveyor.....	1	30 in x 143 ft.....	5	5	17,900	5,400	23,300
08105	Belt conveyor.....	1	24 in x 35 ft.....	2	2	7,400	2,300	9,700
08106	Belt conveyor.....	1	24 in x 50 ft.....	5	5	10,000	3,000	13,000
08107	Belt conveyor.....	1	30 in x 148 ft.....	5	5	18,400	5,600	24,000
08108	Filtrate receiver.....	5	10 ft diam x 10 ft.....	-	-	15,200	14,400	29,600
08109	Filtrate pump.....	5	2 in x 2 in rubber-lined, centrifugal..	1	5	3,400	900	4,300
08110	Vacuum pump.....	5	5-in piston.....	25	125	16,500	3,700	20,200
08111	Slusher.....	1	2-drum, including scraper bucket.....	75	75	17,600	5,400	23,000
08112	Dryer.....	4	80 in x 40 ft.....	25	100	520,600	63,100	583,700
08113	Belt conveyor.....	4	18 in x 18 ft.....	2	8	15,200	4,600	19,800
08114	Belt conveyor.....	1	24 in x 60 ft.....	5	5	6,100	1,800	7,900
08115	Belt conveyor.....	1	24 in x 200 ft.....	10	10	23,000	6,900	29,900
08116	Belt scale.....	1	24 in.....	.5	.5	4,600	1,200	5,800
08117	Belt tripper.....	1	24 in.....	3	3	10,000	4,400	14,400
08118	Storage bin.....	1	3,000-ton.....	-	-	75,500	105,700	181,200
-	Subtotal.....	-	-	-	424	952,200	282,300	1,234,500
-	Excavation.....	-	-	-	-	38,800	453,800	492,600
-	Concrete.....	-	-	-	-	235,300	524,900	760,200
-	Buildings.....	-	-	-	-	456,700	265,200	721,900
-	Piping.....	-	-	-	-	261,000	219,500	480,500
-	Electrical.....	-	-	-	-	274,500	444,200	718,700
-	Painting.....	-	-	-	-	11,400	18,600	30,000
-	Instrumentation.....	-	-	-	-	18,400	12,700	31,100
-	Insulation.....	-	-	-	-	4,900	1,100	6,000
-	Subtotal.....	-	-	-	-	1,301,000	1,940,000	3,241,000
-	Total direct costs.....	-	-	-	-	2,253,200	2,222,300	4,475,500
-	Field indirect.....	-	-	-	-	-	-	1,111,200
-	Total construction.....	-	-	-	-	-	-	5,586,700
-	Engineering.....	-	-	-	-	-	-	279,300
-	Administration and overhead..	-	-	-	-	-	-	279,300
-	Subtotal.....	-	-	-	-	-	-	6,145,300
-	Contingency.....	-	-	-	-	-	-	614,500
-	Subtotal.....	-	-	-	-	-	-	6,759,800
-	Fee.....	-	-	-	-	-	-	338,000
-	Subtotal.....	-	-	-	-	-	-	7,097,800
-	Interest during construction..	-	-	-	-	-	-	354,900
-	Total.....	-	-	-	-	-	-	7,452,700

TABLE A-12. - Cost summary, tailings disposal section, 40,000-tpd copper concentrator

Item No.	Item	Quantity	Size	Unit hp	Total hp	Cost		Total cost
						Material	Labor	
10100	Sampler.....	3	-	0.25	0.75	\$5,300	\$1,400	\$6,700
10101	Thickener.....	2	260 ft x 22 ft.....	15	30	794,100	241,300	1,035,400
10102	Thickener.....	1	300 ft x 26 ft.....	15	15	516,600	157,800	674,400
10103	Pump.....	6	12 in x 10 in rubber-lined, centrifugal.	50	300	37,200	10,000	47,200
10104	Pump.....	9	2,500-gpm vent turbine..	100	900	109,400	29,200	138,600
10105	Tailings pipe.....	11,000 ft	30 in concrete.....	-	-	253,100	36,500	289,600
10106	Tailings pipe.....	30,000 ft	24 in concrete.....	-	-	474,500	118,800	593,300
10107	Hydrocyclone.....	300	10 in low pressure.....	-	-	170,800	43,200	214,000
10108	Tractor scraper.....	1	32-cu-yd diesel-powered.	500	500	165,600	-	165,600
10109	Dozer.....	1	Diesel-powered crawler tractor, 50,000-lb draw bar pull.	270	270	79,700	-	79,700
10110	Pump and barge.....	1	-	300	300	19,600	5,800	25,400
-	Subtotal.....	-	-	-	2,316	2,625,900	644,000	3,269,900
-	Excavation.....	-	-	-	-	314,400	3,675,600	3,990,000
-	Concrete.....	-	-	-	-	582,200	1,298,800	1,881,000
-	Buildings.....	-	-	-	-	3,606,400	2,093,600	5,700,000
-	Piping.....	-	-	-	-	1,006,300	846,200	1,852,500
-	Electrical.....	-	-	-	-	679,200	1,099,000	1,778,200
-	Painting.....	-	-	-	-	108,300	176,700	285,000
-	Instrumentation.....	-	-	-	-	168,600	116,400	285,000
-	Insulation.....	-	-	-	-	93,100	20,900	114,000
-	Subtotal.....	-	-	-	-	6,558,500	9,327,200	15,885,700
-	Total direct costs.....	-	-	-	-	9,184,400	9,971,200	19,155,600
-	Field indirect.....	-	-	-	-	-	-	4,985,600
-	Total construction.....	-	-	-	-	-	-	24,141,200
-	Engineering.....	-	-	-	-	-	-	1,207,100
-	Administration and overhead..	-	-	-	-	-	-	1,207,100
-	Subtotal.....	-	-	-	-	-	-	26,555,400
-	Contingency.....	-	-	-	-	-	-	2,655,500
-	Subtotal.....	-	-	-	-	-	-	29,210,900
-	Fee.....	-	-	-	-	-	-	1,460,500
-	Subtotal.....	-	-	-	-	-	-	30,671,400
-	Interest during construction.	-	-	-	-	-	-	1,533,600
-	Total.....	-	-	-	-	-	-	32,205,000

TABLE A-13. - General facilities and utilities, mill

Item No.	Item	Quantity	Size	Total cost
11100	Mill office.....	1	50-ft x 50 ft structure within the mill building at \$29.00/sq ft.	\$72,500
11101	Office furniture and equipment..	1	50 ft x 50 ft at \$5.00/sq ft.....	12,500
11102	Repair and service shop.....	1	90-ft x 300-ft structure within the mill building at \$44.00/sq ft, 1/2 charged to mill.	594,000
11103	Shop equipment and tools.....	1	Includes hoists, welders and general shop tools, 1/2 charged to mill.	94,500
11104	Warehouse.....	1	60 ft x 100 ft with 20-ft eave including utilities at \$31.00/sq ft, 1/2 charged to mill.	93,000
11105	Parts inventory.....	1	Parts inventory and maintenance supplies..	1,250,000
11106	Administration building.....	1	40 ft x 80 ft with 10-ft eave including utilities at \$71.00/sq ft, 1/2 charged to mill.	113,600
11107	Utility vehicle.....	4	3/4-ton pickup.....	16,900
11108	Service vehicle.....	2	Flat-bed truck.....	21,000
-	Subtotal.....	-	-	2,268,000
-	Contingency.....	-	-	226,800
-	Subtotal.....	-	-	2,494,800
-	Interest during construction....	-	-	124,700
-	Total.....	-	-	2,619,500

TABLE A-14. - Cost summary, support facilities

Item No.	Item	Quantity	Size	Total cost
12100	Pipeline.....	1	6 in buried gas pipeline, 90 miles at \$58,100.00 per mile.	\$5,229,000
12101	Generator.....	2	25 MW gas turbine generators at \$135.00/KW.....	6,750,000
12102	Road.....	-	Gravel road from townsite to plant, 12 miles at \$115,800.00 per mile.	1,389,600
12103	Railroad.....	1	85 miles of standard gauge track.....	25,979,400
12104	Railroad transmission lines...	1	85 miles at \$27,500.00 per mile.....	2,337,500
12105	Locomotives.....	2	3,000 hp 6-axle unit.....	700,000
12106	Railroad cars.....	25	50 ton cap. hopper cars at \$11,800.00.....	295,000
12107	Railroad cars.....	10	Box cars, flat cars, tank cars.....	295,000
12108	Unloading equipment.....	1	Hopper, conveyor, tripper, 100 hp.....	536,500
12109	Front end loader.....	1	Rubber tired, diesel powered, 3 cu yd bucket.....	48,900
12110	Crawler tractor.....	1	Diesel powered, U-dozer, 63,000 lb draw bar pull.	74,300
12111	Docking facility.....	1	Beaching area for barge.....	500,000
12112	Loading conveyor.....	1	Covered 48 in conveyor, 250 hp.....	1,574,000
12113	Mobile crane.....	2	30-ton capacity diesel-powered, 325 hp.....	210,300
12114	Warehouse.....	1	100 ft x 200 ft unheated warehouse.....	400,000
12115	Office and furniture.....	1	30 ft x 30 ft area within the warehouse w/utilities at \$34.00/sq ft.	30,600
12116	Communications system.....	1	Telephone system between mill and dock.....	430,500
12117	Repair and service shop.....	1	90 ft x 300 ft structure within the mill at \$44.00/sq ft, 1/2 charged to support facilities.	594,000
12118	Shop equipment and tools.....	1	Includes hoists, welders, and general shop tools, 1/2 charged to support facilities.	94,500
12119	Utility vehicle.....	4	3/4 ton pickup.....	16,900
12120	Fuel tank, diesel.....	1	7,500 bbl steel tank at dock.....	130,900
12121	Air strip.....	2	5,300 ft gravel runway.....	496,000
12122	Townsite.....	1	Includes 833 housing units for single and married people, commercial center, school, hospital, and municipal services of streets, electricity, sewers, and water at \$46,300.00 per employee.	38,567,900
-	Subtotal.....	-	-	86,680,800
-	Contingency.....	-	-	8,668,100
-	Subtotal.....	-	-	95,348,900
-	Interest during construction..	-	-	4,767,400
-	Total.....	-	-	100,116,300

TABLE A-15. - Depreciation schedule, dollars

Item	Years straight- line depreciation	Yearly charge, dollars			
		Mine	Mill	Support facilities	Total
Buildings and facilities.....	20	370,800	6,163,100	4,140,200	10,674,100
Long-life mobile equipment.....	10	105,600	24,500	162,400	292,500
Short-life mobile equipment.....	5	1,622,800	7,600	3,400	1,633,800
Long-life stationary equipment.....	20	-	1,506,200	105,500	1,611,700
Tools and equipment.....	10	320,300	135,700	12,500	468,500
Other ¹	20	² 1,124,900	1,159,600	671,800	2,956,300
Total.....	-	3,544,400	8,996,700	5,095,800	17,636,900

¹Includes contingency and interest during development.

²Also includes property acquisition, exploration, development, feasibility studies, environmental studies, and preproduction stripping less credits for mineral mined during development.

TABLE A-16. - Plant utility requirements

Unit	Power kwhr/hr	New water (from own wells), gpm	Recirculated water, gpm	Natural gas, Mcf/hr
Mill:				
Crushing section....	2,600	-	100	-
Concentrator.....	26,800	4,300	12,800	25.8
Byproduct molybdenum recovery section...	400	-	-	1.8
Lime preparation section.....	300	-	-	-
Subtotal.....	30,100	4,300	12,900	27.6
Lighting and cranes...	400	-	-	-
Fresh water.....	2,600	-	-	-
Recirculated water....	1,000	-	-	-
Sanitary water.....	200	100	-	-
General facilities....	400	-	-	4.6
Miscellaneous and contingency.....	200	300	-	-
Subtotal.....	4,800	400	-	4.6
Mine.....	3,300	50	-	4.1
Support facilities ¹ ...	400	50	-	648.5
Total.....	38,600	4,800	12,900	684.6

NOTE.--Power: At \$0.0184/²kw-hr

Mine - $\$0.0184 \times 3,300 \times 8,568 = {}^3\$520,200 = \$0.04/\text{ton}$

Mill - $\$0.0184 \times 34,900 \times 8,568 = {}^3\$5,502,000 = \$0.39/\text{ton}$

Support facilities - $\$0.0184 \times 400 \times 8,568 = {}^3\$63,100 = \$0.01/\text{ton}$

Water: At \$0.20/1,000 gal

Mine - $\$0.20 \times 50 \times 60 \times 8,568 = {}^35,100 = \text{nil}$

Mill - $\$0.20 \times 4,700 \times 60 \times 8,568 = {}^3\$483,200 = \$0.03/\text{ton}$

Support facilities - $\$0.20 \times 50 \times 60 \times 8,568 = {}^3\$5,100 = \text{nil}$

Natural gas: At \$1.00/Mcf

Mine - $\$1.00 \times 4.1 \times 8,568 = {}^3\$35,100 = \text{nil}$

Mill - $\$1.00 \times 32.2 \times 8,568 = {}^3\$275,900 = \$0.02/\text{ton}$

Support facilities - $\$1.00 \times {}^41.3 \times 8,568 = {}^3\$11,100 = \text{nil}$

¹No costs are included for the townsite.

²Includes fuel, lubrication, and repair parts.

³Rounded to the nearest 100.

⁴647.2 Mcf/hr is included in the calculation of power costs.

APPENDIX B.--COST TABLES FOR ARIZONA COPPER OPERATION

TABLE B-1. - Total capital requirement

	Investment, dollars
Mine.....	26,455,500
Mill.....	83,420,100
Support facilities.....	18,561,000
Total plant cost (insurance, tax base).....	128,436,600
Interest during construction.....	6,807,400
Subtotal for depreciation.....	135,244,000
Working capital.....	7,989,600
Total investment.....	143,233,600

TABLE B-2. - Working capital

	Cost, dollars
Direct labor.....3 months..	1,831,500
Payroll, overhead.....do.....	457,900
Operating supplies.....do.....	2,434,800
Indirect cost.....4 months..	1,195,900
Fixed cost.....0.5 percent of insurance base..	642,200
Spare parts.....	1,046,800
Miscellaneous expense.....	380,500
Total.....	7,989,600

TABLE B-3. - Mine pit equipment cost summary, 100,000-tpd open pit mining operation

Item No.	Item	Quantity	Size	Unit hp	Total hp	Total cost
01100	Drill, primary.....	4	Rotary, electric-powered quarry drill, 70,000 lb bit load.	500	2,000	\$918,200
01101	Drill, secondary...	2	Track mounted, with gasoline-powered compressor.	100	200	54,700
01102	Powder truck.....	2	15-ton-capacity, pneumatic AN-FO gasoline-powered.	120	240	46,800
01103	Shovel.....	5	15 cu yd electric powered.....	700	3,500	3,910,600
01104	Truck.....	16	150-ton, rear-dump, diesel-powered...	1,600	25,600	5,600,000
01105	Front-end loader...	3	Diesel-powered, rubber-tired, 6 cu yd bucket.	325	975	272,200
01106	Dozer.....	3	Diesel-powered, rubber-tired, 76,000-lb draw bar pull.	400	1,200	308,300
01107	Dozer.....	5	Diesel-powered, crawler tractor, 50,000 lb draw bar pull.	270	1,350	382,600
01108	Motor grader.....	4	Diesel powered, 14-ft blade, 40,000-lb draw bar pull.	230	920	249,200
01109	Water truck.....	3	Diesel-powered, 5,000-gal capacity...	300	900	131,200
01110	Service vehicle....	15	Gasoline-powered maintenance trucks, cranes, and miscellaneous vehicles.	80	1,200	327,900
01111	Utility vehicle....	50	Forty-five 3/4-ton pickups, 4 sedans, 1 station wagon.	80	4,000	169,400
-	Subtotal.....	-	-	-	-	12,371,100
-	Contingency.....	-	-	-	-	1,237,100
-	Subtotal.....	-	-	-	-	13,608,200
-	Interest during construction.	-	-	-	-	680,400
-	Total.....	-	-	-	-	14,288,600

TABLE B-4. - Plant and buildings cost summary, 100,000-tpd open pit mining operation

Item No.	Item	Quantity	Size	Total cost
02100	Transformer station.....	2	3,200 kV-A 69,000-v to 4,160-v transformer with semi-permanent building.	\$49,400
02101	Switch.....	2	Main disconnect 4,160-v.....	12,600
02102	Distribution wire.....	100,000 ft	Main distribution overhead line, 4-single size 1-0 wires.	105,100
02103	Circuit breaker.....	10	Weatherproof, portable oil circuit breakers.....	63,100
02104	Portable cable.....	7,000 ft	Three conductor extra heavy duty insulation, size 1-0 wire.	29,400
02105	Coupler.....	10	Heavy duty electric couplers for portable cable.....	4,200
02106	Pole.....	104	Poles for overhead distribution system, includes installation.	32,900
02107	Accessories for distribution line.	1	Cross arms, insulators, and accessories, at \$3,900 per mile.	18,400
02108	Primer and cap houses.....	2	20 ft x 20 ft filled concrete building at \$11.00/sq ft.	8,800
02109	Ammonium nitrate bin.....	1	1,000,000-pound capacity steel tank.....	40,100
02110	Blasting equipment.....	1	Galvanometer and generator in a shack on skids.....	1,500
02111	Mine office and change building...	1	60 ft x 100 ft with 15-ft eave including utilities at \$33.00/sq ft.	198,000
02112	Office furniture and equipment....	1	60 ft x 100 ft at \$16.00/sq ft.....	96,000
02113	Mine service building.....	1	80 ft x 125 ft with 36-ft eave including utilities at \$24.00/sq ft.	240,000
02114	Repair and service shop.....	1	120 ft x 250 ft with 36-ft eave including utilities at \$26.00/sq ft.	780,000
02115	Shop equipment and tools.....	1	Includes hoists, welders, and general shop tools.....	180,000
02116	Warehouse.....	1	60 ft x 100 ft with 20-ft eave including utilities at \$16.00/sq ft, 1/2 charged to mine.	48,000
02117			Parts inventory and maintenance supplies.....	1,000,000
02118	Administration building.....	1	40 ft x 80 ft with 10-ft eave including utilities at \$37.00/sq ft, 1/2 charged to mine.	59,200
02119	Fuel tank, gasoline.....	1	10,000-gal horizontal steel tank.....	8,900
02120	Fuel tank, diesel fuel.....	1	7,500-bbl cone roof steel tank.....	75,900
02121	Lube tank, hydraulic and crank case.	2	3,000 and 4,000 gal horizontal steel tanks.....	8,100
02122	-	-	Property acquisition cost.....	300,000
02123	-	-	Exploration, development, and feasibility study.....	3,000,000
02124	-	-	Environmental studies and hearings.....	2,250,000
02125	-	-	Preproduction stripping, 36,000,000 tons at \$0.28 per ton.	10,080,000
-	Subtotal.....	-	-	18,689,600
-	Contingency.....	-	-	1,869,000
-	Interest during development.....	-	-	1,027,900
-	Subtotal.....	-	-	21,586,500
-	Credit for copper mined during development.	-	-	7,711,300
-	Total.....	-	-	13,875,200

TABLE B-5. - Cost summary, primary crushing, conveying, and intermediate storage section, 40,000-tpd copper concentrator

Item No.	Item	Quantity	Size	Unit hp	Total hp	Cost		Total cost	
						Material	Labor		
03100	Cyratory crusher.....	1	54 in.....	-	-	\$371,700	\$70,000	\$441,700	
03101	Crusher motor.....	1	-	500	500	53,600	10,300	63,900	
03102	Apron feeder.....	1	72 in x 18 ft.....	30	30	41,500	7,800	49,300	
03103	Belt conveyor.....	1	48 in x 38 ft.....	2	2	9,500	1,800	11,300	
03104	Belt conveyor.....	1	54 in x 1,484 ft.....	500	500	270,900	51,100	322,000	
03105	Magnet.....	1	54 in x 60 in.....	7.5	7.5	8,700	300	9,000	
03106	Vibrating feeder.....	5	48 in x 6 ft.....	12	60	45,900	8,600	54,500	
03107	Belt conveyor.....	1	48 in x 425 ft.....	500	500	79,000	14,900	93,900	
03108	Surge bin.....	2	200-ton.....	-	-	33,500	56,700	90,200	
03109	Dust collector.....	1	34,000 cfm, wet type..	75	75	23,000	4,400	27,400	
03110	Pump.....	1	8 in x 6 in rubber-lined, centrifugal.	15	15	4,700	900	5,600	
03111	Bridge crane.....	1	75-ton, 5-ton auxiliary, 55 ft span.	85	85	113,100	21,400	134,500	
03112	Passenger elevator.....	1	2,500-lb capacity.....	25	25	31,300	5,900	37,200	
-	Subtotal.....	-	-	-	-	1,800	1,086,400	254,100	1,340,500
-	Excavation.....	-	-	-	-	-	30,900	206,500	237,400
-	Concrete.....	-	-	-	-	-	187,700	239,500	427,000
-	Buildings.....	-	-	-	-	-	364,400	120,900	485,300
-	Piping.....	-	-	-	-	-	208,300	100,100	308,400
-	Electrical.....	-	-	-	-	-	219,000	202,500	421,500
-	Painting.....	-	-	-	-	-	9,100	8,500	17,600
-	Instrumentation.....	-	-	-	-	-	14,700	5,800	20,500
-	Insulation.....	-	-	-	-	-	2,000	300	2,300
-	Subtotal.....	-	-	-	-	-	1,036,100	883,900	1,920,000
-	Total direct costs.....	-	-	-	-	-	2,122,500	1,138,000	3,260,500
-	Field indirect.....	-	-	-	-	-	-	-	569,000
-	Total construction.....	-	-	-	-	-	-	-	3,829,500
-	Engineering.....	-	-	-	-	-	-	-	191,500
-	Administration and overhead...	-	-	-	-	-	-	-	191,500
-	Subtotal.....	-	-	-	-	-	-	-	4,212,500
-	Contingency.....	-	-	-	-	-	-	-	421,200
-	Subtotal.....	-	-	-	-	-	-	-	4,633,700
-	Fee.....	-	-	-	-	-	-	-	231,700
-	Subtotal.....	-	-	-	-	-	-	-	4,865,400
-	Interest during construction..	-	-	-	-	-	-	-	243,300
-	Total.....	-	-	-	-	-	-	-	5,108,700

TABLE B-7. - Cost summary, grinding section, 40,000-tpd copper concentrator

Item No.	Item	Quantity	Size	Unit hp	Total hp	Cost		Total cost	
						Material	Labor		
05100	Belt feeder.....	32	30 in x 111 ft.....	3	96	\$451,200	\$84,900	\$536,100	
05101	Belt conveyor.....	14	30 in x 143 ft.....	7.5	105	232,600	43,700	276,300	
05102	Belt scale.....	10	30 in.....	0.5	5	45,900	8,600	54,500	
05103	Rod mill.....	10	10 ft x 16 ft.....	-	-	1,617,800	380,800	1,998,600	
05104	Rod mill motor.....	10	-	800	8,000	339,700	65,200	404,900	
05105	Rod mill splitter.....	10	-	-	-	43,900	8,200	52,100	
05106	Rod mill charger.....	10	-	-	-	71,100	13,400	84,500	
05107	Rod mill, rod storage rack....	10	-	-	-	7,200	1,300	8,500	
05108	Rod charge.....	900 tons	-	-	-	173,800	-	173,800	
05109	Pump.....	40	10 in x 8 in rubber-lined, centrifugal.	75	3,000	230,500	43,600	274,100	
05110	Hydrocyclone.....	60	20 in.....	-	-	148,400	27,900	176,300	
05111	Ball mill.....	20	10.5 ft x 13 ft.....	-	-	3,213,700	756,400	3,970,100	
05112	Ball mill motor.....	20	-	800	16,000	679,300	130,400	809,700	
05113	Ball mill charge.....	1,340 tons	-	-	-	386,600	-	386,600	
05114	Sampler.....	10	-	0.5	5	17,500	3,300	20,800	
05115	Sump pump.....	3	2.5 in rubber-lined, centrifugal.	7.5	22.5	3,900	800	4,700	
05116	Bridge crane.....	1	30-ton, 5-ton auxiliary, 43-ft span.	25	25	56,800	10,700	67,500	
-	Subtotal.....	-	-	-	-	27,259	7,719,900	1,579,200	9,299,100
-	Excavation.....	-	-	-	-	-	220,000	1,470,200	1,690,200
-	Concrete.....	-	-	-	-	-	1,334,000	1,700,600	3,034,600
-	Buildings.....	-	-	-	-	-	2,589,300	859,100	3,448,400
-	Piping.....	-	-	-	-	-	1,479,900	711,100	2,191,000
-	Electrical.....	-	-	-	-	-	1,556,300	1,439,000	2,995,300
-	Painting.....	-	-	-	-	-	64,800	60,500	125,300
-	Instrumentation.....	-	-	-	-	-	104,200	41,000	145,200
-	Insulation.....	-	-	-	-	-	13,900	1,800	15,700
-	Subtotal.....	-	-	-	-	-	7,362,400	6,283,300	13,645,700
-	Total direct costs.....	-	-	-	-	-	15,082,300	7,862,500	22,944,800
-	Field indirect.....	-	-	-	-	-	-	-	3,931,200
-	Total construction.....	-	-	-	-	-	-	-	26,876,000
-	Engineering.....	-	-	-	-	-	-	-	1,343,800
-	Administration and overhead...	-	-	-	-	-	-	-	1,343,800
-	Subtotal.....	-	-	-	-	-	-	-	29,563,600
-	Contingency.....	-	-	-	-	-	-	-	2,956,400
-	Subtotal.....	-	-	-	-	-	-	-	32,520,000
-	Fee.....	-	-	-	-	-	-	-	1,626,000
-	Subtotal.....	-	-	-	-	-	-	-	34,146,000
-	Interest during construction..	-	-	-	-	-	-	-	1,707,300
-	Total.....	-	-	-	-	-	-	-	35,853,300

TABLE B-9. - Cost summary, byproduct molybdenum recovery section, 40,000-tpd copper concentrator

Item No.	Item	Quantity	Size	Unit hp	Total hp	Cost		Total cost
						Material	Labor	
07100	Thickener.....	1	75 ft x 14 ft.....	7.5	7.5	\$63,300	\$11,300	\$74,600
07101	Pump.....	1	5 in x 4 in rubber-lined, centrifugal...	15	15	3,300	600	3,900
07102	Conditioner.....	1	6 ft x 5 ft.....	5	5	2,000	400	2,400
07103	Rougher flotation unit.....	32	4 banks of 8 cells, 40 cu ft.....	3.75	120	54,700	10,300	65,000
07104	Pump.....	2	8 in x 6 in rubber-lined, centrifugal...	30	60	8,300	1,500	9,800
07105	First cleaner flotation unit.....	10	2 banks of 5 cells, 40 cu ft.....	3.75	37.5	17,500	3,300	20,800
07106	Pump.....	1	6 in x 6 in rubber-lined, centrifugal...	25	25	3,800	800	4,600
07107	Second cleaner flotation unit.....	12	2 banks of 6 cells, 22.5 cu ft.....	2.25	27	18,800	3,600	22,400
07108	Pump.....	2	5 in x 4 in rubber-lined, centrifugal...	15	30	6,500	1,300	7,800
07109	Hydrocyclone.....	3	6 in.....	-	-	2,300	400	2,700
07110	Ball mill.....	1	5 ft x 5 ft.....	-	-	17,600	4,100	21,700
07111	Ball mill motor.....	1	-	60	60	3,200	600	3,800
07112	Ball mill charge.....	1	11 tons.....	-	-	3,100	-	3,100
07113	Third cleaner flotation unit.....	2	2 banks of 4 cells, 22.5 cu ft.....	2.25	18	12,900	2,400	15,300
07114	Pump.....	8	5 in x 4 in rubber-lined, centrifugal...	15	30	6,500	1,300	7,800
07115	Pump.....	1	4 in x 4 in rubber-lined, centrifugal...	10	10	2,500	500	3,000
07116	Fourth cleaner flotation unit.....	10	2 banks of 5 cells, 10 cu ft.....	1.5	15	12,800	2,400	15,200
07117	Pump.....	2	3 in x 3 in rubber-lined, centrifugal...	5	10	2,800	500	3,300
07118	Fifth cleaner flotation unit.....	6	2 banks of 3 cells, 12 cu ft.....	1.5	9	9,000	1,700	10,700
07119	Pump.....	1	2 in x 1.5 in rubber-lined, centrifugal..	3	3	1,100	300	1,400
07120	Insoluble cleaner flotation unit..	6	1 bank of 6 cells, 12 cu ft.....	1.5	9	9,000	1,700	10,700
07121	Pump.....	1	2 in x 1.5 in rubber-lined, centrifugal..	3	3	1,100	300	1,400
07122	Final cleaner flotation unit.....	6	1 bank of 6 cells, 12 cu ft.....	1.5	9	9,000	1,700	10,700
07123	Pump.....	2	2 in x 1.5 in rubber-lined, centrifugal..	3	6	1,100	300	1,400
07124	Drum filter.....	1	4 ft x 6 ft.....	2	2	7,900	1,500	9,400
07125	Dryer.....	1	45 cu ft tumble dryer.....	15	15	79,800	15,000	94,800
07126	Flotation launderer.....	630	12 in.....	-	-	29,000	5,400	34,400
07127	Storage bin.....	2	75-ton.....	-	-	12,600	21,200	33,800
-	Subtotal.....	-	-	-	526	401,500	94,400	495,900
-	Excavation.....	-	-	-	-	11,400	76,200	87,600
-	Concrete.....	-	-	-	-	69,400	88,500	157,900
-	Buildings.....	-	-	-	-	134,700	44,700	179,400
-	Piping.....	-	-	-	-	77,000	37,000	114,000
-	Electrical.....	-	-	-	-	80,900	74,800	155,700
-	Painting.....	-	-	-	-	3,400	3,200	6,600
-	Instrumentation.....	-	-	-	-	5,400	2,100	7,500
-	Insulation.....	-	-	-	-	700	100	800
-	Subtotal.....	-	-	-	-	382,900	326,600	709,500
-	Total direct costs.....	-	-	-	-	784,400	421,000	1,205,400
-	Field indirect.....	-	-	-	-	-	-	210,500
-	Total construction.....	-	-	-	-	-	-	1,415,900
-	Engineering.....	-	-	-	-	-	-	70,800
-	Administration and overhead.....	-	-	-	-	-	-	70,800
-	Subtotal.....	-	-	-	-	-	-	1,557,500
-	Contingency.....	-	-	-	-	-	-	155,800
-	Subtotal.....	-	-	-	-	-	-	1,713,300
-	Fee.....	-	-	-	-	-	-	85,700
-	Subtotal.....	-	-	-	-	-	-	1,799,000
-	Interest during construction.....	-	-	-	-	-	-	90,000
-	Total.....	-	-	-	-	-	-	1,889,000

TABLE B-11. - Cost summary, lime preparation section, 40,000-tpd copper concentrator

Item No.	Item	Quantity	Size	Unit hp	Total hp	Cost		Total cost
						Material	Labor	
09100	Hopper.....	1	50-ton.....	-	-	\$4,600	\$7,700	\$12,300
09101	Belt feeder.....	1	18 in x 21 ft.....	0.25	0.25	3,800	800	4,600
09102	Bucket elevator.....	1	60 ft 8 in x 5 in buckets..	5	5	8,300	1,500	9,800
09103	Storage bin.....	1	250-ton.....	-	-	19,000	32,300	51,300
09104	Vibrating feeder.....	2	12 in x 2 ft.....	1.5	3	1,700	400	2,100
09105	Belt conveyor.....	2	18 in x 58 ft.....	1	2	16,000	3,000	19,000
09106	Ball mill.....	1	5 ft x 14 ft.....	-	-	53,600	12,600	66,200
09107	Ball mill motor.....	1	-	150	150	11,700	2,200	13,900
09108	Ball mill.....	1	4 ft x 10 ft.....	-	-	24,000	42,500	66,500
09109	Ball mill motor.....	1	-	60	60	6,800	1,300	8,100
09110	Pump.....	2	5 in x 5 in rubber-lined, centrifugal.	15	30	6,500	1,300	7,800
09111	Pump.....	1	4 in x 3 in rubber-lined,	10	10	2,400	500	2,900
09112	Hydrocyclone.....	6	10 in.....	-	-	13,800	2,600	16,400
09113	Pump.....	2	5 in x 5 in rubber-lined, centrifugal.	10	20	2,800	500	3,300
09114	Tank with agitator.....	3	18 ft diam x 18 ft.....	3	9	48,100	9,000	57,100
09115	Pump.....	6	5 in x 5 in rubber-lined, centrifugal.	15	90	19,600	3,700	23,300
-	Subtotal.....	-	-	-	379	242,700	121,900	364,600
-	Excavation.....	-	-	-	-	6,900	46,100	53,000
-	Concrete.....	-	-	-	-	41,900	53,400	95,300
-	Buildings.....	-	-	-	-	81,400	27,000	108,400
-	Piping.....	-	-	-	-	46,500	22,300	68,800
-	Electrical.....	-	-	-	-	48,900	45,200	94,100
-	Painting.....	-	-	-	-	2,000	1,900	3,900
-	Instrumentation.....	-	-	-	-	3,300	1,300	4,600
-	Insulation.....	-	-	-	-	400	100	500
-	Subtotal.....	-	-	-	-	231,300	197,300	428,600
-	Total direct costs.....	-	-	-	-	474,000	319,200	793,200
-	Field indirect.....	-	-	-	-	-	-	159,600
-	Total construction.....	-	-	-	-	-	-	952,800
-	Engineering.....	-	-	-	-	-	-	47,600
-	Administration and overhead...	-	-	-	-	-	-	47,600
-	Subtotal.....	-	-	-	-	-	-	1,048,000
-	Contingency.....	-	-	-	-	-	-	104,800
-	Subtotal.....	-	-	-	-	-	-	1,152,800
-	Fee.....	-	-	-	-	-	-	57,600
-	Subtotal.....	-	-	-	-	-	-	1,210,400
-	Interest during construction..	-	-	-	-	-	-	60,500
-	Total.....	-	-	-	-	-	-	1,270,900

TABLE B-13. - General facilities and utilities

Item No.	Item	Quantity	Size	Total cost
11100	Mill office.....	1	50 ft x 50 ft structure within the mill building at \$15.00/sq ft.	\$37,500
11101	Office furniture and equipment.	1	50 ft x 50 ft at \$4.00/sq ft.....	10,000
11102	Repair and service shop.....	1	90 ft x 300 ft structure within the mill building at \$23.00/sq ft.	621,000
11103	Shop equipment and tools.....	1	Includes hoists, welders and general shop tools at \$6.00/sq ft.	162,000
11104	Warehouse.....	1	60 ft x 100 ft with 20-ft eave, including utilities at \$16.00/sq ft, 1/2 charged to mill.	48,000
11105	Parts inventory.....	1	Parts inventory and maintenance supplies..	1,000,000
11106	Administration building.....	1	40 ft x 80 ft with 10-ft eave, including utilities at \$37.00/sq ft, 1/2 charged to mill.	59,200
11107	Utility vehicle.....	4	3/4-ton pickup.....	13,600
11108	Service vehicle.....	2	Flat bed truck.....	19,400
-	Subtotal.....	-	-	1,970,700
-	Contingency.....	-	-	197,100
-	Subtotal.....	-	-	2,167,800
-	Interest during construction...	-	-	108,400
-	Total.....	-	-	2,276,200

TABLE B-14. - Cost summary, support facilities

Item No.	Item	Quantity	Size	Total cost
12100	Road.....	1	20 miles of gravel road at \$60,000.00/mile.	\$1,200,000
12101	Railroad track.....	1	20 miles of railroad at \$50,000.00/mile	1,000,000
12112	Mobile crane.....	1	30-ton capacity.....	100,000
12113	Utility vehicle.....	4	3/4-ton pickup.....	13,600
12114	Townsite.....	1	Includes living quarters for 728 single and married people, commercial center, clinic, and municipal services of streets, electricity, sewers and water at \$20,000.00 per employee.	14,560,000
-	Subtotal.....	-	-	16,873,600
-	Contingency.....	-	-	1,687,400
-	Subtotal.....	-	-	18,561,000
-	Interest during construction...	-	-	928,000
-	Total.....	-	-	19,489,000

TABLE B-15. - Depreciation schedule, dollars

Item	Years straight- line depreciation	Yearly charge, dollars			
		Mine	Mill	Support facilities	Total
Buildings and facilities.....	20	268,900	2,572,600	838,000	3,679,500
Long-life mobile equipment.....	10	97,300	22,800	10,000	130,100
Short-life mobile equipment.....	5	1,497,500	6,600	2,700	1,506,800
Long-life stationary equipment.....	20	-	1,165,200	-	1,165,200
Tools and equipment.....	10	159,300	117,200	-	276,500
Other ¹		² 636,700	570,200	130,800	1,337,700
Total.....	-	2,659,700	4,454,600	981,500	8,095,800

¹Includes contingency and interest during development.

²Also includes property acquisition, exploration, development, feasibility studies, environmental studies, and preproduction stripping less credits for minerals mined during development.

TABLE B-16. - Plant utility requirements

Unit	Power, kwhr/hr	New water (from own wells), gpm	Recirculated water, gpm	Natural gas, Mscf/hr
Mill:				
Crushing section.....	2,600	-	100	-
Concentrator.....	26,600	4,300	12,800	-
Byproduct molybdenum recovery section.....	400	-	-	1.8
Lime preparation section..	300	-	-	-
Subtotal.....	29,900	4,300	12,900	1.8
Lighting and cranes.....	400	-	-	-
Fresh water.....	2,600	-	-	-
Recirculated water.....	1,000	-	-	-
Sanitary water.....	200	100	-	-
General facilities.....	400	-	-	.1
Miscellaneous and contingency.....	200	300	-	-
Subtotal.....	4,800	400	-	.1
Mine.....	3,000	50	-	1.2
Support facilities ¹	-	-	-	-
Total.....	37,700	4,750	12,900	3.1

NOTE.--Power: At \$0.0085/kw-hr

Mine - $\$0.0085 \times 3,000 \times 8,568 = {}^2\$218,500 = \$0.02/\text{ton}$

Mill - $\$0.0085 \times 34,700 \times 8,568 = {}^2\$2,527,100 = \$0.18/\text{ton}$

Water: At \$0.10 per 1,000 gallons

Mine - $\$0.10 \times 50 \times 60 \times 8,568 = {}^2\$2,600 = \text{nil per ton}$

Mill - $\$0.10 \times 4,700 \times 60 \times 8,568 = {}^2\$241,600 = \$0.02/\text{ton}$

Power: At \$0.52 per Mcf

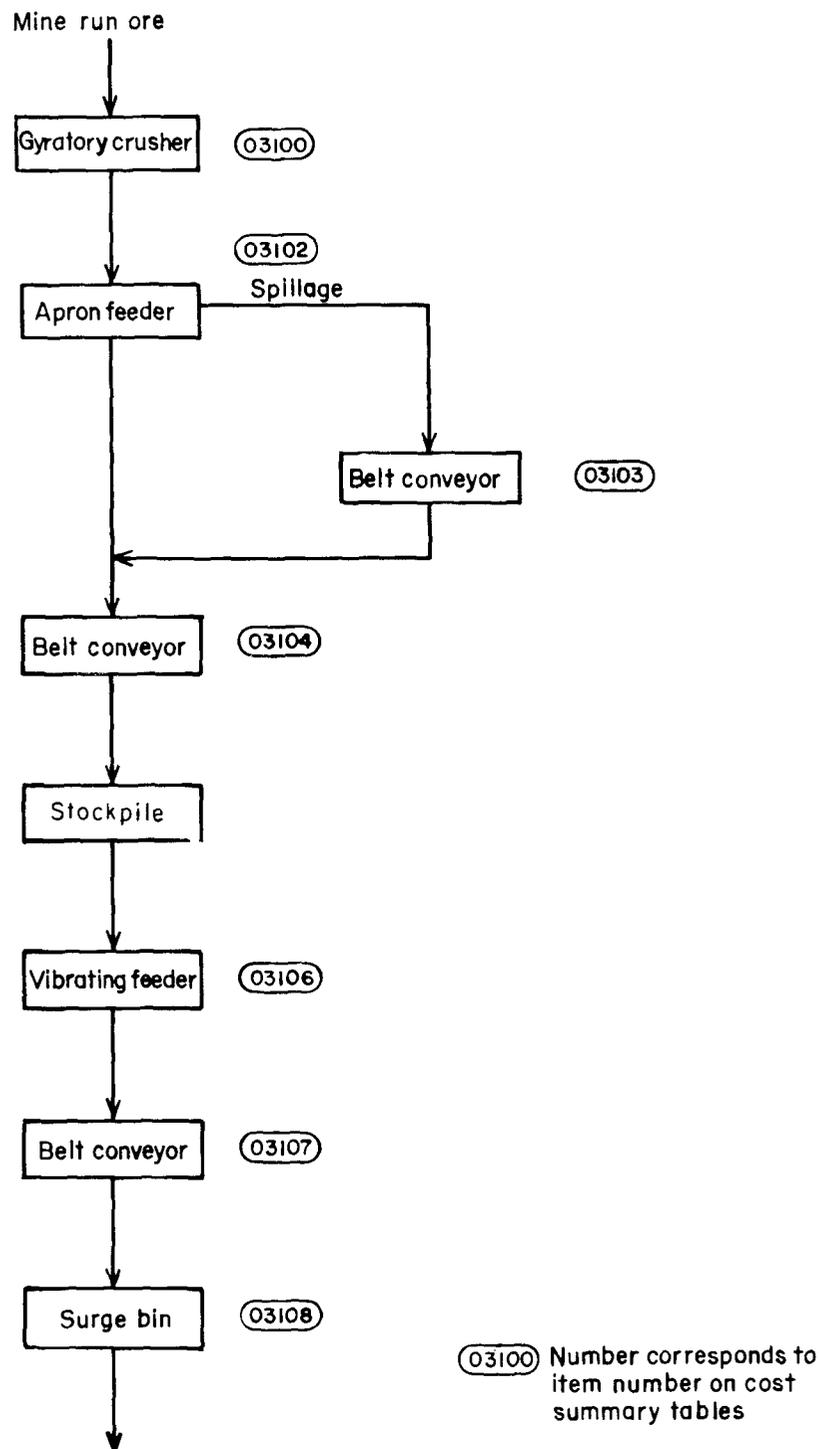
Mine - $\$0.52 \times 1.2 \times 8,568 = {}^2\$5,300 = \text{nil per ton}$

Mill - $\$0.52 \times 1.9 \times 8,568 = {}^2\$8,500 = \text{nil per ton}$

¹No costs are included for the townsite.

²Rounded to the nearest 100.

APPENDIX C.--FLOWSHEET FOR ARIZONA MILL



To secondary and tertiary crushing section

FIGURE C-1. - Flow diagram of primary crushing section, 40,000-tpd copper concentrator.

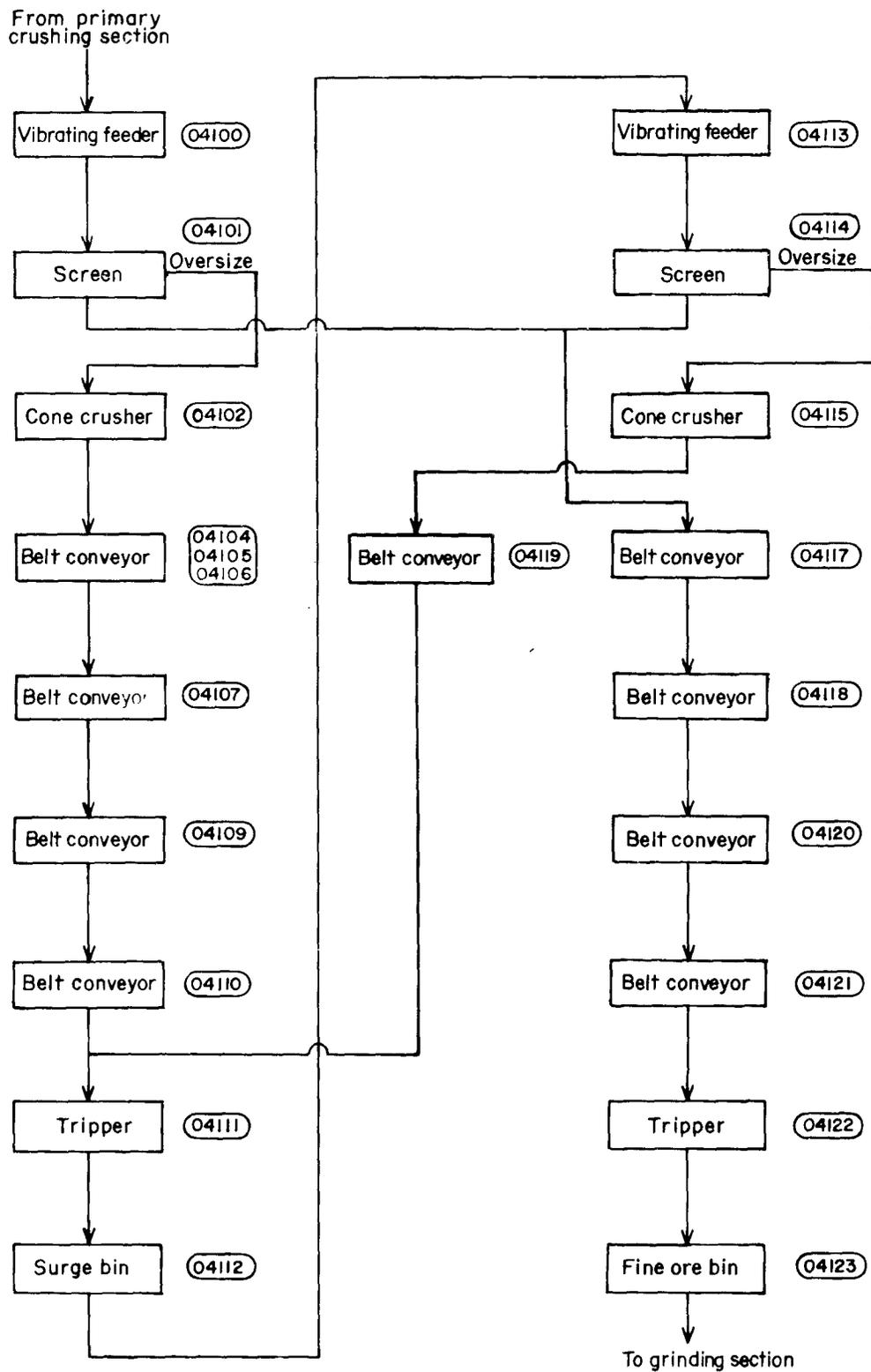


FIGURE C-2. - Flow diagram of secondary and tertiary crushing section, 40,000-tpd copper concentrator.

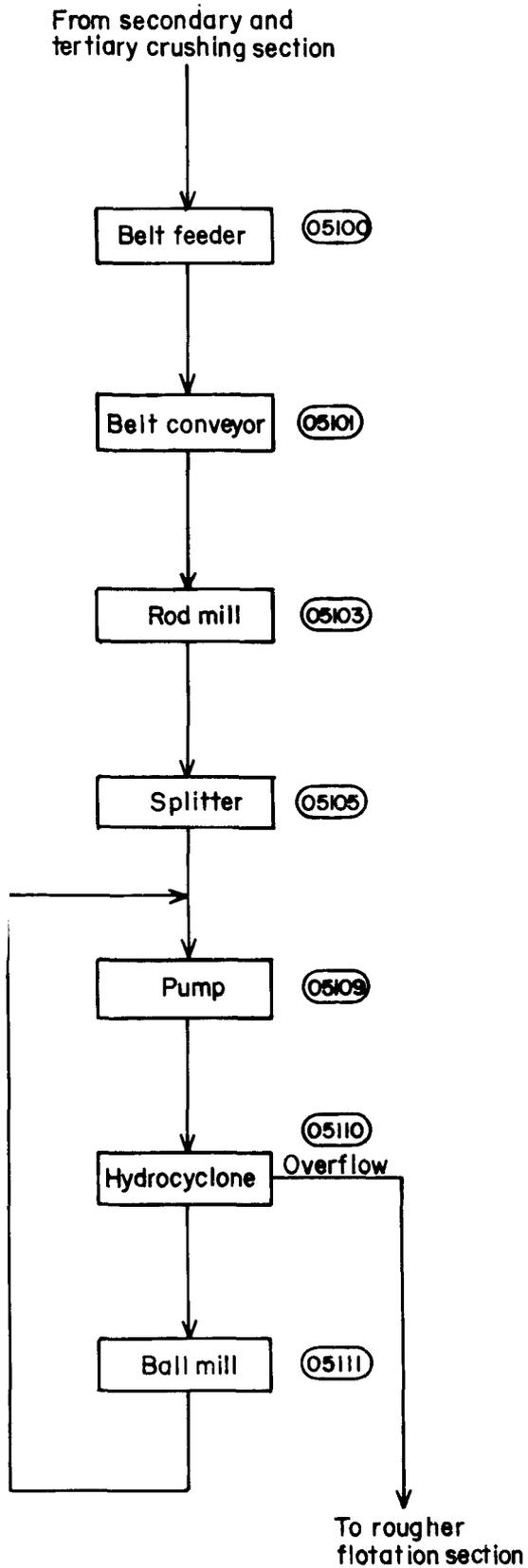


FIGURE C-3. - Flow diagram of grinding section, 40,000-tpd copper concentrator.

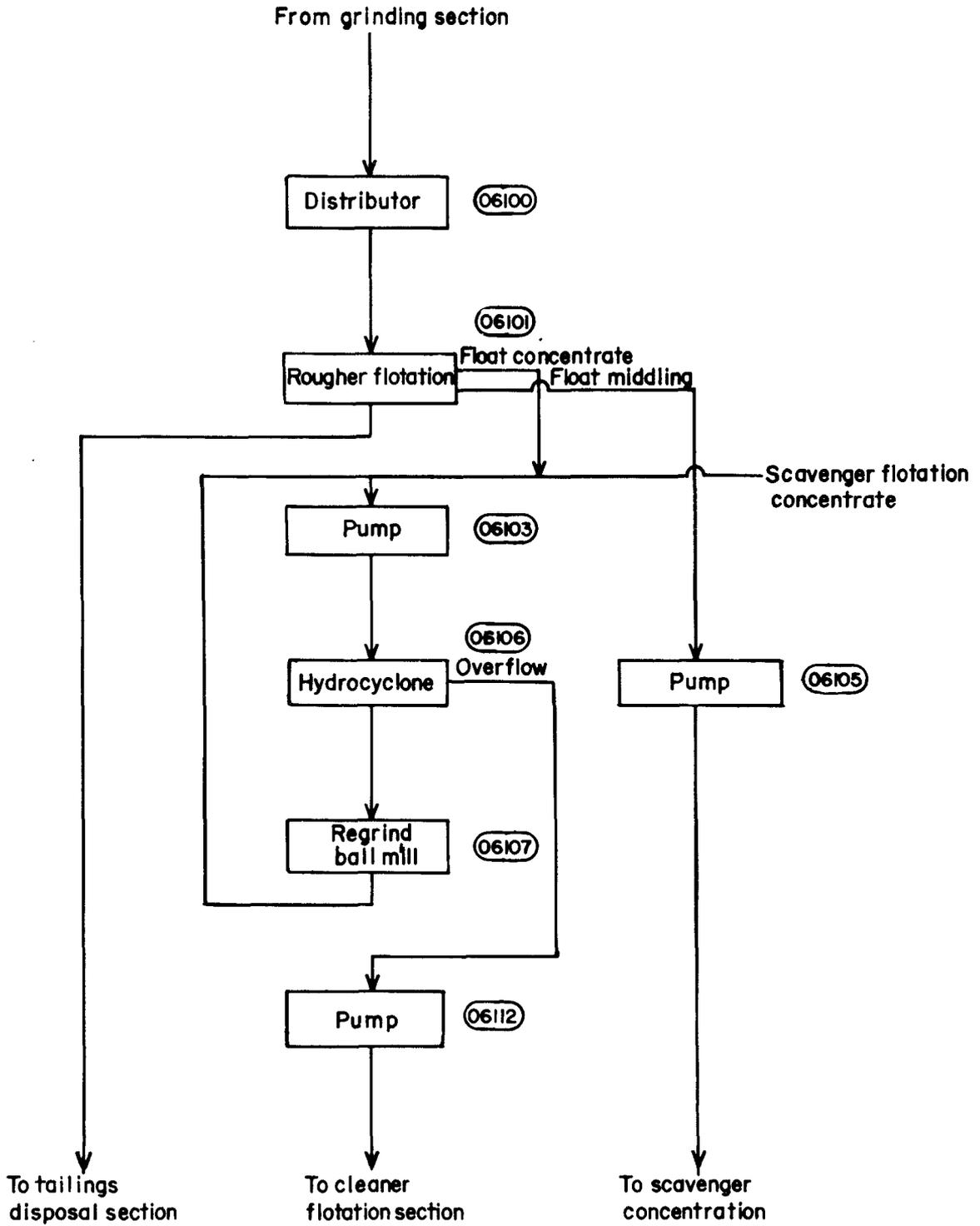


FIGURE C-4. - Flow diagram of rougher flotation section, 40,000-tpd copper concentrator.

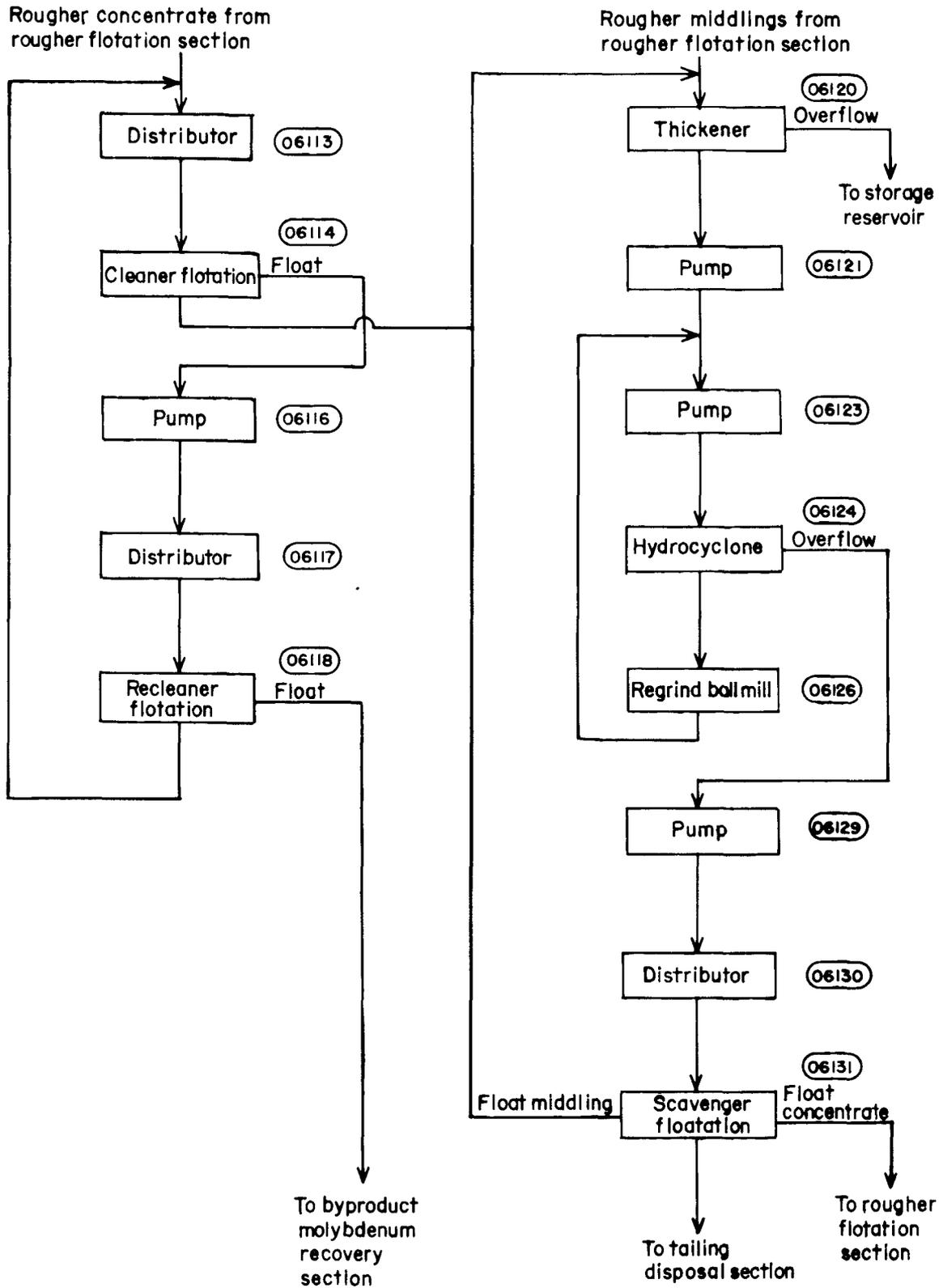


FIGURE C-5. - Flow diagram of cleaner flotation section, 40,000-tpd copper concentrator.

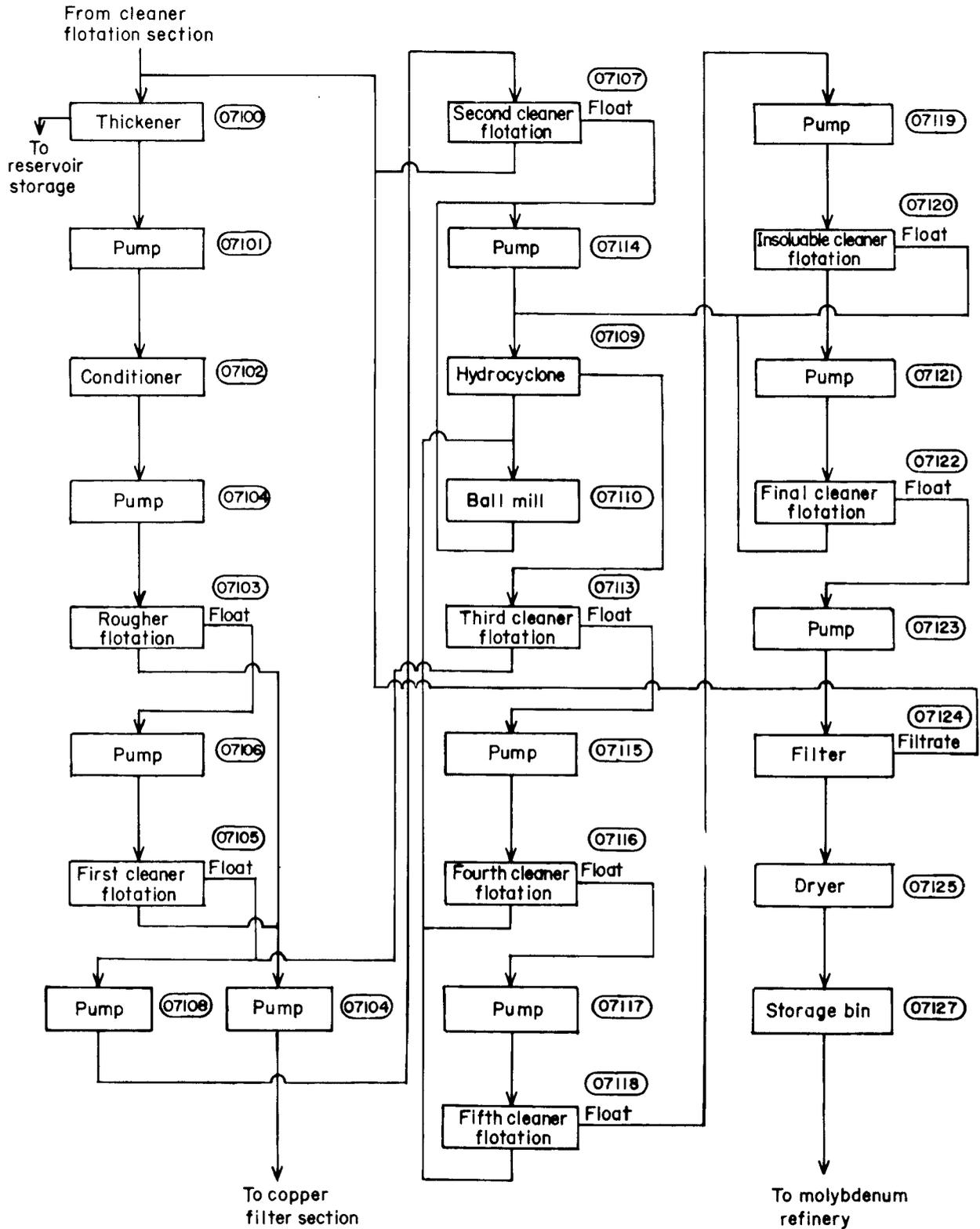


FIGURE C-6. - Flow diagram of byproduct molybdenum recovery section, 40,000-tpd copper concentrator.

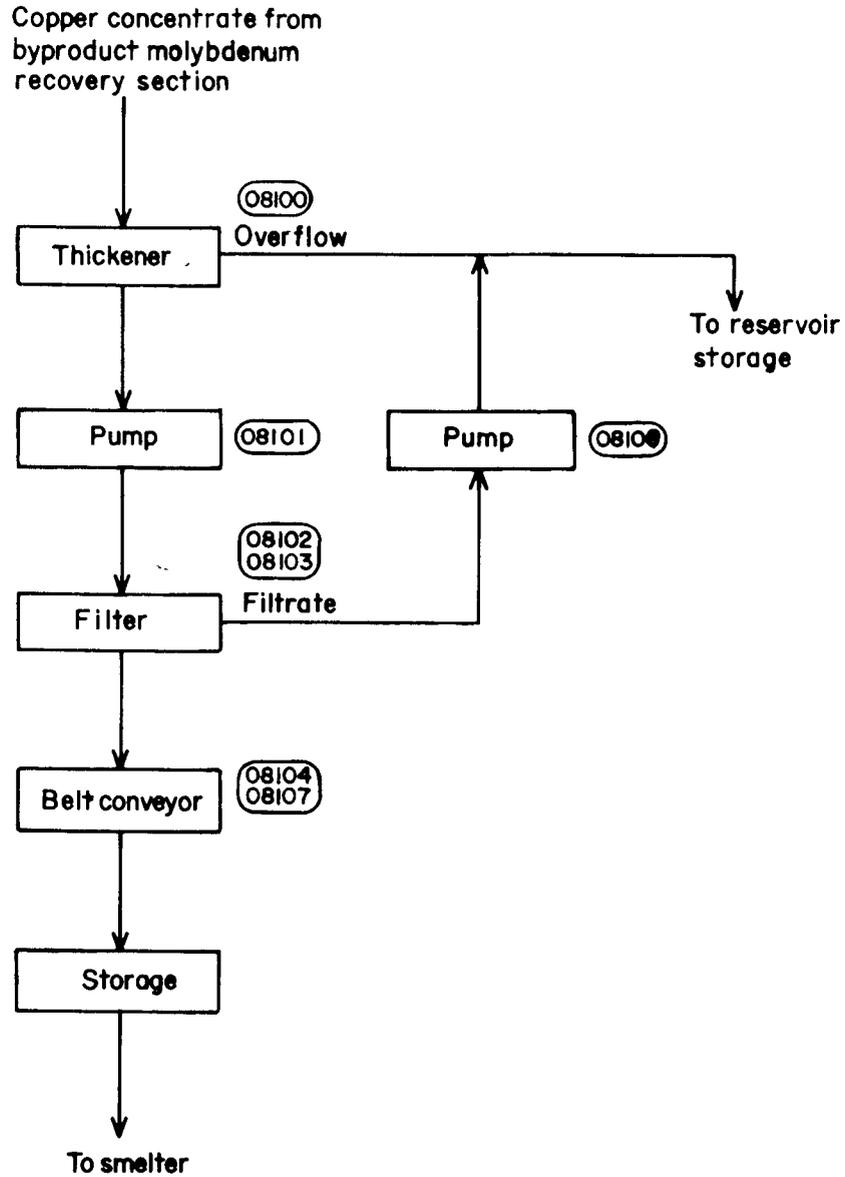


FIGURE C-7. - Flow diagram of copper filter section, 40,000-tpd copper concentrator.

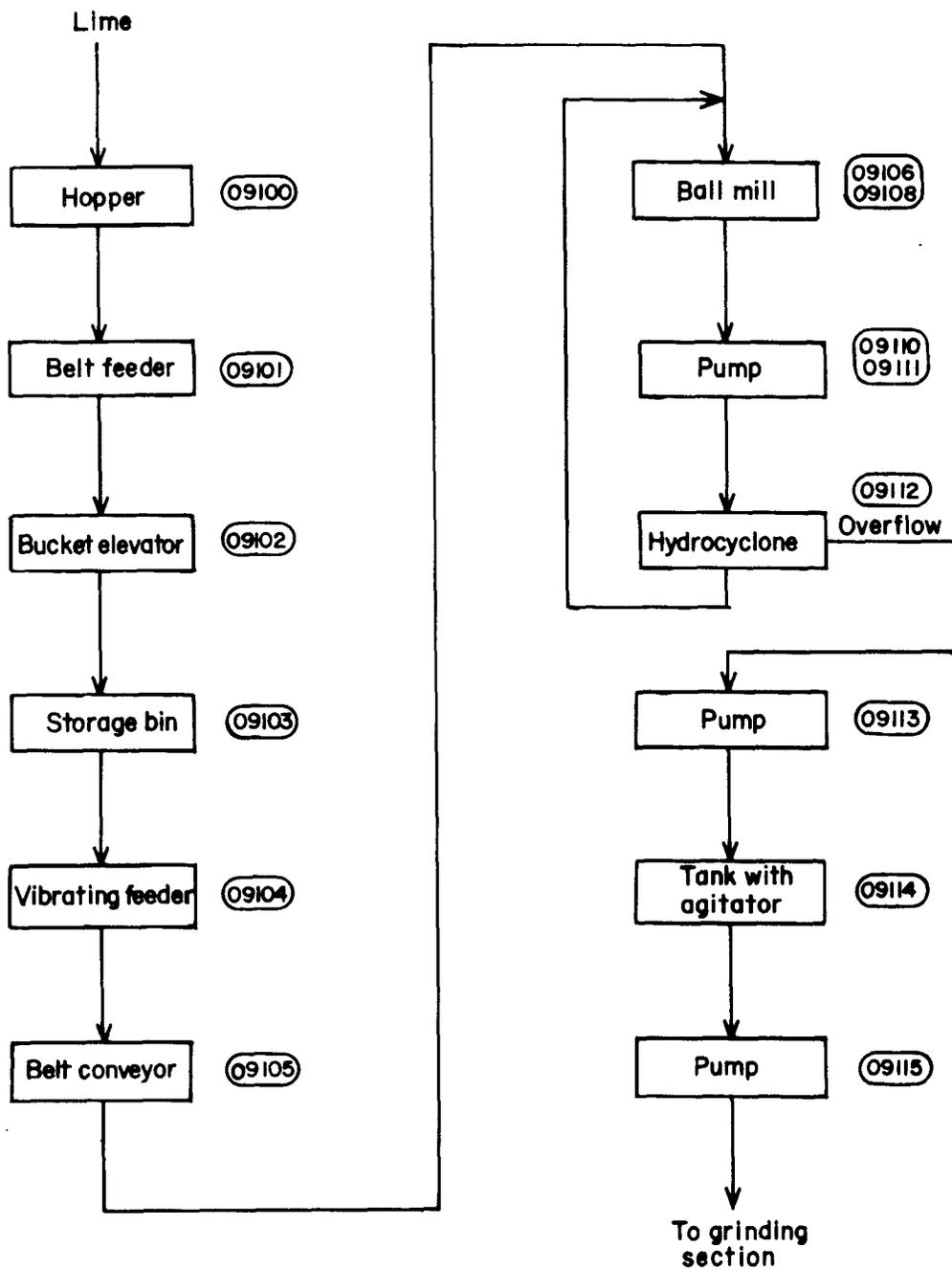


FIGURE C-8. - Flow diagram of lime preparation section, 40,000-tpd copper concentrator.

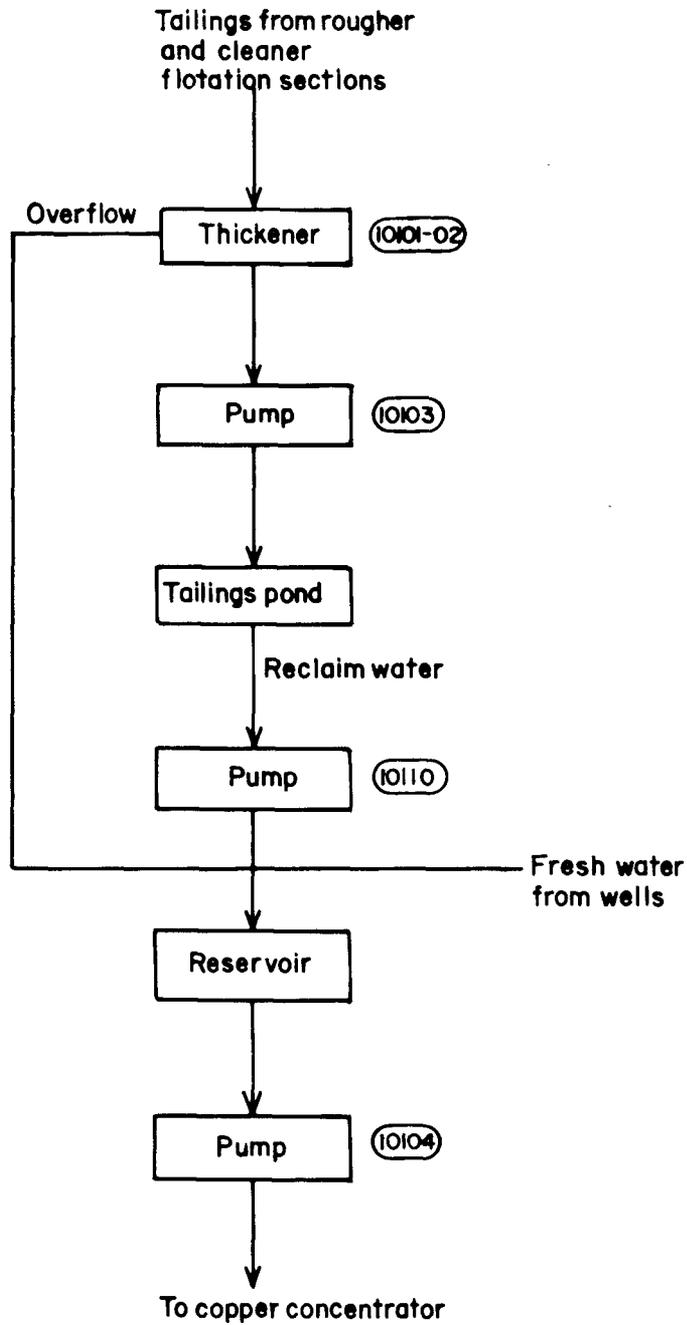


FIGURE C-9. - Flow diagram of tailings disposal section, 40,000-tpd copper concentrator.

APPENDIX D.--DIRECT COST OF MINING, CONCENTRATING, AND SUPPORT FACILITIES

TABLE D-1. - Direct mining cost, dollars

Item	Alaska	Arizona
Direct labor:		
880 man-hr/day--\$7.15/man-hr × 357 days/yr.....	2,246,200	-
880 man-hr/day--\$4.50/man-hr × 357 days/yr.....	-	1,413,700
Supervision--15 percent of labor.....	336,900	212,100
Subtotal.....	2,583,100	1,625,800
Maintenance:		
826 man-hr/day--\$7.65/man-hr × 357 days/yr.....	2,255,800	-
590 man-hr/day--\$5.00/man-hr × 357 days/yr.....	-	1,053,200
Supervision--20 percent of labor.....	451,200	210,600
Maintenance supplies and parts.....	3,248,000	2,840,100
Subtotal.....	5,955,000	4,103,900
Materials:		
Explosives.....	594,200	320,400
Drill bits and steel.....	160,400	147,500
Fuel.....	940,200	699,100
Tires.....	1,371,000	1,313,500
Miscellaneous operating supplies.....	306,600	249,400
Subtotal.....	3,372,400	2,729,900
Power.....	520,200	218,500
Water.....	5,100	2,600
Natural gas.....	35,100	5,300
Payroll overhead--25 percent of payroll.....	1,322,500	722,400
Taxable subsidies--15 percent of payroll.....	793,500	-
Subtotal.....	2,676,400	948,800
Total direct cost.....	14,586,900	9,408,400

TABLE D-2. - Direct concentrating cost, dollars

Item	Alaska	Arizona
Direct labor:		
1,243 man-hr/day--\$7.00/man-hr × 357 days/yr.....	3,106,300	-
1,243 man-hr/day--\$4.40/man-hr × 357 days/yr.....	-	1,952,500
Supervision--15 percent of labor.....	465,900	292,900
Subtotal.....	3,572,200	2,245,400
Maintenance:		
876 man-hr/day--\$7.50/man-hr × 357 days/yr.....	2,345,500	-
835 man-hr/day--\$4.90 man-hr × 357 days/yr.....	-	1,460,700
Supervision--20 percent of labor.....	469,100	292,100
Maintenance supplies and parts.....	1,926,300	1,267,200
Subtotal.....	4,740,900	3,020,000
Materials:		
Rods, balls, grinding and crushing surfaces-- \$0.265/ton × 40,000 tons/day × 357 days/yr.....	3,784,200	-
Rods, balls, grinding and crushing surfaces-- \$0.175/ton × 40,000 tons/day × 357 days/yr.....	-	2,499,000
Reagents--\$0.12/ton × 40,000 tons/day × 357 days/yr.....	1,713,600	-
Reagents--\$0.08/ton × 40,000 tons/day × 357 days/yr.....	-	1,142,400
Miscellaneous operating supplies.....	549,800	364,100
Subtotal.....	6,047,600	4,005,500
Power.....	5,502,000	2,527,100
Water.....	483,200	241,600
Natural gas.....	275,900	8,500
Payroll overhead--25 percent of payroll.....	1,596,700	999,600
Taxable subsidies--15 percent of payroll.....	958,000	-
Subtotal.....	8,815,800	3,776,800
Total direct cost.....	23,176,500	13,047,700

TABLE D-3. - Direct support facilities cost, dollars

Item	Alaska	Arizona
Direct labor:		
304 man-hr/day--\$7.00/man-hr × 260 days/yr.....	553,300	-
240 man-hr/day--\$4.40/man-hr × 260 days/yr.....	-	274,600
Supervision--15 percent of labor.....	83,000	41,200
Subtotal.....	636,300	315,800
Maintenance:		
200 man-hr/day--\$7.50/man-hr × 260 days/yr.....	390,000	-
80 man-hr/day--\$4.90/man-hr × 260 days/yr.....	-	101,900
Supervision--20 percent of labor.....	78,000	20,400
Maintenance supplies and parts.....	727,900	80,100
Subtotal.....	1,195,900	202,400
Power.....	63,100	-
Water.....	5,100	-
Natural gas.....	11,100	-
Payroll overhead--25 percent of payroll.....	276,100	109,500
Taxable subsidies--15 percent of payroll.....	165,600	-
Subtotal.....	521,000	109,500
Total direct cost.....	2,353,200	627,700