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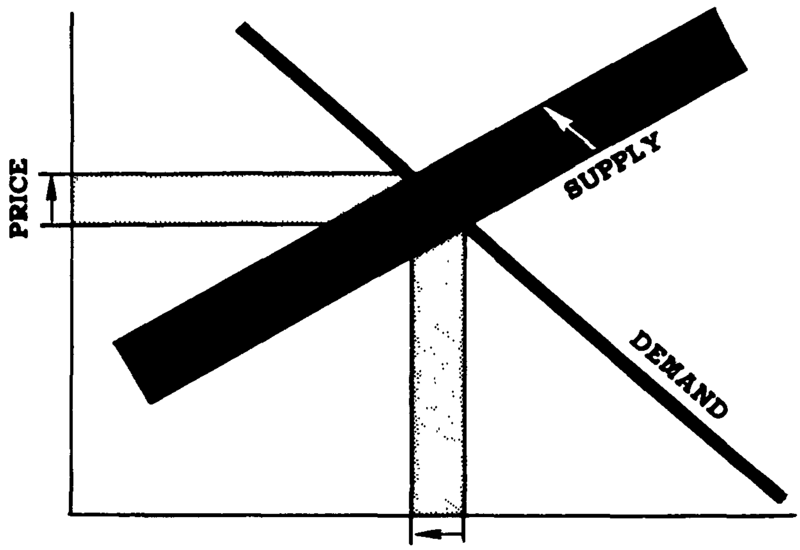
ECONOMIC ANALYSIS
OF
PROPOSED EFFLUENT GUIDELINES

THE ORE MINING AND DRESSING INDUSTRY



U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Planning and Evaluation
Washington, D.C. 20460

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This report has been reviewed by the Office of Planning and Evaluation, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

PREFACE

The attached document is a contractors' study prepared for the Office of Planning and Evaluation of the Environmental Protection Agency ("EPA"). The purpose of the study is to analyze the economic impact which could result from the application of alternative effluent limitation guidelines and standards of performance to be established under Sections 304(b) and 306 of the Federal Water Pollution Control Act, as amended.

The study supplements the technical study ("EPA Development Document") supporting the issuance of proposed regulations under Sections 304(b) and 306. The Development Document surveys existing and potential waste treatment control methods and technology within particular industrial source categories and supports proposal of certain effluent limitation guidelines and standards of performance based upon an analysis of the feasibility of these guidelines and standards in accordance with the requirements of Sections 304(b) and 306 of the Act. Presented in the Development Document are the investment and operating costs associated with various alternative control and treatment technologies. The attached document supplements this analysis by estimating the broader economic effects which might result from the required application of various control methods and technologies. This study investigates the effect of alternative approaches in terms of product price increases, effects upon employment and the continued viability of affected plants, effects upon foreign trade and other competitive effects.

The study has been prepared with the supervision and review of the Office of Planning and Evaluation of EPA. This report was submitted in fulfillment of Task Order No. 21, Contract 68-01-1541 by Arthur D. Little, Inc. Work was completed as of October 1975.

This report is being released and circulated at approximately the same time as publication in the Federal Register of a notice of proposed rule making under Sections 304(b) and 306 of the Act for the subject point source category. The study is not an official EPA publication. It will be considered along with the information contained in the Development Document and any comments received by EPA on either document before or during proposed rule making proceedings necessary to establish final regulations. Prior to final promulgation of regulations, the accompanying study shall have standing in any EPA proceeding or court proceeding only to the extent that it represents the views of the contractor who studied the subject industry. It cannot be cited, referenced, or represented in any respect in any such proceeding as a statement of EPA's views regarding the subject industry.

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EXECUTIVE SUMMARY

A. PURPOSE AND SCOPE

The United States Environmental Protection Agency (EPA) is charged under the Federal Water Pollution Control Act Amendments of 1972 with establishing effluent limitations which must be achieved by point sources of discharge into the navigable waters of the United States. Among the numerous industries covered by the Act are the subgroups of the metal mining industries identified as major group 10 in the Standard Industrial Classification (SIC) Manual, 1972, published by the Executive Office of the President (Office of Management and Budget). This industry category includes establishments engaged in mining ores for the production of metals, and includes all ore dressing and beneficiating operations, whether performed at mills operating in conjunction with the mines served or at mills operated separately. These include mills which crush, grind, wash, dry, sinter, or leach ore, or which perform gravity separation or flotation operations.

The purpose of this study was to assess the economic impact on the U.S. metallic ore mining and dressing industry (Table 1) of the cost of meeting EPA standards for pollution abatement applicable to the discharge of water streams from point sources.

TABLE 1

METALLIC ORE MINING AND DRESSING INDUSTRY CATEGORIES

SIC 1011 – Iron Ores
SIC 1021 – Copper Ores
SIC 1031 – Lead and Zinc Ores
SIC 1041 – Gold Ores
SIC 1044 – Silver Ores
SIC 1051 – Bauxite Ores
SIC 1061 – Ferroalloy Ores
SIC 1092 – Mercury Ores
SIC 1094 – Uranium/Radium/Vanadium Ores
SIC 1099 – Metal Ores, Not Elsewhere Classified

Compliance with the water pollution abatement standards may require the industry to install new physical facilities in its present operations, modify its current technical operations, or incorporate specialized facilities in new installations. Furthermore, the industry may have to install equipment and facilities capable of three levels of effluent water treatment such that:

- *Level I* – by 1977, for current industry installations, the best practicable control technology currently available (BPCTCA) is being used to control the pollutant content in the streams discharged by the industry;

- *Level II* – by 1983, for current industry installations, the best available technology that is economically achievable (BATEA) is being similarly used; and

- *Level III* – new source performance standards (NSPS) for new industry installations discharging directly in navigable waters to be constructed after the promulgation of applicable guidelines for water pollution abatement, the incorporation of facilities that will be capable of meeting these guidelines.

The study included the compilation and analysis of extensive data on the industry categories, and the assessment of the impact using cost data provided by the guidelines contractor.

B. CONCLUSIONS

The impact analysis carried out in this report has resulted in the following conclusions:

1. *Iron Ore Mining and Processing:* Only 8% of the industry would be impacted by the need to meet either BPCTCA or BATEA effluent guidelines. The impact on this portion of the industry would be slight with an estimated increase in product costs of only $0.03 per ton of pellet product. The impact on the whole industry would be negligible, and we would anticipate no impact on employment or community effects and no balance of payments effects.

2. *Copper Ore Mining and Processing:* Some 20% of this industry would be impacted by the BPCTCA and BATEA effluent guidelines. However, the impact on the major part of this impacted group would be negligible. A small portion of the industry (one company equal to 0.05% of the industry) would be severely impacted and would have a product price increase of $0.04 per lb of copper produced. (Note: As this report was being prepared, the operation represented here closed for economic reasons.)

3. *Lead and Zinc Mining and Processing:* About 45% of this industry would be impacted and directly affected by the BPCTCA and BATEA effluent guidelines. For this impacted portion, the product price increase would be slight ($.002 per lb of combined lead and zinc produced); however, capital outlays for facilities to meet guidelines requirements would amount to 60-70% of the annual capital expenditures or about 3% of the total invested capital.

While these outlays may appear sizeable, we believe they can be accommodated without significant adverse effect. As a result, there will be no employment or community effects and no effects on the balance of payments.

4. *Gold Ore Mining and Processing:* About 48% of the industry would be impacted by the BPCTCA and BATEA effluent guidelines. On this group, the product price increase would amount to \$2.15 per ounce of gold produced, and the capital outlay would be about 2.2 times the average annual capital expenditures or 10% of the total capital investment.

   These amounts of capital expenditure are sizeable; but because of the current prosperity of the industry, the additional capital cost can most likely be financed without evident strain. As a result, there will be no employment or community effects and no effects on the balance of payments.

5. *Silver Ore Mining and Processing:* About 80% of this industry would be directly affected by the proposed BPCTCA and BATEA guidelines. The impact would represent an increase of only \$.014 per ounce of silver produced; however, the capital required would amount to 17% of the average annual capital expenditures and 1.4% of the total investment. We do not believe this would have a significant impact or adverse effect on the industry. There would be no employment or community effects and no effects on the balance of payments.

6. *Bauxite Ore Mining:* 40% of this industry would be impacted by the BPCTCA and BATEA effluent guidelines. For this group the product price increase would be \$0.66 per ton of alumina produced. This is a small increase on a product selling for \$12.82 per ton (1972). Capital requirements would be about 10% of the average annual expenditures and 2.0% of the total investment.

   We do not believe this would have an adverse effect on this industry, and there would be no employment or community effects and no effects on the balance of payments.

7. *Ferroalloy Ore Mining and Processing:* This industry would have different impact effects for BPCTCA and BATEA.

   a. BPCTCA For this guideline, 2.0% of the industry would be impacted in a negligible way but 0.1% of the industry (representing about 17 small operators) would be severely impacted. This small group would have a product increase of $1.58 per ton of ore product and would require an investment of 2.4 times its average annual capital expenditures. It is likely that this group will be forced to close, but being such a small portion of the industry the lost production should have no impact on the ferroalloy market, prices, or on the balance of payments. Employment would be locally affected with the loss of about 50 jobs.

   b. BATEA For this guideline 93% of the industry would be impacted in a negligible way and the same 0.1% of the industry would be impacted as described above.

      The 93% portion would have a product price increase of only $0.01 per unit of product produced, which is essentially negligible; but it would require a substantial investment representing 22% of the average annual investment. We believe that this is manageable, and that there would be no adverse impact on the industry. There would be no employment or community effects and no effects on the balance of payments.

8. *Mercury Ore Mining and Processing:* The mercury industry would not be impacted by either BPCTCA or BATEA effluent guidelines.

9. *Uranium–Vanadium Ore Mining and Processing:* 45% of this industry would be impacted by imposition of the BPCTCA and BATEA effluent guidelines. The impact on product cost would be negligible, but the investment required would be 4-6% of the estimated annual capital expenditures and 2-4% of the total invested capital. This however would be manageable by the industry, and we do not believe that there would be any adverse impact on employment or community, and there would be no balance of payments effects.

10. *Metal Ores (NEC)* For these ores (titanium, platinum, rare earths, beryllium, antimony) there will be no appreciable impact due to the imposition of BPCTCA or BATEA effluent guidelines.

I. APPROACH

The economic impact of effluent guidelines on the ore mining and dressing industry was assessed by characterizing in some detail each of the ten subcategory ore mining industries. This characterization included a description of the ore reserves, mining and beneficiation practices, water usage, products produced, types of firms, types of plants, financial profiles, pricing policies, production and cost of production, employment, and potential constraints on financing additional capital assets. This information was then supplemented by Bureau of the Census data and cost data from the Guidelines Development Contractor to determine the impact of increased costs.

The Bureau of the Census data included its 1972 information on value added in mining, cost of supplies and machinery, value of shipments and receipts, and capital expenditures. This data is summarized in Table I-1 for the ore mining and dressing industries of concern in this study.

The guidelines contractor developed effluent limitations guidelines and standards of performance on the basis of numerous site visits, extensive sampling and analysis of effluent streams, mail and telephone surveys, and detailed cost estimates. The contractor studied the full range of control and treatment technologies applicable to each ore mining and dressing category and essentially assessed the cost of compliance with proposed standards on a plant-by-plant basis.

The effluent guidelines proposed by the contractor set forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available (BPCTCA) and the degree of effluent reduction attainable through the application of the best available technology economically available (BATEA). The standards of performance and pretreatment standards for new sources (NSPS) set forth the degree of effluent reduction achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives.

A. BASIS FOR IMPACT ANALYSIS

The economic analysis carried out for each ore mining subcategory assesses impact of compliance in terms of:

- Price effects,
- Production effects,
- Financial effects – corporate impact,
- Balance of payments effects, and
- Employment and community effects.

TABLE I-1

1972 BUREAU OF CENSUS DATA – SELECTED MINING INDUSTRIES
(Millions of Dollars)

		Value Added in Mining	Cost of Supplies and Machinery	Value of Shipments & Receipts	Capital Expenditures
Industry 1011*	– Iron Ores	701.9	423.7	1065.4	60.1
Industry 1021	– Copper Ores	1025.3	772.5	1588.5	209.2
Industry 1031	– Lead & Zinc Ores	199.7	77.6	251.3	26.0
Industry 1041	– Gold Ores	46.6	12.5	55.6	3.5
Industry 1044	– Silver Ores	13.9	7.4	19.5	1.9
Industry 1051	– Bauxite and Other Aluminum Ores	24.0	7.6	28.0	3.6
Industry 1061	– Ferroalloy Ores	135.2	61.3	160.5	36.0
Industry 1094	– Uranium – Radium – Vanadium Ores	155.0	114.7	227.1	42.4
Industry 1092	– Mercury and Ores N.E.C.	30.2	28.7	44.4	14.5

*SIC Code Number

1. Price and Production Effects

Price and production effects were considered together. Insofar as a firm perceives the prices at which it sells as beyond its influence – a perception characteristic of competitive relations among sellers – its decision is confined to the quantity of output to be sold. The sum, at each possible price, of the quantities to be sold by the firms composing the industry constitutes the supply and this supply, in conjunction with demand, determines price and quantity.

To the extent that sellers are not competitively arrayed, they (or at least some of them) see themselves as having some influence over price. Such firms (which may be called oligopolists) necessarily treat both quantity and price as associated parts of any market decision. Under these circumstances a supply schedule independent of the demand schedule cannot be conceived, but it is possible, by making the needed assumptions about the market behavior of sellers, to infer from cost schedules in conjunction with the demand schedule the quantities and prices that will move through the market.

Similar comments may be made with respect to buyers. In a competitive situation buyers select quantities on the basis of going prices; the aggregated quantities compose demand and thereby have an impact on price. Buyers who see themselves as influencing price (and who may be called oligopsonists) select price and thus the associated quantity. Although aggregate demand independent of supply cannot then be conceived, the total consequence for price and quantity can be estimated if the market behavior patterns of buyers can be discerned.

The costs of compliance appear as additions to the plant's fixed costs (depreciation, interest, etc.) and variable costs (operating expenses that are functions of output levels). The variable costs show as marginal (incremental) costs that determine the output level that is most profitable (least unprofitable) for the enterprise. The total costs (variable plus fixed) set a floor for sales price below which the firm will be unwilling to go over the long term.

It is to be expected that insofar as compliance costs do prompt altered output levels, for most firms and for the industry as a whole that change will be downward. However, to the extent that some establishments in an industry are less affected than others by the costs of abatement, those that are least affected may enlarge, not reduce, the level of production. For such firms, prices will have risen relative to costs, thereby inducing increased output. The new larger total output may be either more profitable or less profitable than ex-compliance output. In the rare instance, the new higher cost pattern may lead to the enlargement of industry output, but with impaired profitability; this can happen only as it is worthwhile for firms as part of their compliance programs to modify production processes in a way that introduces scale economies.

Were the impact of compliance costs upon the industry as a whole large enough to affect quantity and price in the market significantly, it would be necessary to understand the competitive/noncompetitive structure of that market in order to appreciate the price and quantity changes that would be occasioned. In the absence of such significant effect, a depiction of market structure is not needed.

The dimensions of demand, including the elasticity of quantities with respect to change in price, matter for an industry only as compliance induces some significant modifications in the behavior of sellers in the market. Where there are no significant modifications in response to any guideline no analysis of demand is called for. Similarly, where there are no significant changes in the industry's demand for inputs (apart from compliance inputs) the supply of these inputs need not be analyzed.

2. Financial Effects

There are financial effects that deserve to be considered if the additional capital funds that must be obtained to finance abatement can be mobilized only at higher interest cost, or if, in the extreme case, the funds available are insufficient to achieve compliance and to meet all the other capital requirements of the enterprise. These adverse financial effects are likely, of course, only if the enterprise is marginally viable even in the absence of occasion for abatement outlays or if compliance costs are significantly large and evidently will impair profits.

In general, the capital and operating costs to achieve pollution abatement would not be incurred by the companies in the absence of pollution abatement regulation; that is, they cannot be justified on the basis of conventional return-on-investment criteria. In plant-by-plant and company-by-company analysis of pollution abatement impact, two viewpoints have to be considered. The availability of capital for pollution abatement equipment at each plant has to be viewed from the standpoint of the resources available to the entire corporation. However, the justification for spending this capital at a particular plant would result from a study of that particular plant's economics which would take into account alternatives such as cost of production from a refitted plant, shifting production to other plants, and most important, the probability that this particular plant will remain a profitable entity.

It is, of course, to be expected that a large industrial corporation which is clearly viable, profitable, and acknowledged to have strong managerial and technical resources, will have access to substantial capital – in the form of debt or equity or both, plus pollution control bonds as a source of "off the balance sheet" financing.

3. Balance of Payments Effects

Balance of payments effects were assessed only with respect to an industry as a whole. If the result of pollution abatement is higher prices for the output of the industry, substitute goods may be attracted from abroad and thus enlarge the outflow of foreign exchange. If the output is an export good, the higher prices can occasion either higher or lower exchange inflows depending upon the elasticity of the foreign demand for the American good. Insofar as abatement results in lower prices of inputs to the industry, domestic input suppliers may be inclined to market their goods abroad, thus enlarging the inflow of foreign exchange. If inputs are imported, lowered prices and/or quantities can reduce the exchange outflow.

4. Employment and Community Effects

Employment and community effects are a function of the extent to which the level of operations is reduced in any affected enterprise in the industry. If the curtailment is significant or if the facility is completely shutdown, the employment and other community effects can be severe. On the other hand, compliance can mean enlarged output for those firms in the industry for which output prices have risen relative to costs. In such cases employment will be enlarged and the effects upon the community will be those of growth rather than of decline.

B. LEVELS OF IMPACT

By means of economic impact analysis each ore mining and milling industry can be separated into the following impact groups:

A. Those plants and companies where there will be no cost or a negligible cost imposed directly by the effluent guideline.

B. Those plants or companies where there will be some cost of compliance but where such a cost increase will not be sufficient to cause any significant impact on profits or on behavior in any of the markets in which sales or purchases are made. In other words, production and prices will be unaffected in consequence of the firm's own costs of compliance.

C. Those plants or companies where the costs of compliance would affect significantly: (a) the volume of production at the going prices of inputs and outputs and/or (b) the profitability of the firm and the cost and availability of capital to the firm.

C. LIMITS OF THE ANALYSIS

The costs provided by the Effluent Guideline Development Document are order-of-magnitude costs and in no way can be used as definitive engineering estimates. In using the costs developed by the Document and presented in this study, it must be remembered that these costs are applicable only to the degree of control proposed by the regulations described herein and cannot be construed to apply to any other degree of control.

Furthermore, the economic impacts assessed in this report for the various industry groups are a result of only those water pollution control requirements and resultant costs also described herein. The assessment does not include the economic impacts due to such things as air pollution control, OSHA standards, toxic or hazardous materials, increases in the prices of fuel and raw materials, etc. In fact, it should be noted that an economic impact results from any event that affects any of the following:

- Profitability
- Volume of production
- Price of output
- Price of any input

Although the impact of water pollution controls is, considered alone, insignificant for any enterprise or for the industry as a whole, the analysis does not rule out the possibility that the controls in combination with other factors affecting the industry may carry significant impact.

The range of error for costs developed in this manner can at best be within plus or minus 30%.

II. WATER USAGE IN THE METALLIC ORE MINING AND DRESSING INDUSTRY

The metal mining and dressing industry is a large user of water (Table II-1). Of the mineral industry segments under study, iron ore and copper ore mining account for by far the major uses and discharges of water, lead and zinc ore mining uses moderate amounts of water, and the usage of water by the other minerals is of minor importance.

The operation of, and the associated water use and discharge of metal mining and processing plants, is complex. Almost all of the operations involve mines (both open pit and underground) and various types of ore dressing plants where the valuable constituents in the ores are recovered. In the industries under study the combinations of mines and plants vary considerably. In general, however, the usage of water in the metallic ore mining and dressing industry is as follows:

- *Underground mines* consume some water, mainly for wet drilling to control dust. The amount is very small compared to that used in mining and milling plants. These mines often generate water from underground sources and have to pump it to the surface. Mine water is often used in the general milling process.

- *Open pit mines* consume essentially no water since dry drilling is the usual practice. These mines, if below the local water table, can generate substantial amounts of water, which is collected in sumps. Water from the sump, is pumped out of the pit for discharge or use in the plant system. Many of the copper mines also use significant amounts of water for dump leaching.

- *Milling plants* are by far the major users and dischargers of water in the mine-mill complex. Most milling or concentrating operations are wet processes, although there are exceptions such as the dry processing of some mercury ores and concentrates.

Wet milling processes often require about 3 to 6 tons of water per ton of ore processed. For example, the major method for concentrating copper ore is flotation, which is often carried out at 25% solids: i.e., three tons of water (720 gallons) per ton of ore processed.

In 1962, A. Kaufman (Trans. Society Mining Engineers – March 1967) estimated that 64% of the water used by the entire mineral industry was in processing, 27% for cooling and condensing, 6% in mining, and 3% for miscellaneous purposes. (See also Table II-2.)

TABLE II-1

METALLIC ORE MINING AND DRESSING INDUSTRY WATER USAGE AND DISCHARGE, 1968
(billion gallons per year)

		Water Intake				Gross Water Usage,	Water Discharge			
SIC CODE	Industry Segment	Total	Mine Water	Other	Treated Before Use	Including Recirculated	Total	Mine Water	Other	Treated Before Discharge
1011	Iron Ores	340	10	330	11	659	344	17	327	29
1021	Copper Ores	109	7	102	11	447	68	3	65	12
1031	Lead and Zinc Ores	17	6	12	*	21	54	40	14	8
1041	Gold and Silver Ores	6	1	5	*	11	7	1	6	1
1051	Bauxite and Al Ores									
1061	Ferroalloy Ores									
1092	Mercury Ores									
1094	Uranium – Vanadium	7	2	5	2	11	7	1	6	3
109	Miscellaneous Metal Ores	21	3	18	3	51	19	2	17	12
10	Metal Mining Total Industry	499	27	472	25	1202	500	67	433	65

*Less than 0.5.

Source: U.S. Department of Commerce 1967 Census of Mineral Industries; issued in 1971.

TABLE II-2

WATER USED – SELECTED MINERAL INDUSTRIES, 1962
(billion gallons per year)

Commodity	Intake	Gross Water	Recirculated	Consumed	Discharged (by difference)
Iron Ores	112.6	252.1	138.7	7.6	105.8
Copper Ores	81.0	174.6	94.4	29.7	50.5
Lead and Zinc Ores	22.9	24 8	2.0	1.5	21.3
Gold Ores	54.6	58.7	4.1	0.6	54.0
Uranium – Vanadium	7.2	8.3	1.0	3.0	4.3
Totals	278.3	518.5	240.2	42.4	235.9

Source: A. Kaufman, *Trans. Soc. Mining Engrs.,* March 1967.

Tables II-1 and II-2 show some significant differences in the two estimates of water for the same industry segments, which cannot be explained simply by the six-year time span between the two, thus indicating the difficulty in obtaining accurate information about water use in the mineral industry.

Figure II-1 shows the water flowsheet for a typical mine-mill complex, but there are many variations, depending on the particular industry segment. For example, almost all the large copper mines in the arid southwest have no discharge. Water is scarce and utilized to the utmost. The same is true of several gold mines in Nevada and some uranium operations. Also the flowsheet does not apply to some operations where no large amount of mill water is used, such as some mercury operations where processing is dry, and the only water used is for cooling purposes and is recycled.

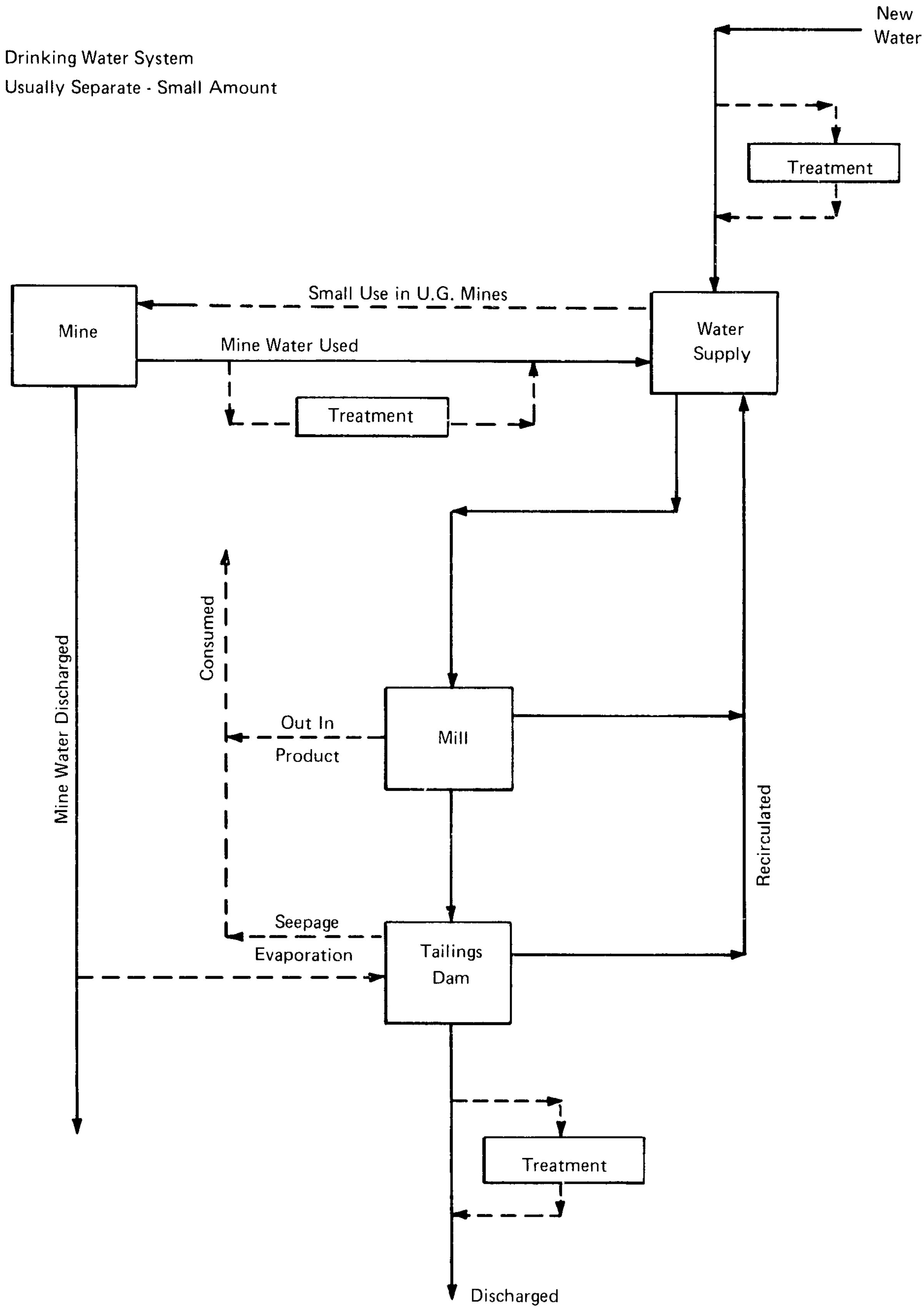


FIGURE II–1 MINE–MILL COMPLEX: TYPICAL WATER FLOW

III. IRON ORE MINING AND PROCESSING (SIC 1011)

A. INTRODUCTION

The 1972 usable iron ore shipments in the United States, exclusive of by-product ore (sinter from pyrite roasting), amounted to about 75 million long tons, valued at over $950 million and equivalent to a per capita consumption of about 1,000 pounds.

About 95% of the iron ore consumed in the United States goes to iron blast furnaces, with the remainder going to steel furnaces. Eighty-five percent of the ore used by the domestic iron and steel industry is furnished from captive mines owned and/or operated by the large integrated iron and steel companies. For instance, United States Steel Corporation owns and operates five iron ore mining and/or milling facilities in Minnesota and one in Wyoming. In addition to such domestic captive holdings, several of the larger companies control or have an interest in iron mines abroad.

The heart of the iron ore industry in the United States is the Lake Superior iron mining district in Minnesota and Michigan. Relatively small but significant production occurs also in New York, Pennsylvania, Alabama, Missouri, Texas, Wyoming, Utah, Georgia, Wisconsin, and California. Table III-1 shows the 1972 statistics of crude iron ore mined and the mine distribution by region. Over 80% of the total 188 million long tons of crude ore comes from the Lake Superior district. Crude ore production in 1973 was about 217 million long tons.

World-wide, and exclusive of the United States, iron ore production in 1972 was about 757 million long tons.

U.S. mine production has dropped during the last several years. In 1970, for example, it was about 90 million long tons; in 1971 it was 80 million long tons; and in 1973 it was 75 million long tons. In 1973, however, production increased to about 91 million long tons.

B. INDUSTRY DESCRIPTION

The Iron Ores Industry includes establishments engaged primarily in mining, beneficiating, or otherwise preparing iron ores and manganiferrous ores valued chiefly for their iron content. This industry includes production of sinter and other agglomerates except those associated with blast furnace operations.

1. Reserves

Iron ore is a mixture of iron oxide minerals occurring in combination with various impurities. The major iron-bearing minerals of importance are hematite

TABLE III-1

U.S. CRUDE IRON ORE PRODUCTION[1] IN 1972

District and State	Number of Mines	Total Production (thousands long tons)
Lake Superior District:		
Michigan	5	26,919
Minnesota	18	126,099
Wisconsin	1	2,477
Total	24	155,495
Southeastern States		
(Alabama, Georgia, North Carolina)	6	1,280
Northeastern States		
(New York, Pennsylvania)	4	6,818
Western States:		
Arizona	1	–
Missouri	2	4,703
Montana	1	9
Utah	4	4,828
Wyoming	3	4,836
Other[2]	13	9,678
Grand Total	58	187,648

1. Exclusive of ore containing 5% or more Mn.
2. Includes California, Colorado, Idaho, Nevada, New Mexico and Texas.

Source: Department of the Interior – U.S. Bureau of Mines Minerals Yearbook, 1972.

(Fe_2O_3) and magnetite (Fe_3O_4).* Most of the major ore deposits in the United States are found in the very ancient Pre-Cambrian rock formations located in the Lake Superior District. These deposits have resulted from the leaching of silica by surface waters from a siliceous banded iron formation. This natural process has resulted in an iron content ranging from about 50% to about 65%. The unleached unenriched ore formation of the Lake Superior District is known as taconite and in recent years has become the major source of iron units in the United States.

Oolitic iron ore, another form of ore body, occurs throughout the Appalachian region and is popularly referred to as "red ore." It furnishes some of the feed to blast furnaces in the Birmingham, Alabama, steel district. The iron content ranges from 25% to 40% and the ore has a relatively high phosphorus content.

Another important form of deposit is the contact-Metamorphic type found in the Western Cordilleras in our western states. Iron exists here in the form of magnetite, sometimes associated with minor amounts of the base-metal sulfides. Iron content varies from 50% to 65%.

U.S. reserves are large and have been reported as follows:

	Million Long Tons
Proven	10,494
Potential	96,353
Total	106,847

The total available resources of iron ore have increased substantially in recent years, primarily as a result of improved beneficiation techniques through which the very abundant low-grade iron formations can be economically converted to high-grade blast furnace charge materials. It is conceivable that this trend will continue as more sophisticated mining, beneficiating and transportation techniques render the very low-grade deposits economically attractive.

2. Mining

To a large extent, the physical characteristics of an ore body determine the mining method employed to exploit it. When the deposit lies below a relatively shallow overburden, open pit mining methods are used because of the favorable stripping ratio – the amount of overburden that must be removed per ton of ore mined. The economic stripping ratio varies from mine to mine, being as high as 7 to 1 for some direct-shipping ores, and no greater than 0.5 to 1 in many taconite deposits.

When the stripping ratio is too high to make open pit mining economical, underground mining is used. In general, underground mines have less productivity per man-hour than do open pit mines. Consequently, the number of underground iron ore mines has been decreasing progressively over the last three decades.

U.S. crude ore production in 1972 came from six underground mines and 52 open pits. In the same year, open pit mines accounted for 94.5% of the crude iron mined. The absolute number as well as the relative proportion of underground mines has been declining steadily in recent years as high costs and stringent consumer product specifications have forced the marginal mines to close down operations. For example, the total number of iron ore mines in the United States in 1969 was 92, of which 12 were underground, and in 1970 there were 74 iron ore mines, of which 10 were underground.

3. Beneficiation

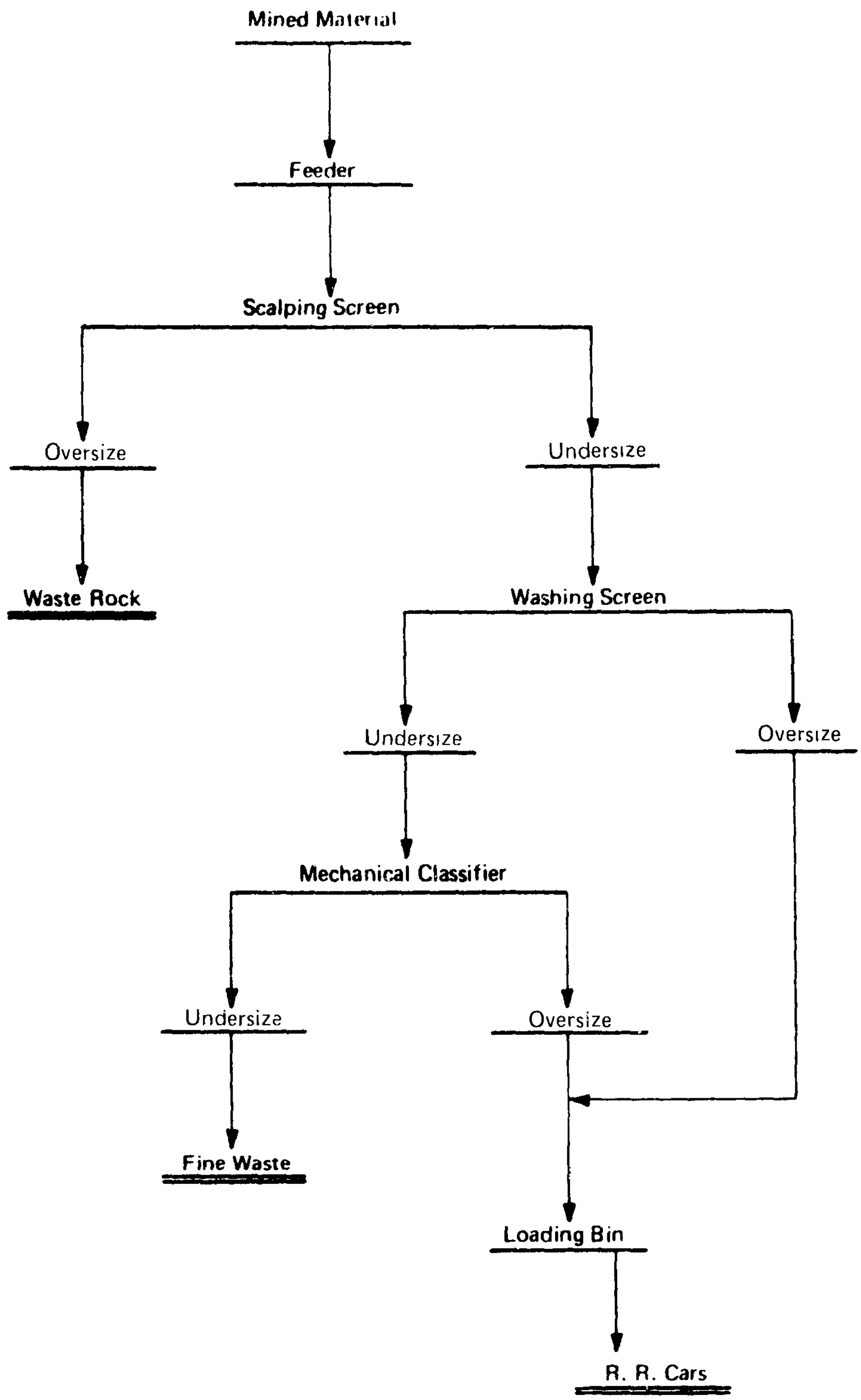
Beneficiation is any method of treating an iron mineral to produce a more desirable blast furnace burden. Thus, it includes such processes as crushing, grinding, screening, concentrating, classifying, pelletizing, and sintering. However, since sintering is generally carried out at the steelworks rather than at the mine, this agglomeration technique is not considered relevant to the present study.

The stringency of customer specifications for iron ore has made some form of ore beneficiation mandatory prior to shipment. The least that can be done to an ore is to crush and screen it, since optimum blast furnace operation demands ore sizes of +1/2 to -4 inch. In general, however, the exact beneficiation flowsheet adopted is determined by the characteristics of the ore. As the ore grade deteriorates and the level of impurities increases, the flowsheet becomes more complex. Figures III-1 and III-2, for example, illustrate, respectively, the flowsheets for a simple wash ore and a complex "intermediate" ore.

As stated previously, the ore characteristics and the ultimate use of the concentrate jointly determine the degree and type of beneficiation practiced. High-grade hard lump ores are generally sized to +1/2 inch -4 inches. The undersized material is either sold as such or agglomerated into pellets, briquettes, or nodules. On the other hand, soft iron-bearing materials containing clay and sand are beneficiated by washing in log washers or on screens and in various types of classifiers. From 45% to 70% of the iron can be recovered by this treatment and the concentrate contains 40% to 60% iron.

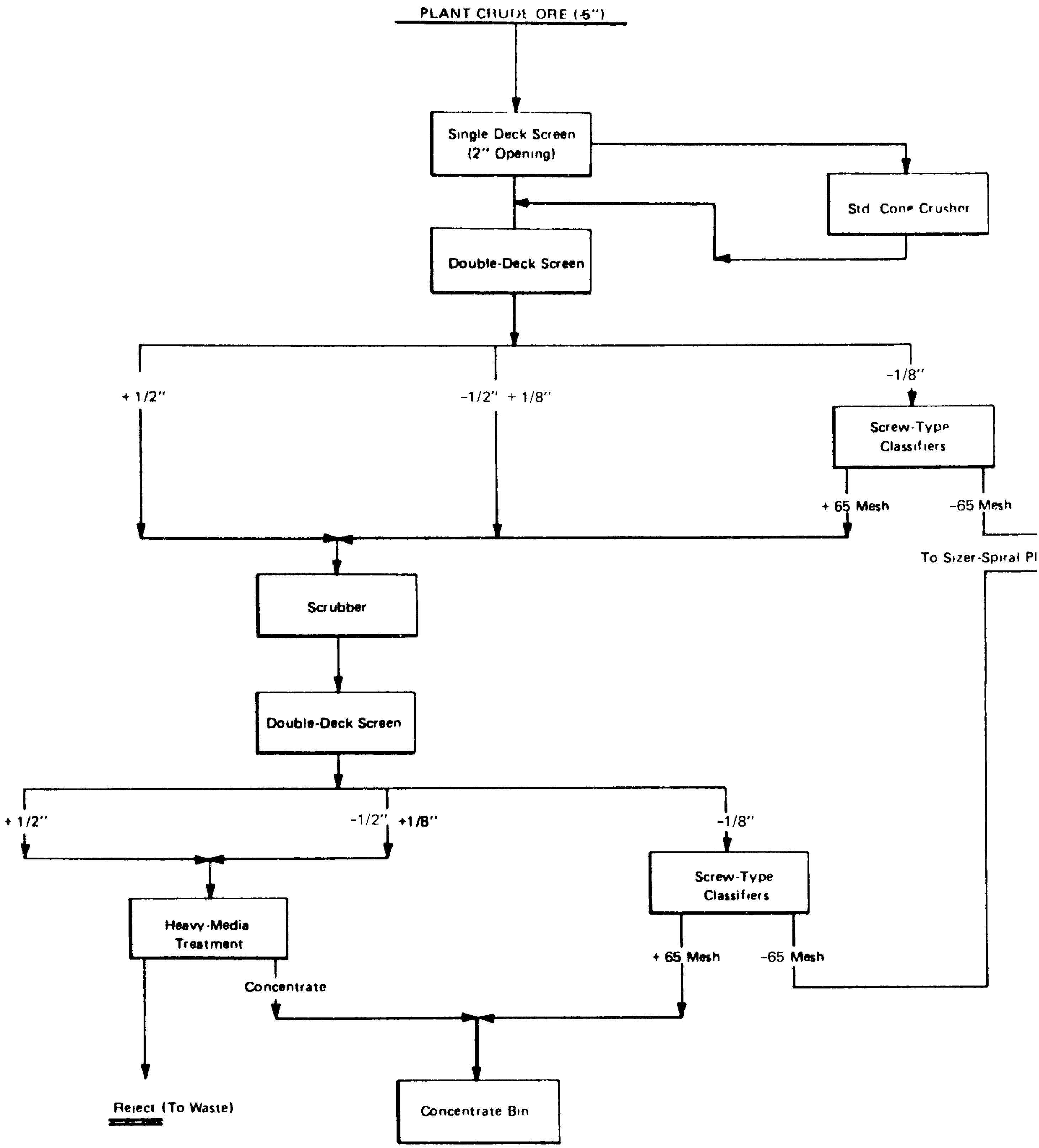
Coarse ore (>1/2") is gravity concentrated by jigging or heavy-media separation, whereas Humphrey spirals and wet cyclone separators are used to concentrate fine ores and the tailings from jigs and wash plants.

In the U.S. today, most of the salable iron units are produced in the form of pellets. These pellets are made by plants, particularly those in Minnesota, that process the taconite-type ores.



Source: *Watkins Encyclopedia of the Steel Industry*

FIGURE III-1 BENEFICIATION FLOWSHEET FOR A SIMPLE WASH-ORE



Source: Adapted from *Watkins Encyclopedia of the Steel Industry, 1969*

FIGURE III-2 BENEFICIATION FLOWSHEET FOR TREATMENT OF COMPLEX INTERMEDIATE ORE

Taconite ores can be magnetic (with magnetite mineralization) or nonmagnetic (with hematite mineralization) There is a significant production from nonmagnetic taconites, but the magnetic type accounts for some 55% of all U.S. iron ore production.

The magnetic ores are processed by fine grinding and magnetic separation techniques; a typical concentrator line is shown in Figure III-3. A large plant will consist of many similar "lines" or units. (One plant in Minnesota has 30.) Although the diagram shows a two-stage autogenous grinding procedure, some plants use the conventional rod mill, ball mill system. Also shown is a cationic flotation step which removes silica from the final magnetic concentrate to improve the product quality. This step is not commonly used in all plants.

Agglomeration, as performed at the mine site, is aimed at consolidating all -1/2 inch iron ores and ore mineral concentrates into sizes suitable for furnace charging. Pelletizing, the principal agglomeration technique, involves forming the moist material into balls that are then heat-hardened (induration) into durable pellets.

In the United States about 1% of usable domestic iron ore production is obtained as a by-product during the processing of copper, titanium and molybdenum ores. Where the economics justify it, iron also may be extracted as a co-product in the mining of copper, lead and zinc sulfide ores. The iron "cinder" derived in this manner is subsequently sintered for feeding to the blast furnace. However, the large-scale availability of high-grade pellets has drastically curtailed the demand for cinder. Iron may also be recovered from the processing of complex vanadium-bearing ores as well as from nickel plants. The former practice has been commercialized in South Africa and the U.S.S.R., and the latter process is practiced in Canada where iron-nickel pellets are thus produced.

4. Water Usage

The process of winning a concentrate from crude iron ore involves a combination of unit operations such as crushing, screening, gravity separation, cycloning, flotation and magnetic separation. Nearly all of these processes are wet operations that together consume anywhere from 600 to 7,000 gallons of water per ton of concentrate. Other operations also consume water: air conditioning, power generation, boiler feed, sanitary services, and miscellaneous cooling and condensing requirements. To satisfy these water needs, the iron ore mining/milling industry in 1968 took in 340 x 10^9 gallons, and its gross water consumption (including recirculated or reused water) amounted to 659 x 10^9 gallons. The corresponding water discharge (including mine water drained and discharged) was 344 x 10^9 gallons, of which about 8% received some form of treatment prior to discharge.

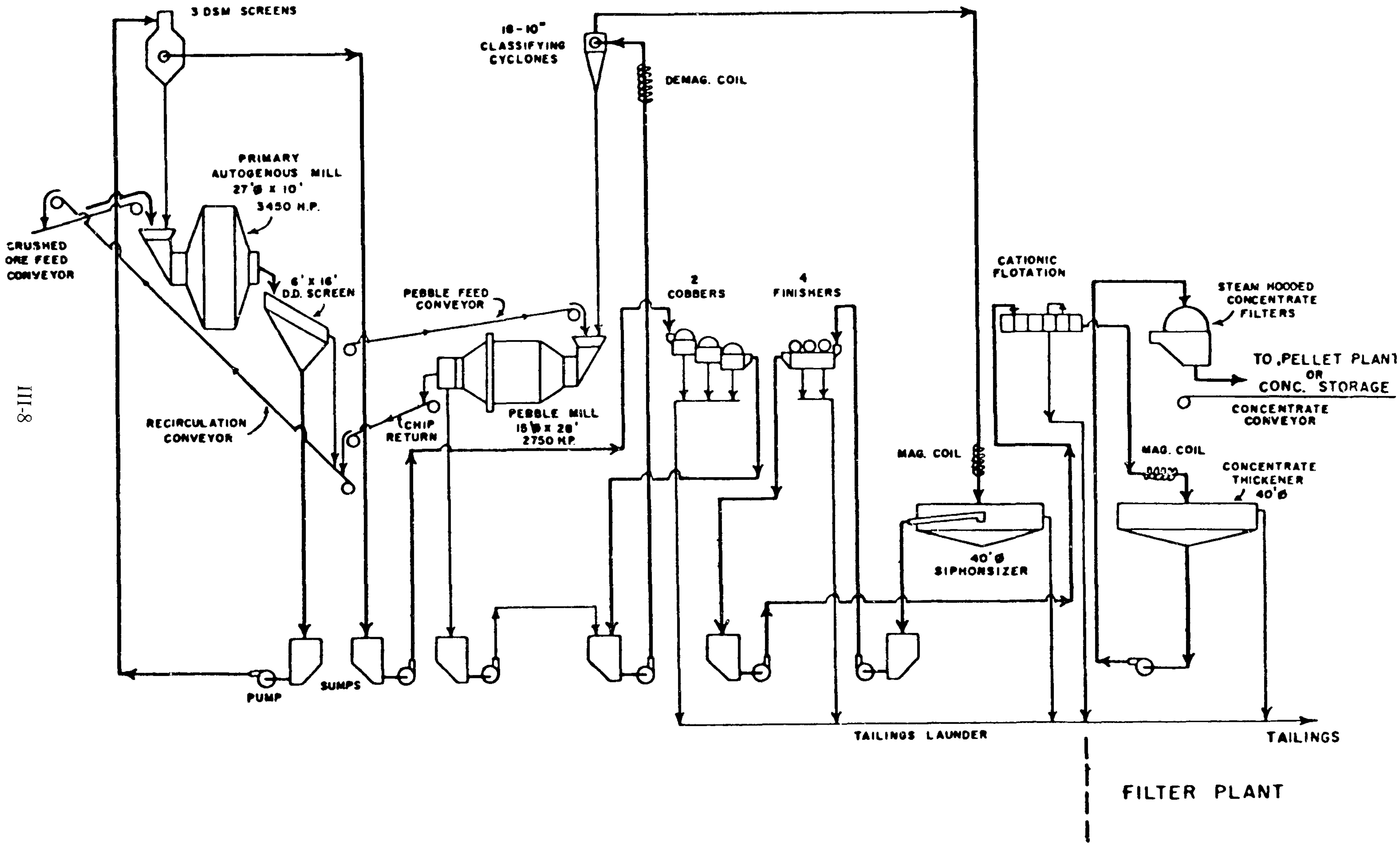


FIGURE III-3 TYPICAL CONCENTRATOR LINE

Among the treatment processes were primary and secondary settling in ponds or lagoons, coagulation with chemicals, and trickling and sand filtration. The need for some form of treatment can be appreciated from the fact that the tailings wastewater generated during iron ore beneficiation contains 70,000 to 500,000 mg of suspended solids per liter, 98% of which settles very rapidly and thus deposits large volumes of solids. Moreover, post treatment partially clarifies the wastewater and makes it suitable for reuse in the plant operation. A water balance for a typical Minnesota taconite mine and mill is shown in Figure III-4.

5. Products and By-products

The iron ore mining industry produces direct shipping ore, concentrates, and agglomerates (pellets). The production of these products in 1972 and their average grade were as follows:

	Thousands of Long Tons	% Fe
Direct Shipping Ore	5,830	55
Concentrates	14,757	65
Agglomerates (Pellets)	54,847	64

The pellets represent the major product and are usually produced in pelletizing plants located at the mine and concentrator site.

Unlike the nonferrous metals industries, there are essentially no by-products produced by the iron ore industry.

C. INDUSTRY OVERVIEW

The domestic iron ore mining industry can be divided into three major sectors:

1. Integrated steel and iron companies that mine iron ore principally for their own use:

   Armco Steel Corp.
   Bethlehem Steel Company
   CF&I Steel Corp.
   Inland Steel Co.
   Jones & Laughlin Steel Corp.
   Kaiser Steel Corp.
   Lone Star Steel Co.
   National Steel Corp.
   Republic Steel Corp.
   U.S. Pipe & Foundry Co.
   United States Steel Corporation

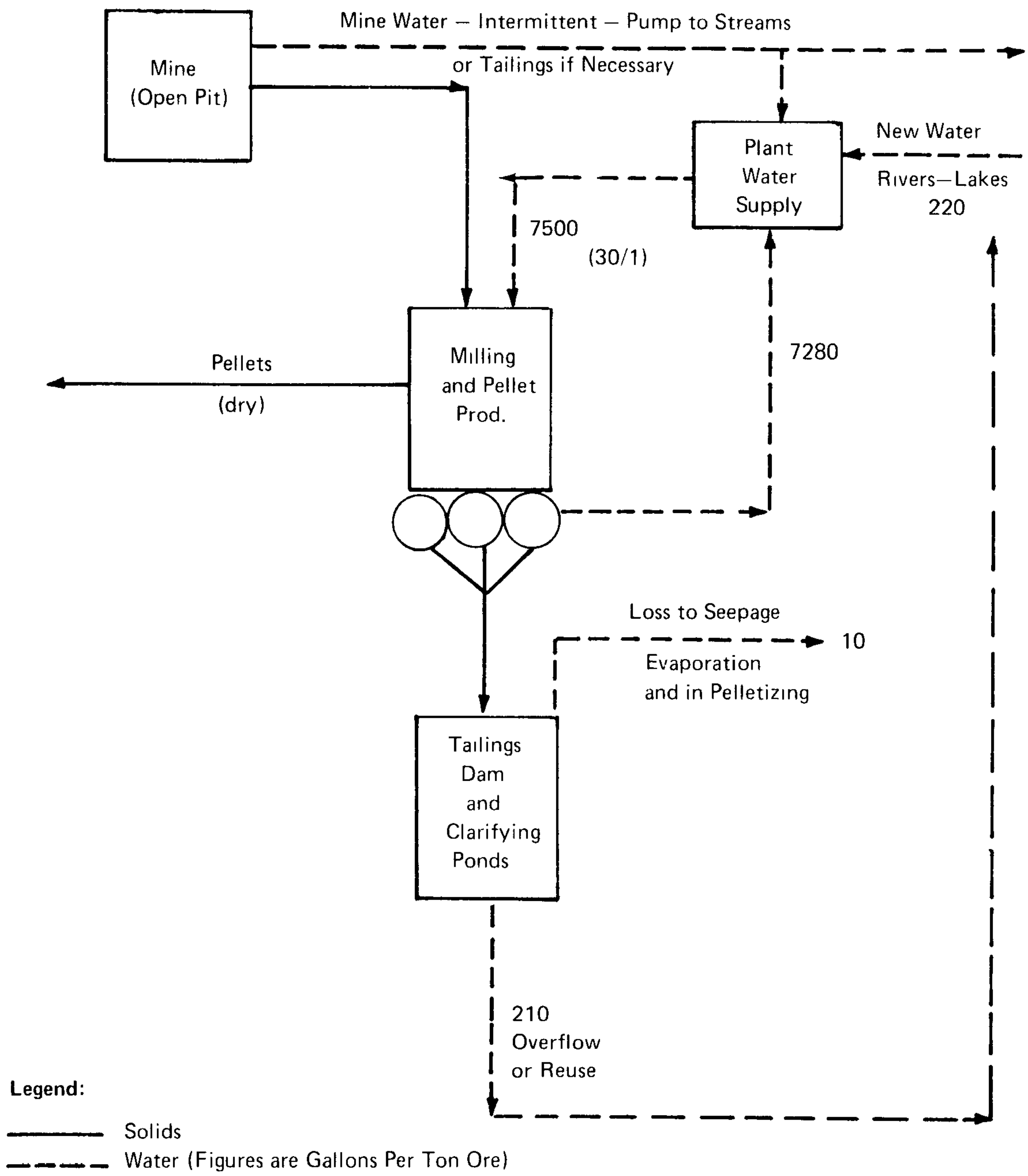


FIGURE III–4 WATER BALANCE
TYPICAL MICHIGAN–MINNESOTA TACONITE MINE AND MILL

2. Independent mining companies that produce ore under contract with others or for sale on the open market:

The Cleveland-Cliffs Iron Co.	Pittsburgh Pacific Co.
The Hanna Mining Co.	Rhude & Fryberger, Inc.
Nevada-Barth Corp.	Snyder Mining Co.
Oglebay Norton Co.	The Standard Slag Co.
Pickands Mather & Co.	

These independent ore suppliers make up less than 20% of the industry, but in several instances an independent company has been retained to manage jointly financed large-scale operations.

3. Joint ventures of two or more companies that have been formed to mine on a scale larger than any one company could practically support:

- **The Marquette Iron Mining Co.**

  Manager and Operator: The Cleveland-Cliffs Iron Co.

  Owners:

  The Cleveland-Cliffs Iron Co.
  International Harvester Co.
  Jones & Laughlin Steel Corp.
  The Wheeling-Pittsburgh Steel Corp.

- **Erie Mining Co.**

  Manager and Operator: Pickands Mather & Co.

  Owners:

  Bethlehem Steel Corp.
  Interlake Steel Corp.
  The Steel Co. of Canada, Ltd.
  The Youngstown Sheet & Tube Co.

- **Pioneer Pellet Plant**

  Manager and Operator: The Cleveland-Cliffs Iron Co.

  Owners:

  Bethlehem Steel Corp.
  The Cleveland-Cliffs Iron Co.
  McLouth Steel Corp.
  Republic Steel Corp.

- **Eveleth Taconite Co.**

  Owners:

  Ford Motor Co.
  Oglebay Norton Co.

- **Reserve Mining Co.**

  Owners:

  Armco Steel Corp.
  Republic Steel Corp.

- **Pilot Knob Pellet Co.**

  Owners:

  Granite City Steel Co.
  The Hanna Mining Co.

- **Butler Taconite Project**

  Operator: The Hanna Mining Co.

  Owners:

  Inland Steel Co.
  The Hanna Mining Co.
  Wheeling-Pittsburgh Steel Corp.

- **Meramec Mining Co.**

  Owners:

  Bethlehem Steel Corp.
  St. Joe Minerals Corp.

- **Humboldt Mining Co.**

  Owners:

  The Cleveland-Cliffs Iron Co.
  Ford Motor Co.

- **Empire Iron Mining Co.**

  Manager and Operator: The Cleveland-Cliffs Iron Co.

  Owners:

  The Cleveland-Cliffs Iron Co.
  Inland Steel Co.
  International Harvester Co.
  McLouth Steel Corp.

- **The Negaunee Mine Co.**

  Manager and Operator: The Cleveland-Cliffs Iron Co.

  Owners:

  Bethlehem Steel Corp.
  The Cleveland-Cliffs Iron Co.
  McLouth Steel Corp.
  Republic Steel Corp.

- **The Mesaba-Cliffs Mining Co.**

  Manager and Operator: The Cleveland-Cliffs Iron Co.

  Owners:

  The Cleveland-Cliffs Iron Co.
  Detroit Delaware
  Jones & Laughlin Steel Corp.
  National Steel Corp.
  Wheeling-Pittsburgh Steel Corp.

- **National Steel Pellet Project**

  Manager and Operator: The Hanna Mining Co.

  Owners:

  The Hanna Mining Co.
  National Steel Corp.

Steel companies in the United States generally are vertically integrated from the production of raw materials to the production of semifinished steel and industrial shapes. The larger steel companies produce their own coal, coke, limestone, and some manganese and ferroalloy metals ore, in addition to iron ore that they produce for their own use. In a few instances these companies produce iron ore for sale. The older and larger steel companies own or control some parts of the transportation systems that bring raw materials to the steel mills. A few own rail lines complete with rolling stock. Finally, many own or have an interest in ocean-going ships, lake carriers, and barges, and many integrated steel companies are engaged in international operations.

The industrial trend toward diversification is beginning to affect the iron and steel industry. Kaiser Steel Corporation is a subsidiary of Kaiser Industries Corporation. Control of the Lone Star Steel Company was acquired recently by Philadelphia and Reading Corporation, a holding company. Several iron and steel companies have merged with nonferrous metal mining and fabricating companies as well as with nonmetal companies; Jones & Laughlin Steel Corporation, for example, became part of Ling-Temco-Vought, Inc., Woodward Iron Co. was taken over by the Mead Corporation, and Youngstown Sheet and Tube Co. became a wholly-owned subsidiary of Lykes-Youngstown Corp.

According to the Bureau of the Census data, in 1972 there were 112 operating establishments in the iron ore industry in the U.S. The Lake Superior district (Minnesota and Michigan) accounts for most of the nation's iron ore production; other facilities are located in New York, Pennsylvania, Alabama, Missouri, Texas, Wyoming, Utah and California.

Table III-2 lists U.S. mines by company, and gives production for 1972 and 1973, mine type, ore grade, stripping ratio, facilities, mill size, number of employees, age, and product amount and type. Many of the facilities are owned by the major steel producers; it has been estimated that captive mines (including mines outside the U.S.) furnish about 85% of the ore used by the domestic iron and steel industry.

Table III-3 shows employment for selected years since 1954 in the iron ore mining/milling industry. The downward trend reflects, on one hand, the closing of a number of smaller, high-cost mines in favor of more efficient large-scale operations, and, on the other hand, the increasingly capital-intensiveness of iron ore mining and milling.

The ore production in 1973 for the major companies is given in Table III-4. This production is long tons of crude ore for companies producing over 1,000,000 tons per year.

Today, the typical iron ore establishment has on the order of 200 employees and produces about 1.6 million long tons of ore per year.

D. FINANCIAL PROFILES

Financial profiles for the major independent iron ore producers (Cleveland-Cliffs, Hanna Mining Co., Pickands Mather, Oglebay Norton) are given in the appendix.

E. PRICE EFFECTS

1. Determination of Prices

Essentially all domestic iron ore is sold on the basis of a guaranteed analysis, which is achieved by beneficiation and/or blending and grading. The blending begins by selective sequential mining, so that as it leaves the mine the material will be consistent and uniform in grade and physical characteristics. Ore that is beneficiated and agglomerated near the mine site is in final form for marketing. Natural ore and some concentrates, however, may be further blended during transport and transfer from trains to ships.

TABLE III-2

IRON ORE MINING AND BENEFICIATION FACILITIES IN U.S.

Company and Mine	Location	Mine Type	Ore Grade % Iron	Strip Ratio OB/Ore	Facilities*	Millions Tons/Yr 1972	Millions Tons/Yr 1973	Mill Size LT/day	Employees	Age (Years)	Product MMLT/Yr (1973)	Product Type	
Cleveland-Cliffs													
Empire	Michigan	O.P	33	1 0	MCA	11 1	10 4	45,000	827	11	3 5	Pellets	
Marquette Co -Republic	Michigan	O P	36	1 4	MCA	8 1	8 1	24,000	831	19	2 7	Pellets	
-Humboldt	Michigan	-	-	-	A		0 9		242				
Negaunee - Mather	Michigan	U G	55	-	M	2.2	2 0	------	575	32	2 0	Ore	
- Pioneer	Michigan	-	-	-	A			------	113	1 0	1 6	Pellets	
Tilden Mine	Michigan	O.P	36	0.3	MCA	0	0	36,000	618	1	---	Pellets	New 1974
Mesaba - Canisteo	Minnesota	O.P	38	N A	M.C	3.2	3 2	29,000	228	42	1 1	Conc	
Hanna Mining Co													
Butler	Minnesota	O.P	22	1 5	MCA	N A.	14.0	23,000	520	8	2 5	Pellets	
Groveland	Michigan	O P.	35	0.7	MCA	N A	10.5	14,000	475	16	2 0	Pellets	
Pierce	Minnesota	O.P.	49	1.5	M C	N.A.	2 8	9,500	200	18	1 6	Conc.	
National Steel	Minnesota	O P.	31	1.4	MCA	7 2	8.6	24,000	569	8	2 6	Pellets	
Pilot Knob	Missouri	U.G.	35	0	MCA	2.0	1 9	6,000	435	7	1 0	Pellets	
Whitney	Minnesota	O.P	N.A.	.3	M.C	0	0	20,000	337	2	---	New 197-	
Inland Steel													
Sherwood	Michigan	U.G	55	0	M	0 4	0 4	------	109	35	0 4	Ore	
Black River Falls	Wisconsin	O P.	33	1.7	MCA	2.4	2 7	9,000	239	6	1 0	Pellets	
Jones & Laughlin													
Hill Annex	Minnesota	O P	37	0.1	M C	2 4	3.5	20,000	200	58	1.0	Conc	
Lind-Greenway	Minnesota	O.P	30	2.4	M.C.	2 2	3.6	20,000	170	23	1 0	Conc	
McKinley	Minnesota	O P	57	2.5	M W	1 9	3.2	17,000	245	7	2 3	Ore	
Benson	New York	O P	23	2	M C.	0 9	0.9	9,600	509	31	0 9	Conc	
Kaiser Steel													
Eagle Mountain	California	O.P.	34	4 7	MCA	5 6	10 9	18,000	1500	27	3 9	Pellets	
Lone Star Steel													
Lone Star	Texas	O.P	27	0 4	MW	N A.	1.4	16,000	130	28	N.A	Ore	
Luck Mining Co													
Silver City	New Mexico	O P.	43	0.3	M	N.A.	05	------	11	37	03	Ore	
Meramec Mining Co													
Sullivan	Missouri	U.G	45	0	MCA	3.1	2 9	12,000	797	14	1 6	Pellets	
N L Industries													
McIntyre	New York	O P.	28	3 2	M C	1.3	1 5	5,000	206	33	0 3	Conc	
Nevada Barth Co													
Barth	Nevada	O P	60	1 0	M	0 1	0 1	------	20	15	0 1	Ore	
Oglebay Norton													
Evelyth-Thunderbird	Minnesota	O P.	24	0.4	MCA	6 4	6.2	17,000	472	10	2.1	Pellets	
Pickands Mather													
Erie Mining Co	Minnesota	O.P	32	1.6	MCA	29 3	32 7	90,000	2768	18	11 7	Pellets	
Pittsburgh Pacific													
Mesobi Div - 2 Mines	Minnesota	O.P.	N.A.	2.5	M	0.2	1.5	-------	226	15	1 5	Ore	
Reserve Mining Co													
Mitchell - Davis	Minnesota	O P.	24	1 9	MCA	26 3	29.8	85,000	2850	20	10 4	Pellets	
Rhude & Fryberger													
Gross-Nelson	Minnesota	O.P	48	2.8	M.C	0.2	0 4	6,000	55	9	0.3	Conc	
Hull-Rust	Minnesota	O.P	58	1.4	MW	0.2	0 4	4,000	49	10	0 2	Ore	
Rana	Minnesota	O P.	58	0.3	MW	N.A.	N A	3,600	29	1	0.1	Ore	
U S. Pipe & Foundry													
Russelville	Alabama	O.P	48	0 5	M C.	N.A.	0 2	1,000	46	21	N A	Conc	
U S Steel													
Arcturus	Minnesota	O.P	N A.	N.A	N A	N.A.	N.A	N.A.	N A	N A	N A	N A.	
Minntac	Minnesota	O P.	22	0 4	MCA	9.6	13 9	110,000	2940	8	12.3	Pellets	
Plummer	Minnesota	O.P	N.A.	N.A.	MW	1.6	2 7	N A.	N A	N A	N.A.	Ore	
Rouchleau	Minnesota	O P.	N A.	0.3	M.C	3.5	2.9	N.A	N.A.	32	N A	Conc.	
Sherman	Minnesota	O.P	N A.	0 4	M C	7 9	4 3	N A	N A	27	N A	Conc	
Stephens	Minnesota	O P	N.A	0.1	N A.	1.1	N.A.	N.A.	N.A.	18	N A	N A	
Atlantic City	Wyoming	O P.	N.A	N.A.	MCA	1.7	1.8	N A.	529	13	1 5	Pellets	
Desert Mount	Utah	O P	N.A.	N.A.	N A.	0 5	0 6	N A	N A.	N A	N.A		
Utah International													
Cedar City	Utah	O.P	40	0 7	M C.	0.4	0 4	6,000	180	29	N.A	Conc.	
C F & I													
Comstock	Utah	O.P	52	1 0	M	0 9	1 0	4,700	57	22	1 0	Ore	
Sunrise	Wyoming	U.G	40	0	M C.	0.5	0 5	3,600	225	75	0 5	Conc	
Bethlehem Mines Corp													
Grace Mine	Penn	U G.	42	0	MCA	2 1	2 2	7,000	815	17	1 1	Pellets	
Coons Pacific	Minnesota	---	--	0	C	0	0	N.A.	57	25	N A	Conc	
Standard Slag													
Beck Mine	California	O.P.	N.A.	4 5	M	0 4	0.5	2,000		N A.	N.A	Ore	
Iron Mountain	Nevada	O.P	N.A	N.A	M			N.A.		N.A.	N.A	Ore	
Dunbar & Layton Co.	Georgia	O.P.	N.A	N.A.	N.A.	N.A	N A	N.A	18	N.A	N.A	Ore	
Lumpkin Mining Co.	Georgia	O.P.	N.A.	N.A.	N.A.	N.A	N.A	N.A.		N A.	N.A	Ore	
Luverne Mining Co.	Georgia	O P	N A.	N.A	N A.	N.A.	N.A.	N.A.	15	N A.	06	Ore	
Cities Service Corp													
Coppernill	Tennessee	U.G.	N.A.	0	MCA	N.A	1 8	6,000	2100	N A.	1 0	Pellets	

*M = Mine
C = Concentrator
A = Agglomeration
W = Washer
N A. = Not Available

Source Compiled by ADL from published data, June 1975

TABLE III-3

EMPLOYMENT IN THE IRON ORE MINING/MILLING INDUSTRY

Year	Number of Mines: Total	Number of Mines: With 20 or More Employees	Number of Employees: Total	Number of Employees: In Production Work
1954	225	135	34,200	28,200
1958	243	128	30,100	22,500
1963	208	101	23,100	18,100
1967	146	79	22,600	18,000
1972	112	56	19,700	15,300

GENERAL STATISTICS BY EMPLOYMENT SIZE OF ESTABLISHMENT: 1972

1972 code	Item	Establishments (number)	All employees: Number (1,000)	All employees: Payroll (million dollars)	Production, development, and exploration workers: Number (1,000)	Production, development, and exploration workers: Man hours (millions)	Production, development, and exploration workers: Wages (million dollars)	Value added in mining (million dollars)	Cost of supplies, etc., and purchased machinery installed (million dollars)	Value of shipments and receipts (million dollars)	Capital expenditures (million dollars)
1011	IRON ORES										
	Establishments, total	112	19.7	218.2	15.3	30.2	155.6	701.9	423.7	1,065.4	60.1
	Establishments with an average of--										
	0 to 4 employees E3	39	.1	.8	.1	.1	.5	1.0	2.1	6.1	.2
	5 to 9 employees E2	9	.1	.7	(Z)	.1	.1	2.0	1.1	3.0	.1
	10 to 19 employees E3	8	.1	1.3	(Z)	.1	1	1.5	5	2.0	.1
	20 to 49 employees	12	3	3.5	.2	.5	2.2	15.6	26.1	20.3	3.4
	50 to 99 employees	7	.6	6.2	.2	.4	2.0	11.1	(D)	32.1	(D)
	100 to 249 employees	17	2.8	31.3	2.0	4.0	20.6	91.0	51.8	112.7	3.2
	250 to 499 employees	6	2.3	26.0	1.7	3.4	17.7	71.9	38.0	107.1	5.5
	500 to 999 employees	10	6.8	72.6	5.8	11.1	58.7	190.5	303.6	290.6	17.6
	1,000 to 2,499 employees	3	6.7	75.9	5.2	10.2	53.1	305.3	(D)	460.9	(D)
	2,500 employees or more	1	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
	Establishments covered by admin. records E0	17	-	.3	-	-	.2	.8	.2	.9	.1

Note The payroll and sales data for most single-unit companies, generally with less than 5 employees, were obtained from administrative records supplied by other agencies of the Federal government instead of from a Census report. These payroll and sales data were then used in conjunction with industry averages to estimate the balances of the items shown in the table The following symbols are shown for those size classes where administrative records account for 10 percent or more of the total of a size class

E1--10 to 19 percent E3--30 to 39 percent E5--50 to 59 percent E7--70 to 79 percent E9--90 to 99 percent
E2--20 to 29 percent E4--40 to 49 percent E6--60 to 69 percent E8--80 to 89 percent E0--100 percent

A summary of the data obtained from administrative records and included in the respective size classes is shown in the last line of the table.

- Represents zero (D) Withheld to avoid disclosing figures for individual companies Data for this item are included in the underscored figures above. (Z) Less than half of the unit of measurement shown (under 50 thousand dollars or man-hours, under 50 employees)

SOURCE: Abstracted from 1972 Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census

TABLE III-4

MAJOR COMPANIES – IRON ORE PRODUCTION (1973)

Company	Millions Long Tons Crude Ore
Cleveland-Cliffs	24.6
Hanna Mining Co.	37.8
Inland Steel	3.1
Jones and Laughlin	11.2
Kaiser Steel	10.9
Lone Star Steel	1.4
Meramec Mining Co.	2.1
N. L. Industries	1.5
Oglebay Norton	6.2
Pickands Mather	32.7
Reserve Mining	29.8
U.S. Steel	26.2
C.F. & I.	1.5
Bethlehem Mines	2.2
Pittsburgh Pacific	1.5
Total	192.7

Major defined as those producing over 1 million long tons of crude ore per year.

Most domestic iron ore originating outside the Lake Superior district reaches consuming points in railroad cars. Most Lake Superior ore is transported in Great Lakes iron ore carriers ranging up to 45,000-ton capacity. Those hauling ore that originates on the shores of Lake Superior pass through the Sault Sainte Marie locks, and this limits their size to 1,200 by 110 ft. Since the Great Lakes transportation system is closed by ice three or four months of the year, the mines either stock-pile ore or shut down during the winter. Most of the direct shipping mines and those producing wash and gravity concentrate ores close down; mines with complex beneficiation plants operate year round.

Iron ore prices range from about \$5 per ton for some of the brown ores in the Southeastern district to \$15 per ton for high-grade iron ore agglomerates in the Northeastern and Western districts. While these are published prices, and they indicate only the range in which a buyer can expect to obtain ore on the open markets, most iron ore prices are negotiated. The contracts involve time and delivery considerations besides price. More than 80 percent of the ore is produced by captive mines (mines producing for company blast furnaces) and therefore does not reach the open market.

Prices for Lake Superior ores are governed by the Lake Erie price, which is established each year by the publication of a major contract between a prominent iron ore producer and a steel corporation. Historically, it has been the first contract of the year, published before the start of the shipping season. Lately, however, the Lake Erie price has been steady, except for small changes in transportation costs. From 1962 until 1970, when increases were again made, most independent ore merchants served notice early in January of each year that prices would be unchanged.

The Lake Erie price is based on a long ton of standard ore containing 51.5 percent iron, delivered at the rail of a vessel at the lower lake ports. Prices are adjusted in proportion to the iron content above or below 51.5 percent iron, by penalties for excess impurities and premiums for lump structure and high manganese content.

Phosphorus content lower than 0.045 percent commands a premium while a higher phosphorus percent carries a penalty.

In addition to the standard deductions for iron contents of less than 50 percent, arbitrary penalties are also exacted for high silica and for fine structure.

Hard ores of high-iron, low-silica contents are often sold as lump grade, generally priced as Old Range Non-Bessemer plus premiums for lump structure.

Ores containing more than 5 percent natural manganese are recognized as standard manganiferrous iron ores and are generally priced as Old Range Non-Bessemer on the combined natural iron and manganese content, plus a premium for the natural manganese in excess of 5 percent. Ores containing between 2 and 5 percent of natural manganese are also sometimes marketed as manganiferrous at prices which recognize some small value for the manganese content.

Premiums for lump structure and high manganese content are determined by negotiation between buyer and seller.

2. Costs of Production

Investment and operating costs for iron ore mining and milling plants vary with different types of deposits, ores, mines and processes. To give an order of magnitude, we have estimated the costs for a typical Lake Superior Region taconite mining and milling operation. These are summarized in Table III-5. In this case, the cost centers are mining, concentrating, pelletizing, general overhead, royalties and taxes, and amortization. The usual product is pellets with 62-66% iron.

TABLE III-5

TYPICAL COST ESTIMATES FOR TACONITE MINING, MILLING AND PELLETIZING

	Cost		
Operation	**$/Long Ton Ore**	**$/Long Ton Pellets**	**¢/Fe Unit**
Mining	0.70	1.40	2.2
Concentrating	1.17	2.34	3.7
Pelletizing	–	2.36	3.7
General Overhead	–	0.50	0.8
Royalties & Taxes	–	1.57	2.5
Amortization*	–	2.44	3.9
Total	–	10.61	16.8

*Based on an investment of $365 million with a 15 year amortization period and 10,000,000 L.T./yr production.

Source: ADL Estimates.

3. Potential Constraints on Financing Additional Capital Assets

An important aspect of the iron ore mining and beneficiating industry of the Great Lakes Region is its intimate relationship to the major steel companies, who, with a few large consumers such as Ford Motor and International Harvester, are the customers for iron ore and pellets. The steel companies have extensive holdings in mining companies and are participants in joint ventures producing beneficiated ore and pellets. While this is public information, a perusal of the list of names of iron mining companies does not indicate the full extent of steel company involvement.

A few independent companies manage iron ore properties in the Great Lakes Region on behalf of the steel companies, and may themselves have an operating interest. It is not uncommon for such a company to receive a reimbursement for all operating expenses, plus a management fee based on the tons of iron ore produced, which depends in part upon the ore requirements of the steelmaking owners. Ordinarily, the management contracts run for the economic life of the property but may be terminated earlier. Iron ore sales to steel companies are typically under long-term contract at prevailing published market prices at the date of shipment. The nature of the management agreement and sales contract terms suggest that the steel companies primarily bear the risk of cost increases.

The availability of financing for capital assets depends largely on the prospects of large U.S. steel companies. Constraints on financing stem from imports of iron ore pellets, the effect on steel company profits of higher iron ore prices, and the effect on domestic steel consumption of a full pass-on of pollution control cost to steel customers. In general, the constraints on financing additional capital assets can be discussed under the categories of financial, competitive and regulatory constraints.

a. Managerial Constraints. It is management's task to choose from among investment alternatives and decide on the optimum utilization of the corporation's resources and borrowing power, and to formulate and implement plans accordingly. Many steel companies are now involved in raw materials ventures and these activities typically require a commitment of capital. The funds available to the corporation include, of course, its total cash generation, its borrowing power, and ability to raise additional equity capital. The constraints here are the costs of capital vis-à-vis the expected rates of return on its investment. Iron ore mining ventures are typically expected to have good rates of return and frequently involve some relatively high risks. Uncertainty over future pollution control requirements is a factor increasing perceived risk and probably also the cost of capital.

b. Financial Constraints. A corporation's earnings and cash flow are generally programmed to meet dividend, reinvestment, and debt service requirements. When external financing is required, there are many considerations dictating the type and amount.

In general, financial institutions and investment firms employ tests of performance and standards or guidelines for debt-to-equity ratios and coverage of fixed charges in a given industry to assess the credit worthiness of a corporate issuer of securities. The capital markets, together with the corporation in question, determine how much capital will be made available, and under what terms, to the borrowing corporation. Existing commitments carry with them an obligation to make certain expenditures, meet debt service schedules, etc.

Loan agreements may restrict the extent to which even a large steel company can diminish working capital, retained earnings, or issue further debt.

c. Competitive Constraints. A process breakthrough which significantly lowers production cost may dictate that capital investments be made: 1) defensively by competitors and 2) offensively by the innovative firm. If a proprietary process is involved, it is conceivable that some firms may not remain economically viable and will be forced to shut down. Similarly, if pollution control costs are so onerous and if competitive market conditions do not permit such incremental costs to be passed on to customers or taxpayers, a firm may elect not to spend the money, assuming it could achieve a greater return on its investment elsewhere.

d. Regulatory Constraints. The financing of certain additional capital assets may be influenced by regulatory considerations. Tax laws and ownership limitations are the most important considerations here. They play a part in regard to both domestic projects (e.g., the effect of depletion allowances, industrial pollution control revenue bond financing) and international projects (depletion allowance, foreign tax credits, ownership limitations).

F. ASSESSMENT OF ECONOMIC IMPACT

The purpose of this section is to assess the economic impact of the guidelines set forth by the Effluent Guideline Document for the iron ore mining and processing industry. These guidelines are:

- Best Practical Control Technology Currently Available (BPCTCA) – to be met by industrial dischargers by 1977.
- Best Available Technology Economically Available (BATEA) – to be met by 1983.
- New Source Performance Standards (NSPS) – to be applied to all new facilities that discharge to navigable waters constructed after the promulgation of these guidelines.

For the purpose of recommending effluent guidelines, the Guidelines Contractor has categorized the iron ore mining and processing industry into the following groups:

1. Mines.
2. Mills with physical/chemical processes.
3. Mills with magnetic and physical separation processes (Mesabi Range).

Special exclusion: No discussion or consideration of iron ore in the U.S. is complete without consideration of the Reserve Mining Company and their operations at Babbitt and Silver Bay. However, because of the contractor's participation in Reserve Mining's current case, the contractor is prohibited from discussing the impact of effluent guidelines on Reserve.

1. Effluent Guidelines

For the mines category, which includes both underground and open pit mines, the recommended parameters and BPCTCA guidelines are given in Table III-6, and the BATEA parameters and guidelines in Table III-7.

NSPS guidelines for iron ore mines are the same as BPCTCA guidelines.

For the mills with physical/chemical processing, the recommended BPCTCA parameters and guidelines are given in Table III-8, and the BATEA guidelines in Table III-9. NSPS guidelines for these mills are the same as BPCTCA guidelines.

For the mills with magnetic and physical separation processes (Mesabi Range), zero discharge is recommended and hence no parameters or guidelines are proposed.

2. Costs of Compliance

The guidelines contractor has estimated the costs of compliance for both BPCTCA and BATEA guidelines. These costs for iron ore mining and milling are summarized in Table III-10 by sub-category and in Table III-11 by companies. The costs in these tables represent the investment needed to install the required treatment facilities and the annual costs to operate them.

The annual costs include amortization (which in turn includes an interest cost at 8%) based on a life of 20 years for facilities and 10 years for equipment.

The fixed cost portion of the annual costs is about 20%. That is, 20% of the total annual cost is fixed cost (amortization plus interest charges in this case).

In Table III-12 we have estimated the incremental cost to the two companies' final product (pellets) due to compliance with both BPCTCA and BATEA guidelines. These are added costs for the particular company unit where effluent treatment is required. Both companies are multi-unit companies.

3. Basis for Analysis

The basis for the analysis of economic impact has been discussed in the "Approach" section of this report.

TABLE III-6

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – IRON ORE MINES

	Concentration (mg/ℓ) in Effluent	
Parameter	**30-day average**	**24-hour maximum**
pH	6* to 9*	6* to 9*
TSS	20	30
Fe (Total)	1.0	2.0

*Value in pH units.

Source: Development Document.

TABLE III-7

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BATEA – IRON ORE MINES

	Concentration (mg/ℓ)	
Parameter	**30-day average**	**24-hour maximum**
pH	6* to 9*	6* to 9*
TSS	20	30
Fe (Total)	0.5	1.0

*Value in pH units.

Source: Development Document

TABLE III-8

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – IRON ORE MILLS EMPLOYING PHYSICAL METHODS AND/OR CHEMICAL REAGENTS

	Concentration (mg/ℓ) in Effluent	
Parameter	**30-day average**	**24-hour maximum**
pH	6* to 9*	6* to 9*
TSS	20	30
Fe (Total)	1.0	2.0

*Value in pH units.

Source: Development Document.

TABLE III-9

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BATEA – IRON ORE MILLS EMPLOYING PHYSICAL METHODS AND/OR CHEMICAL REAGENTS

	Concentration (mg/ℓ) in Effluent	
Parameter	**30-day average**	**24-hour maximum**
pH	6* to 9*	6* to 9*
TSS	20	30
Fe (Total)	0.5	1.0

*Value in pH units.

Source: Development Document.

TABLE III-10

COSTS OF COMPLIANCE FOR IRON ORE MINING AND MILLING

Sub-Category	No.	Thousands M.T. Ore Per Year	Costs (Thousands $) BPCTCA Investment	BPCTCA Annual	BATEA (Total) Investment	BATEA (Total) Annual
Mines	1-12	162,000	0	0	0	0
	13	6,056	118.7	87.8	118.7	87.8
	14	8,130	31.2	12.7	31.2	12.7
Mills	1-12	137,000	0	0	0	0
	13	8,130	124.3	103.6	140.2	148.0
Total 14 mines		176,186	274.2	204.1	290.1	248.5
Total Industry (1972)		187,648				
Sample Represents (% of Industry) (On Tonnage Basis)		94%				

TABLE III-11

SUMMARY – TOTAL COST OF COMPLIANCE BY COMPANIES

Company No.	Thousands M.T. Ore Per Year	Costs (Thousands $) BPCTCA Investment	BPCTCA Annual	BATEA (Total) Investment	BATEA (Total) Annual
A	6,056	118.7	87.8	118.7	87.8
B	8,130	155.5	116.3	171.4	160.7
Total	14,186	274.2	204.1	290.1	248.5
Rest of Industry	173,462	0	0	0	0

TABLE III-12

INCREASE IN COST OF PELLETS DUE TO ADDED COST OF COMPLIANCE

Note: Both companies with added costs produce pellets as the principal product. Mine, mill, and pellet plants operate as a unit.

I. Increase Due to BPCTCA Costs

Company No.	Pellet Production Thousands M.T./Yr. (1972)	Annual Cost to Attain Guideline	$/M.T. Pellets	Value/M.T. 1972 Pellets*	% Annual Cost/Value
A	2,177	87,800	0.04	14.12	0.28
B	3,945	116,300	0.03	14.12	0.21
Total	6,122	204,100	–	–	–

II. Increase Due to BATEA Costs

Company No.					
A	2,177	87,800	0.04	14.12	0.28
B	3,945	160,700	0.04	14.12	0.28
Total	6,122	248,500	–	–	–

*The average value of Lake Superior pellets f.o.b. mine and pellet plant in 1972 was $14.12 per long ton. The value today (June 1975) is approximately $21.60 per long ton.

4. Levels of Impact

The levels of impact have been discussed in the "Approach" section of this report.

In the following approach, the complete impact analysis for each effluent guideline will be discussed before considering the next guideline.

a. Best Practical Control Technology Currently Available (BPCTCA). In Table III-13, we have summarized the information and costs to comply with the BPCTCA guidelines. Shown in Table III-13 for the three impact groups discussed above and for the total industry are the data on tonnage and number of employees, the added operating costs, and the added investment costs as a percentage of capital expenditures and total investment.

(1) Price and Production Effects. As is evident from the table, 86% of the industry would not be directly affected by the guidelines. For the 7.6% that is directly affected, the product cost increase of $0.03 per ton is small and could readily be either passed on or absorbed under normal circumstances. The percentage increase of $0.03 per ton on a $14 per ton product (1972) is less than 1%. There is virtually no impact on the whole industry.

(2) Financial Effects. The added capital investment required for the impacted groups of the industry is only 4% of the estimated annual capital expenditures and only 0.08% of the total invested capital. The percentage of annual capital expenditures (4%) is calculated on the assumption that the investment for pollution control will be accomplished in one year. However, this investment would likely to made over a period of several years, so the effect would actually be less than is indicated here.

(3) Balance of Payment Effects, Employment Effects, and Community Effects. Consideration of the price and production, and financial effects indicates that there will be no output curtailments or plant shutdowns in the iron ore mining and milling industry due to BPCTCA effluent limitations. As a result, there will be no employment or community effects and no balance of payments effects.

b. Best Available Technology Economically Available (BATEA). Table III-14 lists the data and costs for meeting the BATEA guidelines. These are only slightly higher than the BPCTCA data and costs in Table III-13.

For meeting BATEA guidelines, therefore, the effects and impacts are the same as for BPCTCA. That is, there will be no significant impact on the industry or any industry group of it in meeting BATEA standards.

TABLE III-13

SUMMARY OF DATA AND COSTS FOR MEETING BPCTCA GUIDELINES
IRON ORE MINING AND MILLING INDUSTRY

(1972 Data and Costs)

	Impact Group			Total Industry
	"A"	"B"	"C"	
Thousands Long Tons/Yr. Crude Ore	162,000	14,186	0	187,648
Thousands Long Tons/Yr. Product	67,557	6,122	0	78,281*
Percent of Industry – Tonnage Basis	86.3	7.6	0	100
Number of Employees	17,000	1,306	0	19,700
Percent of Employees	86.3	7.6	0	100
Added Investment for Facilities ($)	0	274,200	0	274,200
Added Investment as % of Estimated 1972 Capital Expenditures	0	4.0	0	0.5
Added Investment as % of Estimated Total Investment	0	0.08	0	Negligible
Increase in Annual Operating Cost ($)	0	204,100	0	204,100
$ per ton Crude Ore	0	0.01	0	.001
$ per ton Product	0	0.03	0	.003

*Includes pellets, sinter, concentrate, direct shipping ores (pellet production 55,920,000 long ton or 71% of total).

TABLE III-14

SUMMARY OF DATA AND COSTS FOR MEETING BATEA GUIDELINES
IRON ORE MINING AND MILLING

	Impact Group			Total Industry
	"A"	"B"	"C"	
Thousands Long Tons Crude Ore/Yr	162,000	14,186	0	187,648
Thousands Long Tons Product/Yr	67,557	6,122	0	78,281*
Percent of Industry – Crude Ore Basis	86.3	7.6	0	100
Number of Employees	17,000	1,306	0	19,700
Percent of Employees	86.3	7.6	0	100
Added Investment for Facilities ($)	0	290,100	0	290,100
Investment as % of Estimated 1972 Capital Expenditures	0	4.3	0	0.5
Investment as % of Estimated Total Plant Investment	0	0.08	0	Negligible
Increase in Annual Cost ($)	0	248,500	0	248,500
$ per Long Ton of Crude Ore	0	.02	0	.001
$ per Long Ton of Product (pellets)	0	.04	0	.003

*Includes pellets, sinters, concentrate, direct shipping ores (pellets 55,920 or 71% of total).

c. New Source Performance Standards (NSPS). The guidelines contractor has recommended that for new iron ore mills with magentic processing, the NSPS guideline should be zero discharge. For iron ore mines and mills using physical methods/chemical reagents the NSPS standards should be identical to BPCTCA limitations.

There were no cost estimates provided by the Effluent Guideline Development for the NSPS analysis. Therefore, any statements made with regard to the effect of the NSPS requirement on the construction of new plants within the U.S. must necessarily be qualitative.

However, it can be said with some degree of confidence that the costs for a "grass roots" plant to meet the NSPS standards are no more than the costs for an existing plant in the impact group "B" to meet the BPT and BAT recommended effluent limitations. This is due to the fact that in the construction of a new plant, in-process modifications can oftentimes be made which may be more efficient and economical than add-on treatment technologies for existing plants.

For the above reasons, a new plant designed with the NSPS effluent limitations in mind could be constructed without much difficulty. Therefore, the cost of water pollution control due to the NSPS standards alone will have minimal effect on the decision of the U.S. iron ore mining and milling industry to expand domestic production capacity through the construction of new plants.

IV. COPPER ORE MINING AND PROCESSING (SIC 1021)

A. INTRODUCTION

There are seven major copper producing areas in the world: (1) the western United States; (2) the western slope of the Andes in Peru and Chile; (3) the central African Copperbelt in Zambia and Zaire (Kinshasa); (4) the Ural Mountains and the Kazakstan region in the U.S.S.R.; (5) the Precambrian area of central and western Canada; (6) the Keweenaw Peninsula of Northern Michigan; and (7) Southwest Pacific (Australia, Bougainville).

Of the many copper minerals, only chalcocite, chalcopyrite, bornite, chrysocolla, azurite, and malachite are important commercially. Copper ores occur in many types of deposits in various host rocks. Porphyry copper deposits account for about 90% of the U.S. production and much of the world output, and contain most of the estimated commercial copper reserves of the world.

From a processing viewpoint, copper ores can be classified in three categories: sulfide ores, native copper ores, and oxide ores.

A sulfide ore is a natural mixture containing copper-bearing sulfide minerals, associated metals, and gangue minerals (e.g., pyrites, silicates, aluminates) that at times have considerable value in themselves (e.g., molybdenum, silver, gold, as well as other metals). Most sulfide ores belong to one of three major groups, all of which are represented in the United States, namely:

- The porphyry copper and Northern Rhodesian type deposits that carry copper mostly in the form of chalcocite (Cu_2S), chalcopyrite ($CuFeS_2$) and bornite (Cu_5FeS_4). Copper ranges from a fraction of one percent to several percent, and iron is generally low. The deposits in the southwestern U.S. are of this type.

- Deposits, such as those found in Rio Tinto in Spain, Cyprus, and Tennessee, commonly known as cupriferous pyrite, which generally have 1-3% copper as chalcopyrite, and contain abundant amounts of pyrite and pyrrhotite. Generally, copper-to-iron ratios and copper-to-sulfur ratios are low.

- Arsenic-bearing copper ores, such as enargite (Cu_3AsS_4), with deposits occurring in Butte, Montana; Yugoslavia; Tsumeb in South West Africa; and the Philippines.

The sulfide ores are treated primarily by crushing, grinding, and froth flotation to produce a concentrate (or several concentrates) of sulfide minerals and reject the worthless gangue as tailings.

Native copper ores are those in which some of the copper occurs as the native metal. The Lake Superior District in Michigan is the only major source of ore of this type. Although the reserves of this ore are quite extensive, it contributes only a small portion of the total U.S. mine production of copper.

All non-sulfide, non-native ores of copper are termed "oxide" ores, the oxide copper content being measured by and synonymous with solubility in dilute sulfuric acid. An oxide copper ore can contain copper oxide, silicate or carbonate minerals and gangue. The oxide ores have been treated metallurgically in a variety of ways, the character of the gangue minerals having a very important bearing on the type of metallurgical treatment used. Oxide ores in the U.S. are treated primarily by leaching with dilute sulfuric acid.

Commonly associated with copper are minor amounts of gold, silver, lead, and zinc, the recovery of which can improve mine profitability. Molybdenum, lead and zinc are recovered as sulfides by differential flotation. Minor amounts of selenium, telluriun, and precious metals are extracted in electrolytic refining. On the other hand, arsenic, antimony and bismuth in the ores cause problems in standard pyrometallurgical processing and electro-refining, and thus their presence is a cost penalty. Nickel and cobalt can interfere with electrolytic refining, but they do not occur in significant amounts with the U.S. copper deposits.

B. INDUSTRY DESCRIPTION

The Copper Ores Industry includes establishments engaged primarily in mining, milling, or otherwise preparing copper ores. This industry also includes establishments engaged primarily in the recovery of copper concentrates by precipitation and leaching of copper ores.

1. Reserves

In 1964, the Bureau of Mines reported domestic reserves of 75 million tons of metal in ore averaging 0.86% copper, assuming recovery at 90% of gross metal content. An additional 58 million tons of copper was estimated as potential resources recoverable with technological or economic improvements. Arizona, Montana, Utah, New Mexico, and Michigan accounted for more than 90% of the total reserves.

A 1973 study* estimated the total known domestic resources of copper economically available at various copper prices, allowing for a 12% return on investment:

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*IC 8598, "Economic Appraisal of the Supply of Copper," U.S.B.M., 1973.

Price	Resources in Millions of Short Tons
\$2.00/lb	180
0.75/lb	115
0.50/lb	83

The 83 million tons of reserves indicated above represent 49 years of supply at our present production rate of about 1.7 million tons per year.

A comparison of U.S. copper resources with those of the rest of the world (see Table IV-1) indicates that the U.S. has about 20% of the world's copper resources. It is also evident, however, that many areas of the world have significant copper resources. The major resources are in South America, Africa, U.S.S.R., Canada, Mexico, and Europe.

2. Mining

About 85% of the total copper ore mined comes from open pits; the rest comes from underground mines. Underground mining methods for copper ores involve caving and/or cut-and-fill mining.

3. Beneficiation

The different mineral forms (sulfides, carbonates, oxides, native copper, etc.) require different processing techniques. Many methods have been used to beneficiate the ores; generally only the sulfide ores are amenable to concentration procedures such as grinding and froth flotation.

a. Sulfide Ores

These ores, the most important source of copper, are concentrated by froth flotation. This procedure requires crushing and grinding and classification to about 100 mesh or finer to liberate the particles. Grinding is usually the largest cost item in the process. After grinding, the ore-water mixture is treated with reagents to condition the sulfide particles so that their surfaces become air-avid. The sulfides are then collected with the froth produced in the flotation cells. The final concentrate may contain 11% to 32% copper. Typically flotation is used to separate copper sulfides from pyrite, recover molybdenum from copper concentrate, and recover copper concentrate from complex lead-zinc-copper ore. A typical flowsheet for flotation of a sulfide ore is shown in Figure IV-1.

b. Oxide Ores

Oxide ores occurring in the United States are generally not amenable to flotation, but are generally soluble in various leaching solutions.

TABLE IV-1

IDENTIFIED AND HYPOTHETICAL COPPER RESOURCES
(Millions of Short Tons)

Area	Identified[1]	Hypothetical[2]
United States:		
Eastern	10	5
Western, except Alaska	64	75
Alaska	2	20
Canada	19	50
Mexico	18	20
Central America	1	6
Antilles	2	1
South America	80	50
Europe, excluding U.S.S.R.	25	20
Africa	53	50
U.S.S.R.	39	50
Middle East – South Asia	4	20
China	3	?
Oceania, including Japan	21	30
Australia	3	3
Total	344	400

1. Identified resources: Specific, identified mineral deposits that may or may not be evaluated as to extent and grade and whose contained minerals may or may not be profitably recoverable with existing technology and economic conditions. Based on all categories of reserve figures plus estimates where no figures are available. Amounts are tentative and accuracy will be refined in subsequent publications.

2. Hypothetical resources: Undiscovered mineral deposits, whether of recoverable or subeconomic grade, that are geologically predictable as existing in known districts. Based generally on identified resource figures times a factor assigned according to geologic favorability of the region, extent of geologic mapping, and exploration.

Source: Geological Survey professional paper 820, "United States Mineral Resources," Brobst and Pratt, 1973.

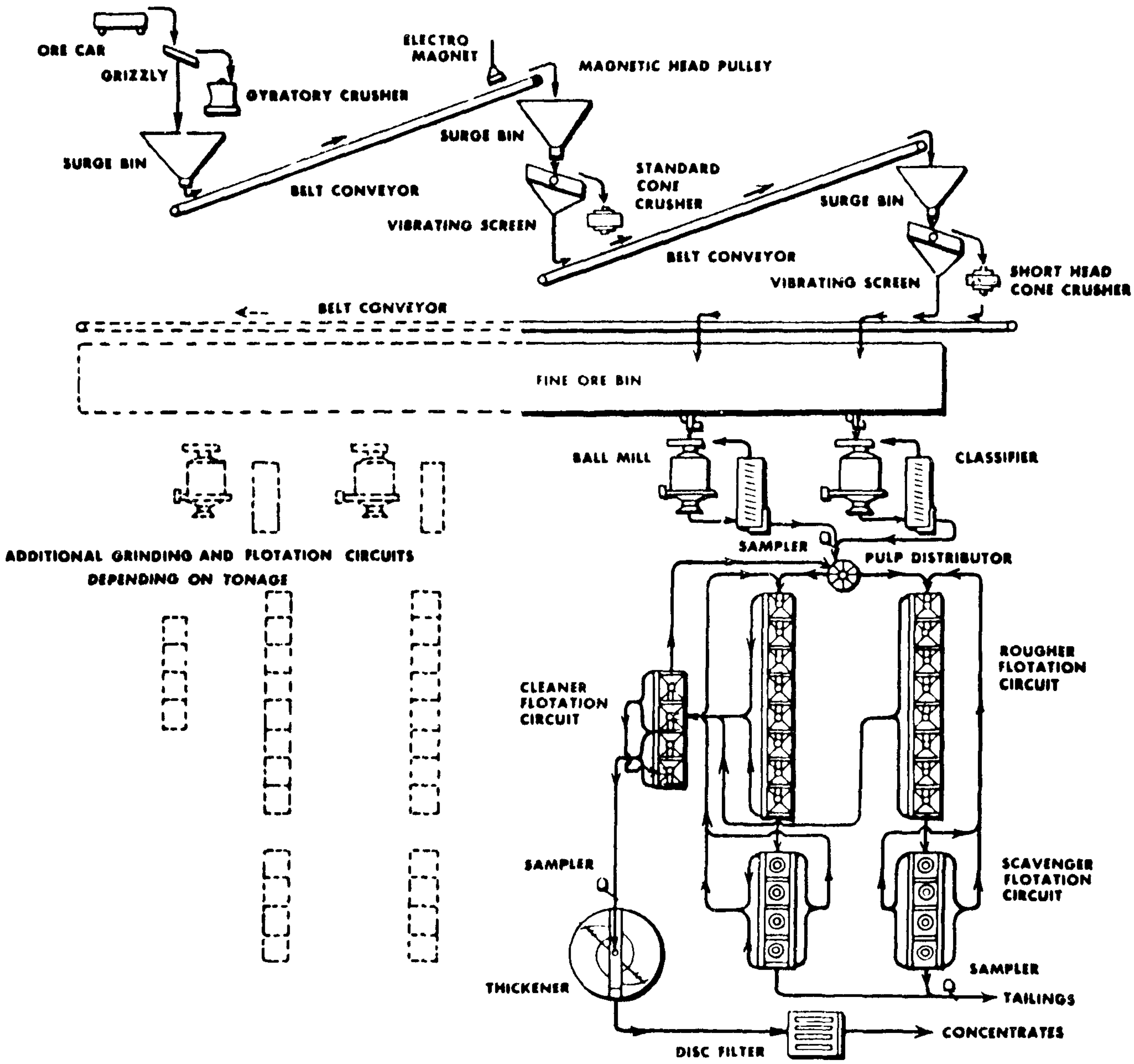


FIGURE IV-1 TYPICAL FLOWSHEET – SULFIDE COPPER ORE FLOTATION

(1) *Acid Leaching.* The ore is properly sized, if necessary, and leached with acid which dissolves the copper. Depending on ore grade and characteristics, the ore is leached in vats (by percolation or with agitation), in heaps, or in place.

Sulfuric acid is the usual solvent for oxidized copper minerals. The presence of ferric sulfate in the leach solution can solubilize some sulfide minerals such as chalcocite. For dissolution of the oxide minerals, about 1.5 pounds of acid per pound of contained copper is required, but total consumption of acid is often much greater because of reaction with gangue minerals.

Copper is recovered from dilute leach solutions by precipitation with scrap iron, and from concentrated leach solutions by electrowinning.

Other minor methods include ammonia leaching, cyanide leaching, the segregation process, and oxide ore flotation.

c. Mixed Ores

The treatment of mixed ore, that is, ore containing both sulfide and oxide minerals, depends on the proportions of the two types of minerals. If sulfides predominate, flotation is used, with reagents that favor flotation of oxide minerals. When the ore contains almost equal amounts of sulfide and oxide minerals, combinations of leaching and flotation are used.

4. Water Use

In 1968, the copper ore mining/milling industry used a total of 109 billion gallons, of which 90% was process water and the remaining 10% was for miscellaneous uses, which include air conditioning, power generation, boiler feed, sanitary services, and miscellaneous cooling and condensing operations. The industry's gross water consumption (including recirculated or reused water) amounted to 447 billion gallons. The corresponding water discharge (including mine water drained and discharged) was 68 billion gallons, of which about 17% received some form of treatment prior to discharge. A typical flowsheet for the water balance in a southwest sulfide copper mining and milling plant is shown in Figure IV-2.

5. Products

The major products of the copper mining and milling industry are sulfide concentrates and copper precipitates, although small amounts of siliceous ores go directly to the smelting process.

Copper concentrates and precipitates are produced principally from ores in Arizona, Montana, Michigan, Utah, Nevada, and New Mexico. In 1972,

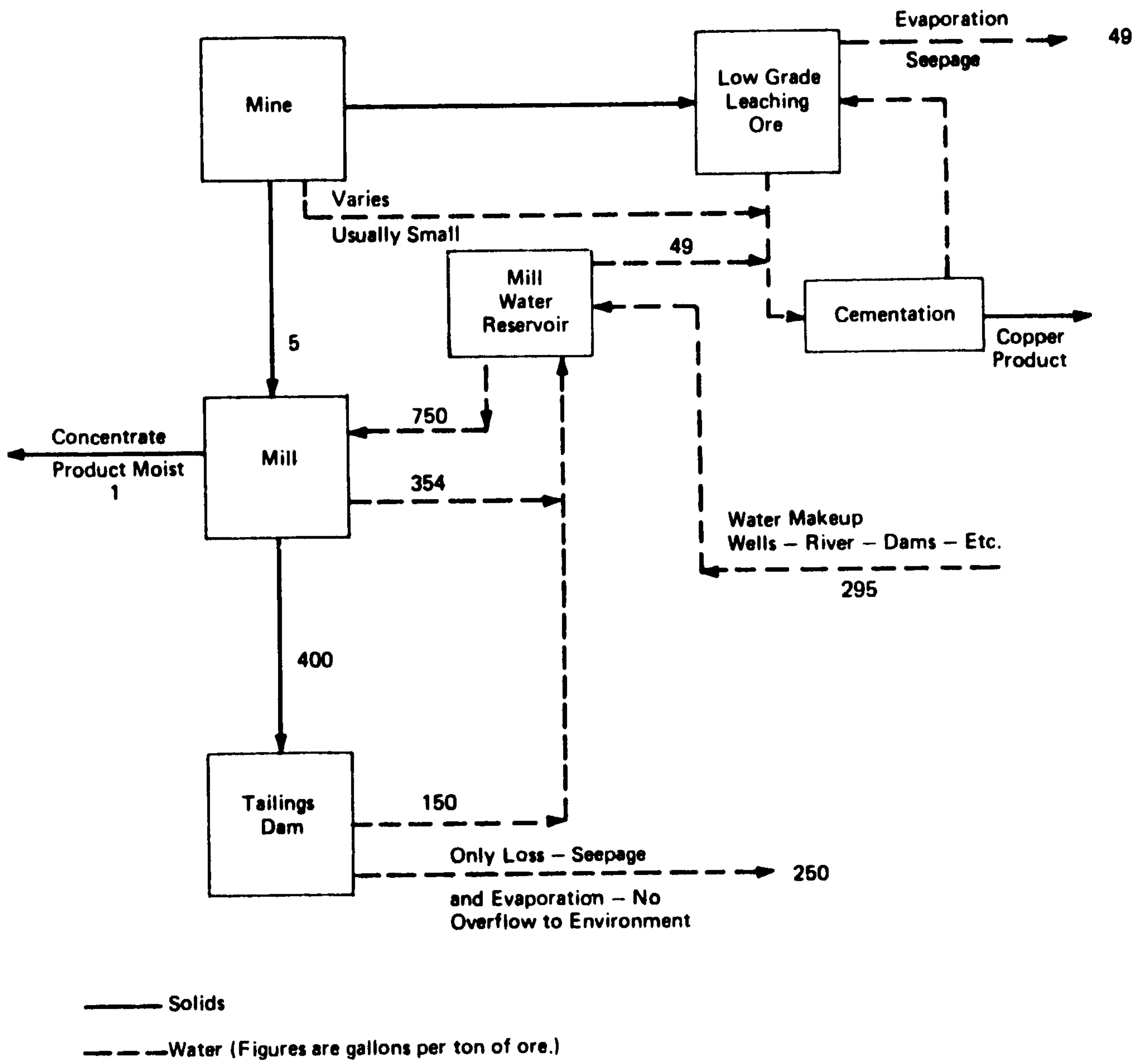


FIGURE IV-2 WATER BALANCE – TYPICAL SOUTHWEST COPPER OPERATION

266,831,000 short tons of ore were mined, with an average grade of 0.55% metallic copper. From this ore, 1,664,840 short tons of copper were produced. This production represented some 23% of the world's total; 87% of the total production was from open pit mines.

Besides production from copper ores there is some copper production as a by-product from certain non-copper, complex lead, zinc, ores but this is a minor amount. In 1972 only 1.9% of the total copper produced was recovered from these sources.

Many of the copper mines also produce by-products – principally molybdenite, gold and silver. Fifteen of the major porphyry copper mines together produce about 25,000 tons of molybdenite annually. In some of the mines the molybdenite is almost a coproduct and is important as a revenue producer to make the mine economically viable. Such is the case at the Sierrita Mine in Arizona.

The porphyry copper ores are also the major source of the metal rhenium which is recovered from the molybdenite concentrates.

In 1972, 17,684,000 tons of oxidized ores were processed by leaching; this is only 6.6% of the total ore processed.

C. INDUSTRY OVERVIEW

1. Types of Firms

The U.S. has been the largest copper producing country in the world since before the turn of the century. In 1972, the domestic primary copper industry was composed of 187 firms. The major producers are vertically integrated with many plants and have mining, smelting, refining, fabricating, and marketing interests. Other large producers mine and have processing facilities through the smelting or refining stages, and many companies mine and concentrate their ores and ship the product to custom plants for smelting and refining. The principal domestic producers are shown in Table IV-2. Of these, Anaconda, Inspiration, Kennecott, Asarco, Magma, Phelps Dodge and White Pine are integrated; Duval, Pima and the Miami Copper Division of the Cities Service Corporation are involved only in mining and milling.

Most of the smaller mining operations do not have their own smelting facilities because of the high capital cost of such facilities. Concentrates produced by the smaller companies are handled by custom smelters, who purchase ores or concentrates from other producers (custom smelting), or treat them for a fee and return the metal to the mining company (toll smelting). Asarco is the major custom smelter and refiner.

TABLE IV-2

PRINCIPAL COPPER-PRODUCING COMPANIES IN THE UNITED STATES – 1973

Company	1973 Mine Production, Short Tons Copper	1972 Mine Production, Short Tons Copper
American Smelting and Refining Co.	75,180	71,714
The Anaconda Company	200,454	233,471
Bagdad Copper Corporation	19,152	18,975
Duval Corporation	131,214	112,966
Inspiration Consolidated Copper Co.	64,705	70,079
Kennecott Copper Corporation	471,721	460,576
Magma Copper Co.	158,263	149,492
Phelps Dodge Corporation	319,566	305,432
Pima Mining Co.	88,140	82,841
Cities Service Co.	33,280	33,366
White Pine Copper Co.	78,179	70,375
Bethlehem Cornwall	1,964	2,779
Cyprus Bruce Mine	3,098	3,140
Hecla – 2 Mines	438	1,939
Idarado Mining	1,657	2,274
Eagle-Picher Ind., Inc.	2,861	4,420
Others*	77,062	41,001
Totals	1,726,934	1,664,840

*By difference

Source: American Bureau of Metal Statistics, Yearbook 1972, 1973.

In 1970 there were 16 copper smelters operating in the U.S., with an aggregate charge capacity of 8.6 million tons; 96% of this capacity was in the western states, and 50% was in Arizona. Four companies (Phelps Dodge, Asarco, Kennecott, Anaconda) controlled about 70% of the mine production capacity, 85% of the smelting capacity, and 81% of the refining capacity. The same four companies also controlled fabricating facilities that consumed over 50% of the copper.

Table IV-3 shows the fifteen principal copper producers and the disposition of their copper. This indicates the degree of integration from mine to smelter to refinery and finally to product sales.

TABLE IV-3

PRINCIPAL COPPER PRODUCERS AND THE DISPOSITION OF THEIR COPPER
UNITED STATES

Company	Where Smelted	Where Refined	Sold By
Asarco	Own plants.	Own refineries.	Asarco
The Anaconda Co., Butte, Mont.	Anaconda, Anaconda, Mont.	Anaconda, Great Falls, Mont.	Anaconda Sales Co.
Anamax Mining Co., Twin Buttes, Ariz.	Inspiration Consolidated Copper Co., Miami, Ariz. Asarco. Hayden, Ariz.	The Anaconda Co., Perth Amboy, N.J., Asarco, Perth Amboy, N.J. U.S. Metals Refining Co., Carteret, N.J.	Anaconda and Amax Copper Inc.
The Anaconda Co., Yerington, Nevada	The Anaconda Co., Anaconda, Mont.	The Anaconda Co., Great Falls, Mont.	Anaconda Sales Co.
Bagdad Copper Corp.	Asarco, Hayden, Ariz., Copper Range, White Pine, Michigan	Asarco, Perth Amboy, N.J., Copper Range, White Pine, Michigan	Asarco, Copper Range Sales Co.
Cities Service Company Miami Copper Operations	Inspiration Sm., Miami, Ariz. Phelps Dodge, Douglas, Ariz.	Raritan Copper Wks. and Phelps Dodge Ref.	Cities Service Company Metal Sales Dept.
Copperhill Operations	Own Plant, Copperhill, Tenn.	Phelps Dodge Ref. Corp.	Cities Service Company Metal Sales Dept.
Copper Range Co.	White Pine, Mich.	White Pine, Mich.	Copper Range Sales Co.
Duval Corporation	Asarco, Tacoma, Washington, Hayden, Ariz., and El Paso, Tex.	Asarco, Perth Amboy, N.J., Tacoma, Washington, Baltimore, Md.	Asarco, Duval Sales Corp.
Inspiration Consolidated Copper Co.	Own Plant, Miami, Ariz.	Own plant, Inspiration, Ariz., and Raritan Copper Wks.	
Kennecott Copper Corp.	Own smelters, Garfield, Utah; Ray, Ariz : McGill, Nevada; Hurley, N.M.	Own refineries at Garfield, Utah, Hurley, N M. Kennecott Refining Corp. at Anne Arundel County, Md.	Kennecott Sales Corp.
Magma Copper Company Superior Division	Own Plant, San Manuel, Ariz.	Own refinery and Phelps Dodge Ref. Corp.	International Minerals & Metals Corp and Magma Copper Company
San Manuel Division	Own Plant, San Manuel, Ariz.	Own refinery and Phelps Dodge Ref. Corp.	International Minerals & Metals Corp. and Magma Copper Company
Phelps Dodge Corp.	Own plants, Douglas, Morenci, and Ajo, Ariz.	Phelps Dodge Ref. Corp.	Phelps Dodge Sales Company, Incorporated
Pima Mining Co.	Phelps Dodge Corp., Magma Copper, San Manuel, Arizona	Phelps Dodge at Laurel Hill, N.Y.	Ametalco, Inc.
Quincy Mining Co.	Quincy Mining Co., Hancock, Mich.	Quincy, Mining Co., Hancock, Mich.	Quincy Mining Co.
White Pine Copper Co.	White Pine, Mich.	White Pine, Mich.	Copper Range Sales Co.

Source: American Bureau of Metal Statistics, Yearbook 1973

2. Types of Plants

In the U.S., over 100 mines produce some amount of copper; copper ore is the principal product of about 50 mines; the others are mostly lead and zinc mines, which produce copper as a by-product or co-product. The largest mines are shown in Table IV-4, as well as 14 smaller mines. The largest five mines each produced more than 100,000 tons of contained metal, amounting to 45% of the total.

In 1972, 94% of domestic copper mined came from Arizona, Montana, Nevada, New Mexico, and Utah; nearly all the remainder came from Michigan, Tennessee, and Missouri (see Table IV-5).

Table IV-4 lists available information for each of the mines and includes mine location, type, ore grade, stripping ratio, facilities at the mine site, production for 1972 and 1973, mill size, number of employees, age, metal production for 1973, and pertinent remarks. Total employment is 41,839. In the cases where there is a smelter (S code under facilities), the employment includes the employees at the smelter.

The 1972 Census of Mineral Industries shows the following employment statistics for the industry (excluding smelting):

Number of Establishments	=	187
Number of Establishments with over 20 Employees	=	70
Number of Employees	=	36,400
Number of Employees in Production	=	27,800

D. FINANCIAL PROFILES

1. Introduction and Background

As indicated previously the primary copper, lead, and zinc industries are mutually interdependent to a considerable extent. Also, several major companies are involved in the production of all three metals as well as gold and silver. Because of this, these nonferrous industries have been treated as a group in this chapter. In most cases, reference is made to company financial data as reported through 1972, and information on company activities as of 1973. In some uses, where appropriate, subsequent information has been noted.

The primary copper, lead, and zinc industries are concentrated. For example, the top three producers in copper – Kennecott, Phelps Dodge, and Anaconda – account for well over half of mine output and smelting capacity, are vertically integrated, and also account for a substantial share of fabricated product sales;

TABLE IV-4

U.S. COPPER MINING OPERATIONS

Company and Mine	Location	Mine Type	Ore Grade % Copper	Stripping Ratio	Facilities*	Millions Tons Ore 1972	Millions Tons Ore 1973	Mill Size Tons/Day	Employees	Age (Years)	Thousands S.T. Copper Produced (1973)	By-products and Remarks
Kennecott Corp.												
Utah Copper	Utah	O.P.	0.65	2.6	MCLSR	35.0	38.3	107,000	7,200	69	255	Moly-Gold-Silver
Ray Mines	Arizona	O.P.	0.91	3.2	MCLS	7.7	8.6	25,400	2,100	20	74	Moly-Gold-Silver
Ray Silicate	Arizona	O.P.	1.35	0	ML	2.6	3.7	8,000	–	6	25	Moly-Gold-Silver
Nevada Mines	Nevada	O.P.	0.78	3.9	MCLS	6.8	7.8	21,500	1,480	67	50	Moly-Gold-Silver
Chino Mines	New Mexico	O.P.	0.88	2.7	MCLS	6.3	8.1	22,000	1,500	63	68	Moly
Phelps Dodge Corp.												
Morenci	Arizona	O.P.	0.82	2.0	MCLS	17.2	18.4	60,000	2,400	33	120	–
New Cornelia	Arizona	O.P.	0.61	1.9	MCLS	9.8	10.3	34,000	1,270	58	54	–
Copper Queen	Arizona	U.G.	4.06	0	MCL	0.6	0.6	16,000	1,500	19	23	Au-Ag-Close-June 1975
Tyrone	New Mexico	O.P.	0 87	3.7	MCL	11.4	15.4	48,000	690	6	104	Au-Ag
Metcalf	Arizona	O P.	0.74	–	MCL	–	–	30,000	–	–	–	New-1975
Magma Copper Co.												
San Manuel	Arizona	U.G	0.69	0	MCSR	21.9	21.9	65,000	2,200	19	136	Moly-Au-Ag
Superior	Arizona	U.G.	4.40	0	MCSR	0.4	0.5	3,500	1,100	65	22	Au-Ag
Anaconda Co.												
Twin Buttes (Anamax)	Arizona	O.P.	0.82	7.6	MCL	18.9	15.1	32,000	1,664	5	74	–
Berkeley Pit	Montana	O.P.	0.76	3.7	MCL	16.6	17.8	50,000	3,500	12	128	–
Butte Mines	Montana	U.G.	3-5	0	M	0.5	0.6			100	–	Closing – 1975
Yerington	Nevada	O.P.	0.86	1.4	MCL	9.4	11.0	30,000	575	22	36	–
Continental East	Montana	O.P.	0.50	3.2	M	0	0.6	–	–	2	14	Phase Out – 1976
White Pine Copper	Michigan	U.G.	1.00	0	MCSR	8.2	8.9	25,000	2,925	20	90	–
Cyprus Mines Corp.												
Pima Mine	Arizona	O.P	0.56	1.6	MCL	18.7	20.2	54,000	1,050	18	88	Moly-Silver
Bagdad	Arizona	O.P	0.70	5.3	MCL	2.0	2.1	6,000	525	35	19	Moly-Silver
Asarco												
Mission	Arizona	O P.	0.70	2.5	MCL	8.4	8.8	22,500	720	14	47	Silver
Silver Bell	Arizona	O.P.	0.70	3.5	MCL	3.8	3.9	13,000	385	21	24	–
Sacaton	Arizona	O.P.	0.70	–	MCL	–	–	9,000	250	2	–	New
San Xavier	Arizona	O.P.	–	–	ML	N.A.	N.A.	4,000	30	3	11	Smelter Flux and Leaching
Inspiration												
Thornton (Plus 3 Others)	Arizona	O.P.	0.71	1 3	MCLSR	10.1	12.8	22,000	1,725	60	43	Moly
Christmas	Arizona	O.P.	0.80	5.8	MC	1.9	1.6	6,000	275	13	70	–

TABLE IV-4 (Continued)

Company and Mine	Location	Mine Type	Ore Grade % Copper	Stripping Ratio	Facilities*	Millions Tons Ore 1972	Millions Tons Ore 1973	Mill Size Tons/Day	Employees	Age (Years)	Thousands S.T. Copper Produced (1973)	By-products and Remarks
Duval Corp.												
Mineral Park	Arizona	O.P.	0.88	0.8	MCL	7.1	6.6	19,000	403	11		Moly
Esperanza	Arizona	O.P.	0.34	1.6	MCL	0	6.0	15,000	492	17		
Sierrita	Arizona	O.P.	0.28	1.5	MC	28.4	29.9	82,500	1,524	5	56	
Battle Mountain	Nevada	O.P.	0.63	6.2	MC	1.7	1.8	4,500	306	8		
Cities Service												
Copper Cities (Miami)	Arizona	O.P.	0.50	0.7	MC	5.1	5.2	14,000	650	21		
Copperhill	Tennessee	U.G.	1-3	0	MCS	1.7	1.3		1,900	20	44	
Pinto Valley	Arizona	O.P.	0.40	13.0	MC	0	0.2	40,000	210	2	–	New Sched. – 1974
Ranchers Development	Arizona	O.P.	0.44	1.5	ML	4.2	3.4	15,000	56	11	7	
Old Reliable	Arizona	–	0.74	–	L	–	–	–	15	1.5	N.A.	Solution
Big Mile	Nevada	O.P.	2.0	–	ML	–	–	–	6	2 5	0.8	Mining – Heap
Earth Resources	New Mexico	O.P.	–	5.1	ML	1.1	1.3	4,000	125	N.A.	N.A.	Leaching
Continental Copper	Arizona	U G.	N.A.	0	N.A.	N.A.	N.A.	N.A.	10	N A.	N.A.	–
El Paso Natural Gas												
Lakeshore (50% Hecla)	Arizona	U.G.	0.75	0	MCL	–	–	15,500	400	1	–	New – 1975
Emerald Isle	Arizona	O.P.	N.A.	N.A.	N.A.	0.3	N.A.	800	31		N.A.	
McAlester Fuel (Zonia)	Arizona	O.P.	N.A.	N.A.	ML		1.9	3,700	30	9	1.9	In-Situ Leaching
Federal Resource Corp.	New Mexico	U.G.	N.A.	0	N.A.	0.1	0.1	450	130		N.A.	
Eagle Picher Ind.	Oklahoma	O.P.	1.92	48.9	MC	0.3	0.2	1,000	100	10	2.9	–
Keystone Wallace	Utah	O.P.	N.A.	N.A.	ML	N.A.	N.A.	2,000	40	5	0.2	–
Micro Copper Corp.	Utah	O.P.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	11	N.A.	N A.	–
Ivey Construction	Wisconsin	U.G.	N.A.	N.A.	N.A.	N.A	N.A.	N.A.	6	N.A.	N.A.	–
U.V. Industries	New Mexico	O.P.	2.0	3.7	N A.	0.8	1.6	7,500	330	N.A.	N.A.	–

*M = Mine
C = Concentrator
L = Leach Operation
S = Smelter
R = Refinery
N.A. = Not Available

TABLE IV-5

U.S. MINE PRODUCTION OF RECOVERABLE COPPER BY MAJOR PRODUCING STATES – 1971, 1972, 1973
(Short Tons)

	1971			1972			1973		
	Amount	**Rank**	**Percent**	**Amount**	**Rank**	**Percent**	**Amount**	**Rank**	**Percent**
Arizona	820,171	1	54	908,612	1	55	931,128	1	54
Michigan	56,005	6	4	67,260	6	4	72,129	6	4
Montana	88,581	5	6	123,110	4	7	133,006	4	8
Nevada	96,928	4	6	101,119	5	6	95,912	5	6
New Mexico	157,419	3	10	168,034	3	10	207,987	3	12
Utah	263,451	2	17	259,507	2	16	257,860	2	15
Others*	39,628	–	3	37,198	–	2	28,912	–	1
Total	1,522,183			1,664,840			1,726,934		

*Others: California, Colorado, Idaho, Maine, Missouri, Pennsylvania, Tennessee, Oklahoma

Source: U.S. Department of Interior, Bureau of Mines

St. Joe Minerals is a major factor in both lead and zinc. Because of the raw material characteristics and the substantial by-product and co-product metal recovery occurring in these industries, the major producers all tend to have significant production of all three metals, and also by-product recovery of silver and other valuable metals. Another feature of these industries is that the major companies have important holdings in foreign mining ventures (which include diversification into other minerals) and participate in joint ventures with each other. Their equity holdings in other companies tend to complement their degree of direct participation in the primary nonferrous metals industries (including aluminum).

Unlike large copper producers, the lead and zinc companies are not integrated forward into fabricated products or end products – e.g., storage batteries, tetraethyl lead, galvanized steel products or zinc die castings.

The major influences on company earnings are operating rates and metal prices; these fluctuate much more than annual consumption or demand. Metal market prices, reflecting the nature of the commodity markets, are very sensitive to small imbalances (actual or perceived) between supply and demand. Although the nonferrous metal market is not a classis commodity market in the sense of a very large number of small independent producers, the non-differentiated nature of primary metal products plus the supply-demand characteristics in the industry – including the many end uses, the foreign sources, the speculators, and hedging transaction effects – indeed result in a commodity market in copper, lead and zinc.

Because of costs, marketing structure, and tax laws, the commodity of commerce is the refined metal. Smelting and refining are equivalent to toll services on a relatively fixed margin; more, if not most, profits come from mining. The result is that profitability of all companies is most sensitive to changes in refined metal prices. Since metal prices are influenced by traditionally cyclical forces, the nonferrous metals companies' revenues and earnings are highly cyclical.

2. Financial Performance

Fifteen or so firms dominate the U.S. primary copper, lead, and zinc industries (excluding secondary producers, independent fabricators, etc.). It is difficult to generalize about profitability and financial conditions on an industry-wide basis because each company has some unusual features. We present in Table IV-6 an estimated breakdown of revenues and earnings, by source and geographic area, as well as other information, to illustrate this point.

TABLE IV-6

REFERENCE DATA

NONFERROUS METALS COMPANIES*

	Asarco	Anaconda Co.	Copper Range	Inspiration Consolidated	Kennecott Copper	Newmont Mining	Phelps Dodge	St. Joe Minerals	Amax	Gulf Resources (Bunker Hill)
Percent Change in Earnings										
Due to 1¢ copper price change:	(low)	(high)	(high)	(med-high)	(low)	(low-med)	(low)			
Due to Pb-Zn metals price change:	(low)	(high)	(high)	(med.)	(low)		(low)	(high)	(low)	(med. - high)
Due to aluminum price change:		(low)					(low)		(med.)	
Reported Income Tax Rate, Percent										
1971	11.0%	$440 MM U.S. tax loss carry forward 1971-81 (and $190 MM foreign tax credits)	(credit)	27.7%	15%	19.3%	35.07%	29.8%	17% excludes dividend income	nil
1970	22.3%		29.4%	33.1%	30%	32.2%	37.6%	29.6%	22%	27%
Mine Production-U.S.A.										
Copper (thous. short tons)									Note: Also 20% Equity in Copper Range Co.	
1971	75.8	182.0	58 6	54.4	456.1	101	281.2		182.0 custom smelter refined	
1970	83.4	242.1	67.8	67.1	518.9	112	313.5		215.0	
Lead (thous. short tons)										
1971	18.7	16.4 Toole Smelter Closed '71			68.6	Joint venture with Asarco. Also holds 8.1% of St. Joe Minerals	Note: P-D owns 772,500 shares Amax stock	303.2	N.A.	44-own 85-others
1970	28.4	18.1			83.7			318.4	75.0	40-own 83-others
Zinc (thous. short tons)										
1971	43.1	0.7 Great Falls Closing '72			17.4			144.0 (conc. produced)	N.A.	67-own 53-others
1970	63.3	0.1			21.7			66.4 mine	32.0	50-own 64-others
Silver (million troy ounces)										
1971	6.66	3.87			3.7				20.0	9.6 refined
1970	6.84	5.02			4.3				40.0	7.8
Aluminum Production (thous. short tons)										
1971	33.6% interest in Revere Copper and Brass	171.7			owns 925,000 shares Kaiser Aluminum		40% interest in Consolidated Aluminum Corp. (Conalco)		260 0	
1970		177.3							247 0	

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed

*For a discussion of New Jersey Zinc Company, a subsidiary of Gulf and Western Industries, see text

TABLE IV-6 (Continued)

	Asarco	Anaconda Co.	Copper Range	Inspiration Consolidated	Kennecott Copper	Newmont Mining	Phelps Dodge	St. Joe Minerals	Amax	Gulf Resources	Cyprus Mines
Estimated Revenue Breakdown											
Copper											
Mining	13-17%	5-10%	75-85%	94-98%	50-55%	85%	40-45%				25-30%
Fabrication		60-65%	15-20%	2-06%	10-15%		40-45%				
Custom Smelting	13-17%	nom.			nom.	nom.	5-10%				
subtotal	26-34%	65-75%	95+%	100%	60-70%	85-90%	90-93%		30%		25-30%
Zinc								44%		76%, includes silver	10-15%
Lead								35%			
Coal					25%					13%	
Aluminum		15-17%					7-10%		35%		
Primary											
Fabrication											
Other Sales											
All Other, n.e.c.	66-74%	8-20%	nom.		8-11%	10-15%		21%	35%	11%	55-60%
	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%
Approximate Earnings Distribution											
Copper											
Mining-U.S.	20-25%	60-70%	95-105%	92+%	68-72%	40-45%	79-83%				
Mining-Foreign	40-45%	15-20%			10%	30-35%	5%				
subtotal	60-70%	80-85%	95-105%	92+%	78-82%	70-80%	85±%				45-55%
Fabrication	2%	2- 4%	(nil)	nom.	nom.		5-10%				
Custom Smelting	5%	1- 2%			nom.		nom.		7-10%		
Total, Copper	70-75%	84-88%	95-100%	95%	85±%	70-80%	95±%				50-60%
Zinc								30±%		[Lead, zinc and silver account for 41% of profit in 1970, and a loss in 1971]	10-15%
Lead								65±%			
Coal					10-12%						
Aluminum		nil					nom.		10-15%		
Primary											
Fabrication											
Other Sales											
All Other, n.e.c. including interest and dividends	25-30%	10-15%	≤5%	≤5%	3- 5%	20-30%	5+%	5±%	80+%		25-35%
	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%
Approximate Source of Pre-tax Profits											
U.S.A.	40-50%	70-80%	100%	100%	95±%	70%	95%	80-90%			40-50%
Canada	5±%	2±%					1%	5±%			10-15%
Mexico	5-10%	15-20%									---
South America	15-20%					5%	5%	10-15%			10-20%
Australia	25-30%	(nom.)			nil	(nom)	(1%)				10-20%
Africa						20-30					---
Other	(nom.)				nil						15-20%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

TABLE IV-6 (Continued)

SELECTED FINANCIAL DATA: MAJOR U.S. NONFERROUS METALS COMPANIES

(Dollar Figures in Millions)

1971	Asarco	Anaconda	Copper Range	Inspiration	Kennecott	Newmont	Phelps Dodge	St Joe	Amax	Gulf Resources	Cyprus Mines
Sales (in millions of dollars)	656 8	946 5	88 6	66 2	1,066 9[o]	240 5[o]	703 6	194 4	756 9	116 2[o]	203.2
Pre-tax Profit (in millions of dollars)	51 7	(5 2)	(6 1)	12 1	102 9	67 5	113 7	27 9	65 8	(3 5)	58.6
Net Income (in millions of dollars)	46 0	(8 7)[a]	(3 5)	8.7	87 2	54 5	73 8	19 6	55 4	(3 9)	27.8
Cash Flow from Operations and Holdings (in millions of dollars)	60.0	84 5	4 9	14 6	180 0	86.0	110 3	29.1	86 5	1 2[d]	52.5
Increase (Decrease) in Debt	14 4	25 0	12 0	(0 1)	52 0	93 2	78.7	(1 0)	130 6	4 6	(5.5)
Dividends Paid	46 2	10.9	0 6	4 8	58 0	28 2	42.9	13.7	36.5	1 1	9.1
Current Ratio: Assets/Liabilities	2 1	3.1	3 2	3 7	2 4	3 5	3 4	3 0	3.3	1 9	1.8
Net Working Capital	174 0	265 0	30 3	19 0	269 0	79 3	209.0	46 5	302 0	18 3	35.8
Capital Expenditures	37 4	89 9	11 9	9 8	150 0 (net)	129 1	75 5	21 2	139 5	7 4	38.1
Long-term Debt, year end	38 1	391 5	36 3	nil	314 6	201 6	166.0	10 7	392.0	48.6	34.9
Equity, year end	673 3	821 0	101 7	69.7	1,192.9	444 1	710 2	171.3	625 2	28 4	207.5
Debt ÷ (debt and equity) Percent based on book values	5.4	32 3	27 3[e]	nil	20 9	31.2	19 0	5 9	38 5	63 1	14.3
Scheduled Debt Repayment (1972 payment excluded from long-term debt at year end 1971)											
1972	3 6	24.6	1.3		43 4[e]	8.7	0.1	1 0	25 7	2 9	
1973	3.6	19 2	7 0[e]		43 2[e]	26 7	0.1		23.4	6 5	
1974	3 6	35 5	7.0		62 3[e]	31.8	12.9		27.5	6 0	
1975	5 2	58 1	N A.		5 1[e]	44.3	0.1		20 6	5.9	
1976	1 6	64 0	N A.		21.7[e]	33 5	0.1[c]		29.7	5 9	
Long-term Financing (in millions of dollars, 1971)			20 0	b	200.0	101.9	150.0		156 9	22 0	
Employment, year end	13,600	27,481	3,644	2,009	30,400	N.A.	15,500	4,503 (USA)	16,000	2,700 1,940 @ Bunker Hill	

Notes: p = preliminary; e = estimate
a/ Before extra-ordinary charge due to write-off of Chilean properties and other expense
b/ Agreement for $13MM advances from toll customer
c/ Above before $22 MM to be received from Conalco debentures
d/ $19.7MM write-downs and reserves, net, excluded
o/ Includes other revenues and/or income, as reported.

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed

Table IV-7 presents financial performance data and averages for the four years 1968-1971; this period covers two relatively good years and two relatively poor years for most of the companies. These data, we believe, are an internally consistent set, and provide a meaningful and representative picture. In Table IV-7, we have not reflected the 1972 data, which would present some distortion as a result of the advent of the U.S. Economic Stabilization Program and price controls, and also because of accounting changes by several companies in that year. We present selected 1972 financial data, as actually reported for each company, in Table IV-8.

The highest rates of return on equity over the 1968-1971 period were shown by Inspiration and St. Joe Minerals. Newmont Mining, which owns Magma Copper, had the highest consolidated operating margin. Newmont also earns substantial income from its large investment holdings, as do AMAX and Asarco. Anaconda and Gulf Resources & Chemicals showed the lowest rates of return on equity. Anaconda's valuable Chilean properties were expropriated and written off in 1971, leaving the company with relatively low-margin domestic mining operations. Gulf Resources had heavy expenses and low offsetting volume at the Bunker Hill lead-zinc operations, but, more significantly, also had substantial write-offs associated with its other minerals and chemicals projects, i.e., Mexican Sulphur (1969), and the Great Salt Lake project (1971).

The aggregated average annual net after-tax income of the eleven companies in Table IV-7 exceeded $500 million. For 1972 (see Table IV-8), the aggregate figure was $400 million.

3. Capital Spending and Funding

Annual new plant and equipment expenditures for the companies in Table IV-7 averages about 10% of gross plant, as stated on the balance sheets. In 1971, which was a poor year for most of the companies, capital expenditures were $710 million, and cash flow was about $650 million. (In the face of weaker earnings in 1971, several companies cut their dividends.) For 1972, capital outlays slightly exceeded $800 million, and cash flow totalled nearly $900 million.

Kennecott, Phelps Dodge and AMAX raised a total of $500 million in long-term financing in 1971. The debt-to-equity ratio of the nonferrous metals companies has been increasing as the pace of their expansion and diversification programs has increased over the last several years.

There has also been an increasing requirement for pollution abatement expenditures, which was acknowledged by many of the companies back in 1970 after passage of the Clean Air Act. This may result in a further increase in corporate debt, and hence, according to financial convention and theory, in

TABLE IV-7

FINANCIAL PERFORMANCE DATA

COPPER, LEAD AND ZINC COMPANIES*

Company	Net Sales For the Year	Operating Income Before Depreciation	Net After Tax Earnings (Before Extraordinary Items)	Capital Expenditures	Operating Ratio Operating Income As A Percent of Sales	Net After Tax Return On Stockholders' Equity	Ratio of Capital Expenditures To Gross Plant A Year End
	MILLIONS OF DOLLARS				PERCENT		
Amax							
1971	756 9	97 9	55.4	139 5			
1970	840 7	115 2	83 6	110 2 (ex RST)			
1969	753 5	99 8	69 1	63 0			
1968	570 6	81 9	59 8	101 2			
			Avg 67 0	Avg 103 5	Avg. 13.6%	Avg 13 5%	Avg 14 6%
Anaconda							
1971	946 5	66 9	(8 7)	89 9			
1970	977 4	108 9	68 1	90 5			
1969	1410 6	393 1	99.3	127 0			
			Avg 52 9	Avg 102 4	Avg. 15.4%	Avg 4 7%	Avg 8 1%
Asarco					Net Income/Sales		
1971	656 8	26 3	46 0	37 4			
1970	717 8	57 5	88 8	68 7			
1969	771 0.	60 1	99 4	25 0			
1968	634 1	38 1	73 2	37 2			
			Avg 76 9	Avg 42 1	Avg 6.5% Avg 11 0%	Avg 13 1%	Avg [illegible]
Copper Range							
1971	88 6	4 7	(3 24)	11 9			
1970	97 5	21 9	9 6	14 0			
1969	10 23	27 8	15 9	12 1			
1968	82 1	19 9	9 7	14 4			
			Avg. 8 0	Avg 13 1	Avg 19 9%	Avg 9 6%	Avg 7 [illegible]%
Inspiration Consolidated							
1971	65 8	16 9	8 7	9 8			
1970	88 8	30 5	17 8	9 7			
1969	69 5	22 5	13 4	9 4			
1968	43 9	8 7	5 7	9 0			
			Avg 11 4	Avg 9 5	Avg 28 1%	Avg 21 0%	Avg 9 6%
Kennecott Copper							
1971	1053 4	191 4	87 2	162 5 Includes Av			
1970	1133 1	322 3	185 0	163 2 of 34 8/Year			
1969	1050 0	286 9	165 4	152 0 Capitalized			
1968	724 5	171.9	111 2	150 0 Mining Costs			
			Avg 137 2	Avg 156 9	Avg 24.4%	Avg 13 1%	Avg 10 5%
Cypris Mines (incl Pima Consol)							
1971	203 2	66 9	27 8	42 5 Includes			
1970	202 5 [141 8	74 2 [32.6	27 4	28 1 Expl			
1969	113 5 ex Pima]	24 4 ex Pima]	24 0	31 5 Net			
1968	113 0	21 2	21 3	8 5			
			Avg 25 1	Avg 27 6	Avg 27 5% (Including Pima 1970-1971)	Avg 15 2%	Avg 14 [illegible]
Phelps Dodge							
1971	703 6	140 5	73.8	75.5			
1970	716 2 Restated	184.7 Restated	108 0	89 2			
1969	672 1 628 9	138.4 N.A	89.5	87 3			
1968	550 4 531.7	98.1 N.A.	64 6	77 7			
			Avg. 84.0	Avg. 82.4	Avg 20 7%	Avg 14 7%	Avg 10 1[illegible]
St Joe Minerals							
1971	194 4	29.6	19.6	21 2			
1970	161 3	35 2	26 2	15 2			
1969	179 0	53.1	37 5	13 4			
1968	150 8	36 8	25 0	10 3			
			Avg. 27 0	Avg. 15.0	Avg 22.8%	Avg 18 7[illegible]	Avg 6 8[illegible]
Gulf Resources Chemical							
1971	115 2	7.8	(3 85)	7.4			
1970	114 4	13.1	4.56	4.0			
1969	113 7	12.1	3 77	5.4			
1968	104.9	11.7	3 45	9 5			
			Avg. 1 98	Avg. 6 6	Avg. 10.0%	Avg 3 9%	Avg 6 2[illegible]
Newmont Mining		**					
1971	197 5	55 2	54 5	129 1			
1970	214 8	97 6	75 2	135 3			
1969	197 0	83 8	64 1	57.0			
1968	154 1	61 3	50 3	58 1			
			Avg 61 0	Avg. 95.0	Avg 39.0%	Avg 17 4%	Avg N.A

NOTE: While reasonable care was taken in compiling this data and presenting it in as consistent a fashion as is possible, we cannot guarantee absolute comparability from one company to the next, due to differences in the nature of earnings, and differences in their accounting for certain balance sheet and income statement items. To the best of our knowledge the above data present an accurate and meaningful basis for selective comparisons.

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed.

*For a discussion of New Jersey Zinc Company, a subsidiary of Gulf and Western Industries, see text
*This table should be read in conjunction with Table VIII-1

**Excludes dividends, interest, net gain on sales of securities and other income in the following amounts.

1968	-	$39.3
1969	-	40.4
1970	-	43.6
1971	-	43.0

TABLE IV-8

SELECTED FINANCIAL DATA: MAJOR U.S. NONFERROUS METALS COMPANIES

(Dollar Figures in Millions)

1972	American Metal Climax	American Smelting & Refining	Anaconda	Copper Range	Inspiration Consolidated	Kennecott Copper	Newmont Mining	Phelps Dodge	St. Joe Minerals	Gulf Resources & Chemical	Cyprus Mines[l]
Sales	863.1	814.3	1,011.6[a]	97.6	85.5[a]	1,145.3	301.7[a]	765.8	205.0	125.6[j]	318.8
Pre-tax Profit (loss)	90.8	59.0	49.6	(4.0)	16.8	104.0[b]	61.9[b]	130.7	36.1	4.7	50 7[l]
Net Income	66.2	49.1	44.1[b]	(2.4)[b]	12.2	47.4[g]	44.8	82.2[a]	24.8[b]	3.5[b]	28.8
Cash Flow from Operations and Holdings, net	123.3	59.9	181.9[g]	6.0	18.3	192.1[b]	79.2[c]	127.1	37.7	8.9	61.8
Increase (Decrease) in Debt	55.1	51.7	(5.9)[h]	(1.3)	18.0	(45.2)	46.3	15.6	24.0	5.0[j]	(12.7)
Dividends Paid	37.3	32.1	2.7	–	4.8	33.1	31.0[d]	43.1	12.7	1.1	9.0
Capital Expenditures and Investments	144.8	68.7	122.6	4.1	27.4	152.0 net	73.4	95.8	79.2 net	9.1	26.8
Current Ratio Assets/Liabilities	3.1	1.7	3.1	3.2	3.7	2.3	2.4	3.5	2.0	2.0	2.1
Net Working Capital	325.5	130.7	291.0	30.4	23.3	290.4	84.8	213.7	33.3	20.8	43.9
Long Term Debt, year-end	458.8	51.0	388.9[h]	35.0	19.1[k]	269.0	224.0	181.3	34.7	53.1	22.3
Equity, year-end	655.5	682.6	971.4	94.8	77.1	1,203.8	490.4	749.3	184.6	31.9	225.9
(Debt) ÷ (Debt and Equity) % based on book values	41%	7%	29%[h]	27%	k/	18%	31%	19%	16%	62%	9%
Scheduled Long Term Debt Repayment (Less Current Maturities)											
1974	18.4	8.6	18.7	1.3	3.2[e]	38.8	32.4	0.6	N.A.	7.7	7 4
1975	41.6	15.1	11.8	1.3	6 0[e]	10.8	34.0	0.4	N.A.	7.3	9 4
1976	30.2	5.2	43.4	1.3	N.A.	4.9	12.5	0.4	N.A.	7.2	0.4
1977	13.7	1.6	0.8	2.0	N.A.	5.0	19.1	25.4	N.A.	7 9	0.4
1978	63.3	N.A.	9.25-18.5	2.6	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	2.5[e]
Long Term Financing, 1972	79.7	16.5	36.8	–	18.0	0.7	101.7	25.0	25.0	j/	nil
Employment, year-end	16,680	14,800[f]	25,907	3,770	2,113	29,100[f]	11,670	15,800	3,963	2,720	N A.

Notes:

a. Includes other revenues and/or income, as reported
b. Before extraordinary items
c. Excludes cost value of securities sold
d. Includes $2.7MM paid to minority stockholders in subsidiaries
e. Estimated
f. Average for the year
g. After extraordinary items
h. After including capitalized lease obligations
i. Includes Peabody Coal as a consolidated subsidiary, as reported
j. Gulf accounted for its investment in Great Salt Lake Minerals & Chemicals Corporation (GSL) a subsidiary not consolidated, on the equity method; effective January 1, 1972, GSL reverted to the preoperating and start-up stage and its 1972 net expenses were deferred in its accounts. Gulf has written off substantially all of their investment in GSL. At December 31, Gulf had guaranteed $9.5MM of GSL long-term debt. Gulf entered into a refinancing agreement in August 1972, for the rescheduling and extension of maturities on Gulf notes payable to banks; and subject to Gulf's pledge of substantial

(Cont) j. assets as collateral. Gulf and subsidiaries guaranteed all the loans under the agreement with the bank. The 1972 agreement prohibited any investment by Gulf in GSL subsequent to December 31, 1972. See text.
k. As of September 30, 1973, total debt had increased to $49.3MM (including current portion), a large part of which was bank loans for pollution control facilities under construction. Stockholders' equity as of September 30, 1973 was $82.3MM.
l. Consolidated statements including Anvil Mining and Pima Mining majority-owned subsidiaries. Marcona Corp , a principal affiliate, and subsidiaries are accounted for on an equity basis. The 1972 figures above are as reported before restatement on the pooling of interests basis to account for the acquisition of Bagdad Copper Corp. in June of 1973 (via an exchange of stock). Pre-tax figure includes minority interests.

further deterioration in the nonferrous metals companies' financial position as a result of higher debt-to-equity ratios and higher fixed charges. Offsetting this, however, is the higher stockholders' equity as a result of substantially better reported earnings for most companies in 1972 (and 1973).

The requirement for spending on pollution control equipment has brought with it federal, state, and local legislation to assist in the financing of such expenditures through various mechanisms for issuance of so-called pollution control revenue bonds. Most of the major nonferrous metals companies have now been involved in such financings for at least a portion of their programs.

A more detailed discussion of the major nonferrous metals companies is given in Appendix A (AMAX, Asarco, Anaconda, Cities Service, Copper Range, Cyprus, Duval, Inspiration, Kennecott, Newmont, Phelps Dodge).

E. PRICE EFFECTS

1. Determination of Prices

The major product of the copper mining and milling industry is copper concentrate, which is produced by the mine mill complex and either smelted in an associated smelter or shipped by rail to a regional type smelter.

Prices for copper concentrates can be categorized as either transfer prices or contractual sales prices. Concentrates are usually transferred to a smelter, since the large mines and mills are captive operations. Concentrates can also be tolled through noncaptive operations, or sold on a delivered basis to a noncaptive smelter. The transfer value or selling price of concentrates is usually in accordance with standard smelter schedules or formulas, which are based on the current quoted prices of electrolytic copper as published in Engineering and Mining Journal or London Metal Exchange. Since these toll charges have in past years been in the neighborhood of 8-12¢/lb of copper content. one can get an idea of the recent value of copper concentrates by deducting this amount from the metal price which in the U.S. has been sold by major producers at the so-called producer price.

Typically, U.S. copper producers sell on the basis of the price prevailing on the date of shipment, regardless of when the buyer placed his order. However, not all producers follow this practice; some sell at the average for the month of shipment as quoted in Engineering and Mining Journal or some other publication. In addition, some sales are made at a firm price (usually that prevailing at the time of sale), particularly to fabricators who prefer this method of fixing the cost of raw material rather than to operate in the hedge market to protect their profit margin.

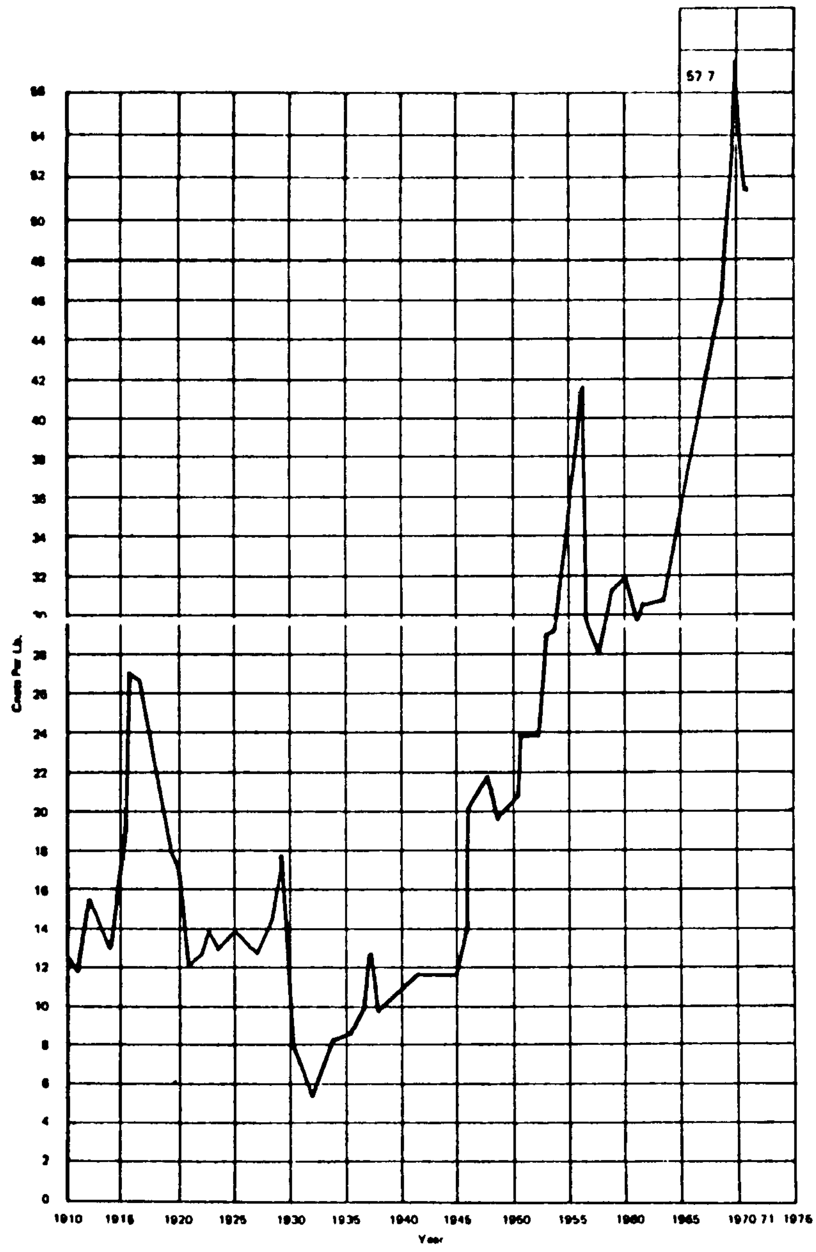
The basic reason behind the use of the domestic producer price is to minimize price changes, which are considered undesirable because users want to know that their raw material costs will be. The wide fluctuations in copper price in markets outside the United States and on commodity exchanges are believed to have encouraged the substitution of other materials for copper – notably the use of aluminum, plastics, and stainless steel. At times, the U.S. government has interceded in copper pricing, notably during World War II and the Korean War, when price ceilings were placed on copper as well as other metals, and again during the Vietnam War, when President Johnson, in the fall of 1965, virtually forced domestic producers to rescind a 2¢ price advance to 38¢/lb, even though prices on the London Metal Exchange at the time were over 60¢/lb.

U.S. producer sales to the market outside the U.S. (accounting for about one-third of refined sales) are, of course, not bound by price ceilings such as those imposed during World War II and the Korean War. If the ceilings are too restrictive, imports decline and scrap flow to the refineries declines. During the Korean War, therefore, the government sanctioned a higher price ceiling for copper of foreign origin than for metal of domestic origin.

Under reasonably balanced conditions, the outside market tends to follow closely the London Metal Exchange price. However, if business is expanding in Europe and slow in the United States, the outside market in the United States tends to be lower than London. When there is a severe shortage in the United States – for instance, during the 1967-68 strike – the outside market in the United States typically moves to a premium over the L.M.E. price sufficient to attract increased imports.

The outside market can be a discount from the producer price or a premium over it. From early 1965 through mid-1970, the outside market was consistently at a premium, but in the summer of 1970 the L.M.E. price dropped below the U.S. producer price. During most of the last half of 1970 and the first few months of 1971, sellers in the outside market in the United States offered copper at substantial discounts from the producer price. A similar situation prevailed from 1961 through 1963. The discounts available during such periods were far smaller than the premiums asked during periods of extreme shortage. Consequently, even though there may be an immediate saving by purchasing on the outside market, most U.S. consumers maintain their purchases from the large domestic producers in order to ensure future availability of copper in times of scarcity.

The recent dollar devaluation and readjustment of the world currencies have also had an effect on the worldwide pricing structure of copper, as has the imposition, then relaxation, of price controls in the United States. An historic record of copper prices (f.o.b. refinery) is shown in Figure IV-3 for the years 1910-1971. Price variations for the period 1971-1974 are shown in Figure IV-4.



SOURCE: E/MJ March 1972

FIGURE IV-3 AVERAGE ANNUAL U.S. COPPER PRICES (F.O.B. REFINERY)

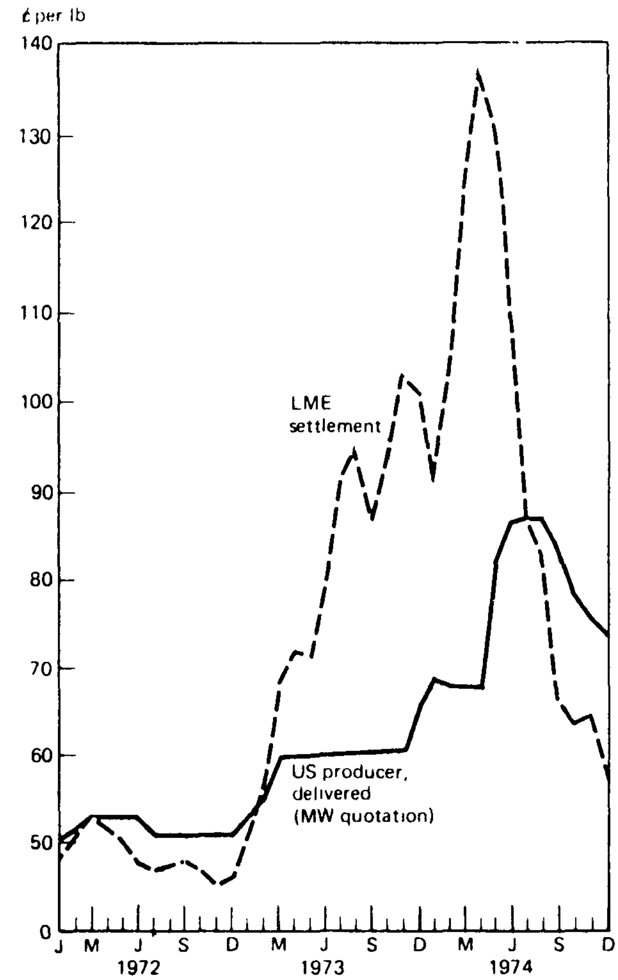


FIGURE IV-4 COPPER PRICES
(Monthly Averages)

During 1973, the prices charged by U.S. producers were limited by price ceilings to 60¢/lb (wire-bar basis). In December of 1973, they were permitted to rise by the Cost of Living Council to 68¢/lb. That price continued until April 30, 1974, when price controls expired. By May, the price had increased to 80¢/lb, and by June, to 85¢/lb. In September of 1974, prices began to move downward, and by the end of the year the price was 68¢/lb. By the end of the first quarter of 1975, the price had gone to 64¢/lb.

2. Costs of Production

Traditionally, the cost of smelting and refining has been small compared to the price of copper. Moreover, these operations are operated at a fixed and relatively low profit margin, which is not very sensitive to the price of the finished product. As a result, the value of the contained metal in a typical concentrate is a high proportion of the value of the primary metal product. This means that the smelting and refining plants are operated mainly as service operations in the conversion of these concentrates to usable metal and alloys. Thus, any changes in price of the primary metal are reflected back to the mine and affect directly the value of the concentrate.

In the 60's, the traditional rule of thumb in determining concentrate value in the copper industry was to assume 4¢/lb for smelting charges and 5¢ for refining charges, so that the value of copper contained in the concentrate is very approximately 9¢/lb below the cathode or wirebar market price. (The 1973/1974 smelter and refinery operating margin was closer to 12¢/lb.) Most of the U.S. smelters are old, and therefore the smelter/refinery margin comprises mainly direct costs with only a small percentage for fixed costs and profit. Because of this, any increase in smelting or refining costs cannot be "absorbed" by the smelter or refinery, but can only be passed backward to the mine, and the net-back to the mine (the net concentrate value realized at the mine, e.g., smelter payment minus transportation costs) would be decreased. Should the market permit an upward adjustment in primary metal price, this increase would then be reflected back to the mine.

The mechanism described above is of primary importance to custom and toll smelters, such as Asarco, since the custom smelter has to compete in an international market for concentrates. When treatment charges at a particular smelter increase, the mines have the option of shipping their concentrates to other smelters that offer them better net-backs. For example, Asarco in Tacoma, Washington, does not treat copper concentrates out of British Columbia because the Japanese smelters are able to offer better terms to the Canadian mines. Thus a custom smelter saddled with increased costs can suffer from a loss of smelter feed. Smelting costs per unit of product increase rapidly when smelters operate below capacity; hence a custom smelter can suffer a major impact if an adequate supply of concentrates is not available. Alternately, if a particular mine does not have other outlets for its concentrates, it has to close if the additional smelting costs cannot be absorbed.

In the case of producers integrated from mining though smelting and refining, a cathode or wirebar is the first product that is actually sold. However, the internal transfer price of the concentrates is usually calcualted on the basis of the primary metal price. Thus, any fluctuations in the primary metal price are again reflected back to the mine and have a major influence on mine profitability.

Figure IV-5 illustrates this mechanism, on the basis of actual custom smelting contracts that were in effect several years ago. It can be seen that any change in wirebar price affects the concentrate value directly, and the smelter and refinery margins remain unchanged.

Investment and operating costs for copper mining and milling plants vary, since there are a variety of different types of deposits to mine and different ores to process. It is, however, possible to estimate order-of-magnitude costs for assumed typical situations.

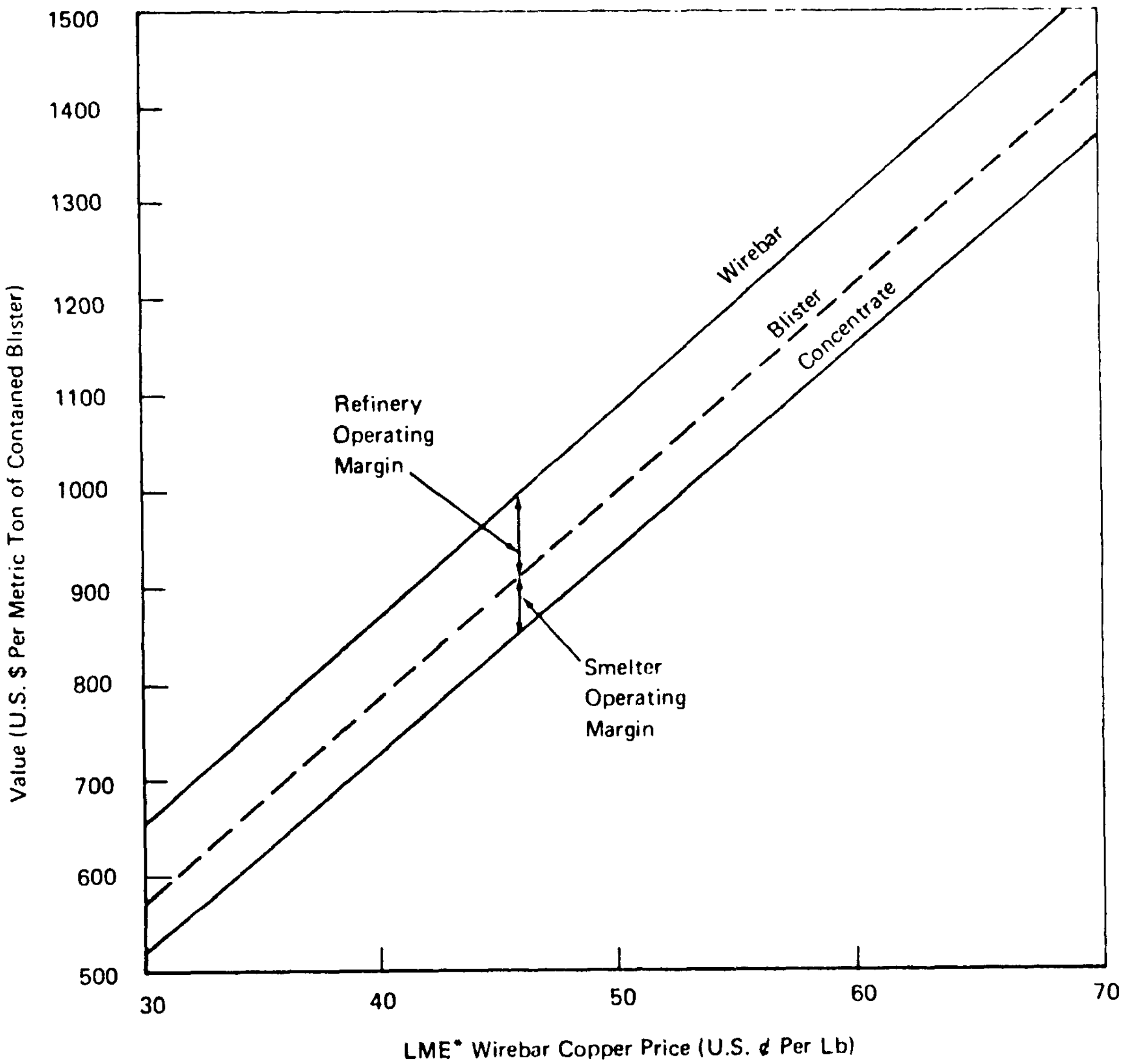
In the case of copper ore mining, we shall consider the following cases:

- An open pit mine producing 30,000 tons of ore per day from an ore of average grade 0.70% copper and with a 2/1 stripping ratio. Assume 90% copper recovery (typical in southwest).
- An underground vein-type mine producing 6,000 tons ore/day by cut-and-fill techniques from a 4.0% copper grade ore.
- An underground block-caving mine producing 30,000 tons/day from 0.7% ore (after dilution).
- An underground room-and-pillar mine producing 25,000 tons/day from 1.0% copper ore.

Estimates of the costs for these mines are as follows:

Mine	$ Millions Investment*	Operating Costs $/Ton Ore	Operating Costs $/lb Copper
Open Pit	26.0	0.70	0.06
Cut-and-Fill	30.0	7.20	0.10
Block-Caving	63.0	2.50	0.18
Room-and-Pillar	38.0	3.30	0.18

*Includes working capital, land and development costs.



* (London Metal Exchange)

Source: Arthur D. Little, Inc.

FIGURE IV-5 DIAGRAMMATIC REPRESENTATION OF VARIATION IN CONCENTRATE VALUE WITH CHANGES IN WIREBAR PRICES

Milling costs for the typical sulfide copper flotation plant associated with the mine can be estimated as follows:

Mine Size (Tons/Day)	Ore Grade	Investment $ Millions	Operating Costs $/Ton Ore	Operating Costs $/lb Copper
6,000	4.0%	18.0	2.20	0.03
30,000	0.7%	61.0	1.35	0.11
25,000	1.00%	52.5	1.40	0.08

3. Potential Constraints on Financing Additional Capital Assets

The constraints on financing additional capital assets (such as pollution control equipment) have been discussed in Section I.

F. ASSESSMENT OF ECONOMIC IMPACT

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Document for the copper ore mining and milling industry. These guidelines are:

- Best Practical Control Technology Currently Available (BPCTCA) – to be met by industrial discharges by 1977.
- Best Available Technology Economically Available (BATEA) – to be met by 1983.
- New Source Performance Standards (NSPS) – to be applied to all new facilities constructed after the promulgation of these guidelines.

For the purpose of recommending guidelines, the Development Document has divided the copper ore mining and milling industry into the following categories.

1. Mines – Open pit and underground.
2. Mines/Mills – Using dump, heap, in-situ or vat leaching.
3. Mines – Flotation.

1. Effluent Guidelines

For the Mines category, the recommended parameters and guidelines for BPCTCA are given in Table IV-9. The same guidelines are recommended for BATEA standards.

TABLE IV-9

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – COPPER MINES

Parameters	Concentration (mg/ℓ) in Effluent 30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Cu	0.05	0.1
Hg	0.001	0.002
Pb	0.1	0.2
Zn	0.5	1.0

*Value in pH units

Source: Development Document

For category 2 (Mines – Mills dump, heap, vat leach) above, zero discharge is recommended, and no guidelines are proposed.

For category 3 (Mills – Flotation), the recommended parameters and guidelines for BPCTCA are shown in Table IV-10. For this sub-category the BATEA recommendation is zero discharge.

TABLE IV-10

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – COPPER MILLS USING FROTH FLOTATION

Parameters	Concentration (mg/ℓ) in Effluent 30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
CN	0.01	0.02
Cd	0.05	0.02
Cu	0.05	0.1
Hg	0.001	0.002
Pb	0.1	0.2
Zn	0.1	0.2

*Value in pH units

Source: Development Document

2. Cost of Compliance

The guidelines contractor has estimated the cost of compliance for both BPCTCA and BATEA guidelines. These costs for copper ore mining and milling are summarized in Table IV-11 by sub-category and in Table IV-12 by company. The costs summarized in these tables are investments needed to install the required treatment facilities and the annual costs which are the yearly costs to operate the facilities. The annual costs include charges for amortization and interest. The fixed cost portion of the annual costs is about 20%.

In Table IV-13, we have estimated the incremental cost added to the five companies involved on the basis of increased cost per pound of recoverable copper metal that would be produced from the concentrate product. These are estimated for both BPCTCA and BATEA guidelines.

3. Basis for Analysis

The analysis of impact on the copper ore industry was carried out as discussed previously in Section I.

4. Levels of Impacts

The levels of impact were discussed in Section I.

5. Best Practical Control Technology Currently Available (BPCTCA)

In Table IV-14 we have summarized the data and costs for meeting the BPCTCA guidelines for the copper mining and milling industry. The table gives information regarding capacities, employees, and investment and operating costs for the three selected segments of the industry described above.

As shown in Table IV-14, three large multi-unit companies (impact group "B") are impacted in an insignificant way, and one operating unit of a large multi-unit company (impact group "C") is severely impacted.

a. Price and Production Effects. Impact group "B" of the industry would have a negligible product cost increase due to BPCTCA compliance; output levels would be unaffected. However, impact group "C" would be severely impacted and would have a product cost increase of 4¢ per pound. This group produces only a small amount of concentrate and sells that product to a custom copper smelter. They would not be able to pass on such an increase and would probably cease operation since they are a marginal producer at best. [Note: As this report was being prepared, the operation represented in impact group "C" closed for economic reasons.]

TABLE IV-11

COPPER ORES – COST OF COMPLIANCE

Sub-Category	No.	Thousands M.T. Ore Per Year	Costs – Thousands $ BPCTCA Investment	BPCTCA Annual	BATEA Investment	BATEA Annual
Mines	1-51	245,000	0	0	0	0
	52	16,553	2.5	0.5	2.5	0.5
	53	1,215	3.2	0.6	3.2	0.6
	54	130	429.8	212.2	429.8	212.2
		262,898				
Mines/Mills – Leaching	–	18,000	0	0	0	0
Mills – Flotation	–	180,000	0	0	0	0
	1- 3	33,000	0	0	0	0
	4	8,058	0	0	1,819.3	480.1
	5	1,215	30.5	6.4	134.5	39.6
	6	130	8.0	10.0	3.9	1.0
	7	34,738	279.1	249.6	188.7	62.9
Total Industry		262,898	753.1	479.3	2,581.9	796.9

TABLE IV-12

SUMMARY – COST OF COMPLIANCE BY COMPANIES
(Combine Mine and Mill where Necessary)

Company	Thousands M.T. Ore Per Year	Costs – Thousands $ BPCTCA Investment	BPCTCA Annual	BATEA Investment	BATEA Annual
A	16,553	2.5	0.5	2.5	0.5
B	1,215	33.7	7.0	137.7	40.2
C	130	437.8	222.2	433.7	213.2
D	34,738	279.1	249.6	188.7	62.9
E	8,058	0	0	1,819.3	480.1
Total	60,694	753.1	479.3	2,581.9	796.9
Rest of Industry	202,204	0	0	0	0
	262,898				

TABLE IV-13

INCREASE IN COPPER METAL COSTS – FOR BPCTCA AND BATEA REQUIREMENTS

I. COSTS FOR BPCTCA STANDARDS

Company	Thousands Short Tons/ Yr Metal Produced	Annual Cost	$/lb Copper
"A"			
Total Company	233	–	–
Affected Division	100	500	negligible
"B"			
Total Company	34	–	.000116
Affected Division	4	7,000	.000875
"C"	3	222,200	.037
"D"	70	0	0
"E"			
Total Company	461	–	.000271
Affected Division	258	249,600	.000484
Total Industry	1,665	479,300	.000144

II. COSTS FOR BATEA STANDARDS

Company	Thousands Short Tons/ Yr Metal Produced	Annual Cost	$/lb Copper
"A"			
Total Company	233	–	negligible
Affected Division	100	500	negligible
"B"			
Total Company	34	–	.00059
Affected Division	4	40,200	.00503
"C"	3	213,200	.036
"D"	70	480,100	.00343
"E"			
Total Company	461	–	.000068
Affected Division	258	62,900	.000122
Total Industry	1,665	583,600	.000175

TABLE IV-14

SUMMARY OF DATA AND COSTS FOR BPCTCA GUIDELINES
COPPER ORE MINING AND MILLING (1972)

	Impact Group			Total
	"A"	"B"	"C"	Industry
Thousands M.T. Ore per year	210,392	52,506	130	266,800
Thousands S.T. Metal product/yr	1,283	362	3	1,665
% of Industry – Ore Basis*	78.9	19.7	0.05	100
Number of Employees	26,509	9,450	77	36,400
% of Employees	72.8	26.0	0.2	100
Added Investment ($)	0	315,300	437,800	753,100
as % of Annual Capital Expenditure	0	1.3	437.8	0.36
as % of Total Investment	0	0.06	15.0	negligible
Added Annual Cost ($)	0	257,100	222,200	479,300
$ per Ton Ore	0	.005	1.71	negligible
$ per Pound Copper Product	0	negligible	0.04	negligible

*98.7% of industry tonnage covered.

Note: Impact Group "B" – Three large multi-plant companies. Group data for impacted operating units of those companies. Not for entire company.

Impact Group "C" – One small mining and milling unit of a large multi-unit company also with small operations in lead and zinc industry.

b. Financial Effects. Table IV-14 indicates that the capital investment required for impact group "B" is only 1.3% of the average annual expenditures and only 0.06% of the total estimated investment. This is not considered severe, and this group should be easily able to provide the funds and pay the costs without any significant impact. However, impact group "C" is again severely affected, with the investment required for BPCTCA compliance being over four times its average annual capital expenditure and 15% of its total plant investment.

c. Other Effects. The discussion above and Table IV-14 indicate that there will be no significant impact on 99% of the copper mining and milling industry, and for these two impact groups there will be no plant closures or production curtailments (or increases). It follows, therefore, that there will be no employment impact within this large portion of the industry.

It appears that one operation (impact group "C") will be forced to close and its production would be lost. This is, however, such a small amount that it would have no impact on the copper market, copper prices or balance of payments. Employment would be locally affected since 77 jobs would be lost with consequent secondary impact on the community around the operation.

6. Best Available Technology Economically Available (BATEA)

Table IV-15 summarizes the data and costs for meeting BATEA guidelines for the copper mining and milling industry.

TABLE IV-15

SUMMARY OF DATA AND COSTS FOR BATEA GUIDELINES
COPPER ORE MINING AND MILLING (1972)

	Impact Group			Total Industry
	"A"	"B"	"C"	
Thousands M.T. Ore/Yr	202,334	60,564	130	266,800
Thousands S.T. Metal Product/Yr	1,213	432	3	1,665
% of Industry – Ore Basis	75.8	22.7	0.05	100
Number of Employees	23,584	12,375	77	36,400
% of Employees in Segment	64.8	34.0	0.2	100
Added Investment ($)	0	2,148,200	433,700	2,581,900
as % of Annual Capital Expen.	0	6.7	433.7	1.2
as % of Total Investment	0	0.37	14.0	negligible
Added Annual Cost ($)	0	583,700	213,200	796,900
$ per Ton Ore	0	.010	1.64	negligible
$ per Pound Copper Product	0	negligible	0.04	negligible

Note: Impact Group "B" – Four major companies (three multi-unit operations and one single unit operation).

Impact Group "C" – One small mining and milling unit of a large multi-unit company.

For BATEA compliance, one more large company is added to impact group "B" which substantially increases the investment and annual costs for that group. However it would still not cause any important impact on that group representing 23% of the industry or on the industry itself.

However, it is important to realize that these conclusions with regard to the economic impact of BATEA guidelines (which require zero discharge) are based on the guidelines contractor's assumption that total recycle will need to handle only the mill process water and that this water will require no treatment (if it is not treated it will affect the copper recovery). In cases where there is heavy rainfall and where there are large amounts of mine water, smelter water, etc., zero discharge will require some treatment plants and perhaps even water evaporation to meet BATEA requirements.

The contractor's costs do not consider those items. If they are considered, the impact could be very extensive and severe.

The BATEA compliance impact on the small unit operation (impact group "C") would be severe and would reinforce the effect of BPCTCA.

7. New Source Performance Standards (NSPS)

The guidelines contractor has recommended that for new copper ore mines, the NSPS guidelines should be identical to the BPCTCA guidelines as indicated in Table IV-9. For the other four sub-categories, zero discharge of process water is recommended.

There were no cost estimates provided by the Effluent Guideline Development Document for the NSPS analysis. Therefore, any statements made with regard to the effect of the NSPS requirement on the construction of new plants within the United States must necessarily by qualitative.

However, it can be said with some degree of confidence that the costs for a "grass roots" plant to meet the NSPS standards are no more than the costs for an existing plant in the impacted group (impact groups "B" and "C") to meet the BPCTCA and BATEA recommended effluent limitations. This is due to the fact that in the construction of a new plant, in-process modifications can oftentimes be made which may be more efficient and economical than add-on treatment technologies for existing plants.

For the above reasons, a new plant designed with the NSPS effluent limitations in mind could be constructed without much difficulty. Therefore, the cost of water pollution control due to the NSPS standards alone will have minimal effect on the decision of the U.S. copper ore mining and milling industry to expand domestic production capacity through the construction of new plants.

G. LIMITS OF THE ANALYSIS

The limits of this analysis were discussed in Section I.

V. LEAD AND ZINC ORES (SIC 1031)

A. INTRODUCTION

In 1972 the lead and zinc mining amd milling industry was composed of 102 establishments with 7,700 employees. The industry processed about 76 million tons of ore containing 478,000 tons of zinc and 619,000 tons of lead.

A variety of ores are mined and the lead and zinc industries are closely associated because lead and zinc minerals often occur in close association in the ores and are mined and processed together. For example, most lead ores contain zinc and many zinc ores contain appreciable amounts of lead. Such ores also often contain copper, antimony, bismuth, gold, and silver, all of which may be recovered as by-products.

The common lead minerals are galena (lead sulfide), cerussite (lead carbonate), and anglesite (lead sulfate). Galena is by far the most abundant lead mineral found in deposits that have been exploited in the United States. Galena is often associated with antimony, copper, zinc, and iron sulfides and also with silver and gold. In a few districts, however, the ore is characterized by simple mineralization, with lead minerals present to the virtual exclusion of other ore minerals. A noteworthy example is the "lead belt," southeastern Missouri, which accounts for more than 74% of U.S. lead production.

The more important economic deposits of lead in the United States occur either as cavity fillings or replacements. Examples of the cavity-filling deposit are the San Juan, Colorado, and the Upper Mississippi Valley districts. Replacement deposits are classified further as follows: massive, as at Leadville, Colorado as well as at Bingham and Tintic, Utah; lodes, as at Park City, Utah, and in the Coeur d'Alene district, Idaho; disseminated, as in the Tri-State district and in southeast Missouri; and metasomatic, as represented by the Central district, New Mexico.

Numerous minerals contain zinc but the principal ore mineral is the sulfide, sphalerite, sometimes called "zinc blende." An exception is the unique and very important deposit found at Ogdensburg, New Jersey, composed of zincite (ZnO), willemite (Zn_2SiO_4), and franklinite ($(Fe, Zn, Mn)O. (Fe, Mn)_2O_3$). Zinc sulfide oxidizes readily to the common minerals smithsonite ($ZnCO_3$) and hemimorphite ($H_2Zn_2SiO_5$).

Sphalerite is commonly associated with lead and iron sulfides and to a lesser degree with copper sulfides and gold and silver minerals. The zinc ores of the Mississippi Valley and eastern United States are characterized by simple mineralization, the zinc being present with relatively minor quantities of lead and little or no copper, gold, and silver. Most sphalerite has associated cadmium as a coating or solid solution in quantities from traces to 2% Other metallic elements commonly associated with sphalerite in small quantities include germanium, gallium, indium and thallium.

Most economic deposits of zinc are cavity fillings, replacements, or combinations believed to have been deposited by mineral bearing solutions of magmatic origin. Cavity fillings include the fissure veins in San Juan and San Miguel Counties, Colorado, the breccia ores in the Jefferson City Mascot area of Tennessee and the Austinville area of Virginia, and the cave and fracture fillings "pitches and flats" of the upper Mississippi Valley area. Replacements also play a part in these same deposits. The extensive replacement deposits in limestones are typified by deposits at Leadville, Colorado; Bingham and Tintic, Utah; eastern Tennessee; New York State; and Metaline area of Washington. Fissure fillings with wall rock replacement from the lode deposits of Butte, Montana; the Coeur d'Alene district, Idaho; and Park City, Utah.

Zinc is the major product in just one region, the upper New York State area near the Canadian border. Some by-product lead is produced here but the mines are essentially zinc mines and account for about 13% of the zinc mined in the United States. The largest true zinc producing mine in the United States is in this area.

B. INDUSTRY DESCRIPTION

The Lead and Zinc Ores Industry includes establishments engaged primarily in mining, milling, or otherwise preparing lead ores, zinc ores, or lead-zinc ores.

1. Reserves

The Bureau of Mines evaluated the domestic lead and zinc reserves in 1964 and its results are summarized as follows.

Lead Reserves:

State	Millions Short Tons Recoverable Lead
Missouri	31.5
Arizona, Colorado, N. Mexico, Utah, Wyoming, S. Dakota	1.9
Idaho, Montana, Oregon, Washington	1.6
Alaska, Arkansas, California, Kansas, Nevada, Oklahoma, Texas	0.3
	35.3

Zinc Reserves:

	Millions Tons Recoverable Zinc
East of Mississippi River	21.73
Arkansas, Kansas, Missouri, Oklahoma, Texas	5.31
Arizona, Colorado, New Mexico, Utah, Wyoming, N. Dakota	3.75
Idaho, Montana, Oregon, Washington	2.59
California, Nevada	.32
Alaska	.03
	33.73

2. Mining

Most lead and zinc ores are mined using underground mining methods, principally classed as open, shrinkage, cut-and-fill, room and pillar, or square-set stoping methods. A few mines, particularly in their early stages of operation, haul mined zinc ores by open pit methods but there is no production from such mines at present. Open stopes with pillars (room and pillar mining) are employed exclusively in mining the near-flat lying ores of the Metaline, Tri-State (Oklahoma, Kansas, Missouri), Upper Mississippi Valley, Tennessee, and Virginia mining districts. The rock structure overlying the ore deposit being mined is supported by the walls of the stope and such pillars as are necessary to assure safe working conditions. If the width of the ore body is such that the roof-span will stand without pillar supports, the entire ore body may be extracted. Very wide ore bodies require a system of pillars to support the roof, with the position and size of the pillars dependent on mass rock properties of the pillars, walls, roof, and floor.

Most of the western lead and zinc mines are vein-type occurrences and are usually mined by shrinkage and cut-and-fill stoping techniques. The upstate New York and Tennessee zinc mines use similar techniques.

3. Beneficiation

Few lead or zinc ores are rich enough in lead or zinc or low enough in deleterious impurities to be smelted directly; consequently, the first step in the conversion of ore into metal or compounds is the physical separation of lead and zinc minerals from other valued ore constituents and from waste material. Simple lead ores, such as coarsely disseminated lead or zinc-lead minerals occurring with a low-specific-gravity gangue, are concentrated by heavy media separators, jigs, and tables after being crushed and ground in a closed circuit with screens or classifiers to give properly-sized feed. Bulk or differential flotation of the slime products or of a reground middling product completes the flowsheet. Ores of this kind are common in the mines of the Mississippi Valley and eastern United States, but in some instances the ores are concentrated wholly by flotation.

Complex sulfide ores such as those of the western United States consist of disseminated mixtures of fine-grained lead and zinc sulfides, usually accompanied by pyrite, copper sulfides and gold and silver in a quartz or quartz-calcite gangue. Such ores may be complicated further by partial oxidation of the sulfides and the presence of high-specific-gravity gangue minerals. The usual procedure on such an ore is to crush and grind in closed circuit with classifying equipment to a size at which the ore minerals are freed from the gangue minerals. When the ore minerals are closely associated the practice is to make a bulk sulfide concentrate, then follow this with regrinding and selective flotation. (A typical flowsheet for a lead-zinc concentrator is shown in Figure V-1.)

4. Water Use

The process of producing a lead or zinc concentrate from a crude ore consumes considerable quantities of water. In addition to process water, other operations that consume water include air conditioning, power generation, boiler feed, sanitary services, and miscellaneous cooling and condensing requirements. To satisfy these water needs, the lead and zinc ore mining/milling industry in 1968 experienced a total water intake of 17 billion gallons, of which 71% was process water and the remaining 29% was for miscellaneous uses as mentioned above. The industry's gross water consumption (including recirculated or reused water) amounted to 21 billion gallons. The corresponding water discharge (including mine water drained and discharged) was 54 billion gallons, of which about 15% received some form of treatment prior to discharge.

The milling procedure for New York State zinc ores requires about three tons of water (720 gallons) per ton of ore which is conventional for this kind of processing since flotation separations are carried out at about 25% solids (3:1 ratio of water to solids). (A typical water balance for a New York State zinc operation is shown in Figure V-2, while that for a Missouri lead mine plant is shown in Figure V-3.)

5. Products and By-products

The lead and zinc mining and milling industry produces two basic products – a lead concentrate and a zinc concentrate. These are produced from lead ores which usually have a small but recoverable amount of zinc; from zinc ores which have recoverable amounts of lead; from the combined lead-zinc ores; and

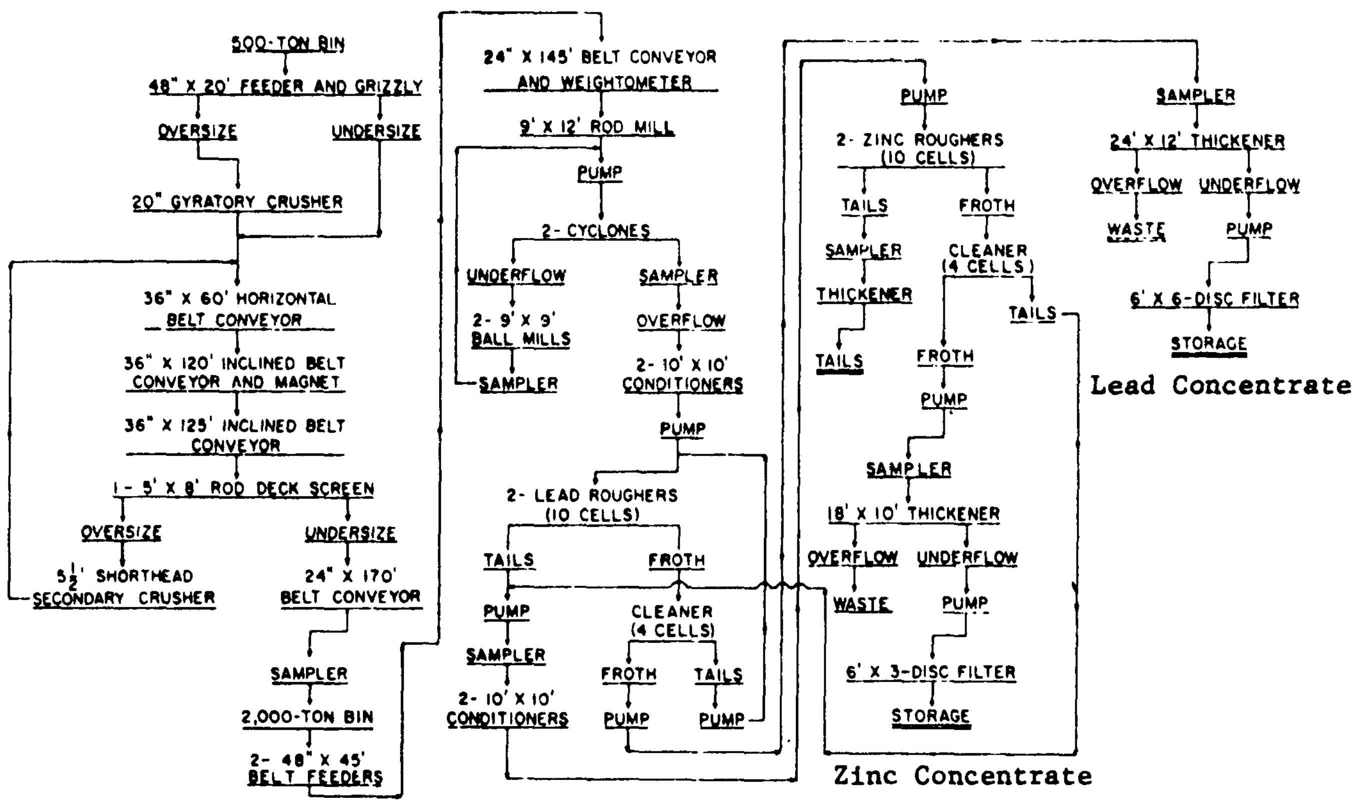


FIGURE V-1 TYPICAL LEAD-ZINC CONCENTRATOR

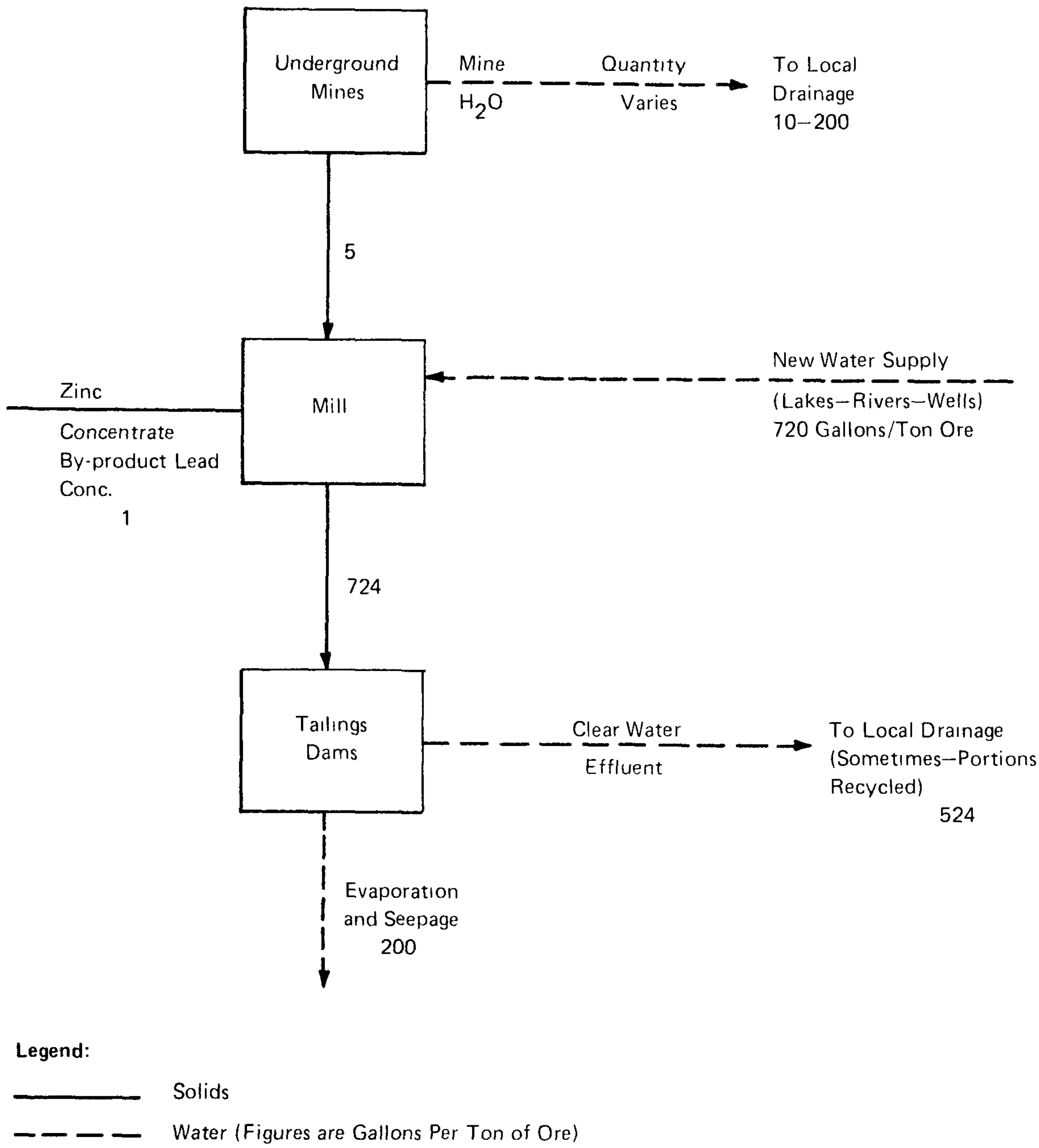
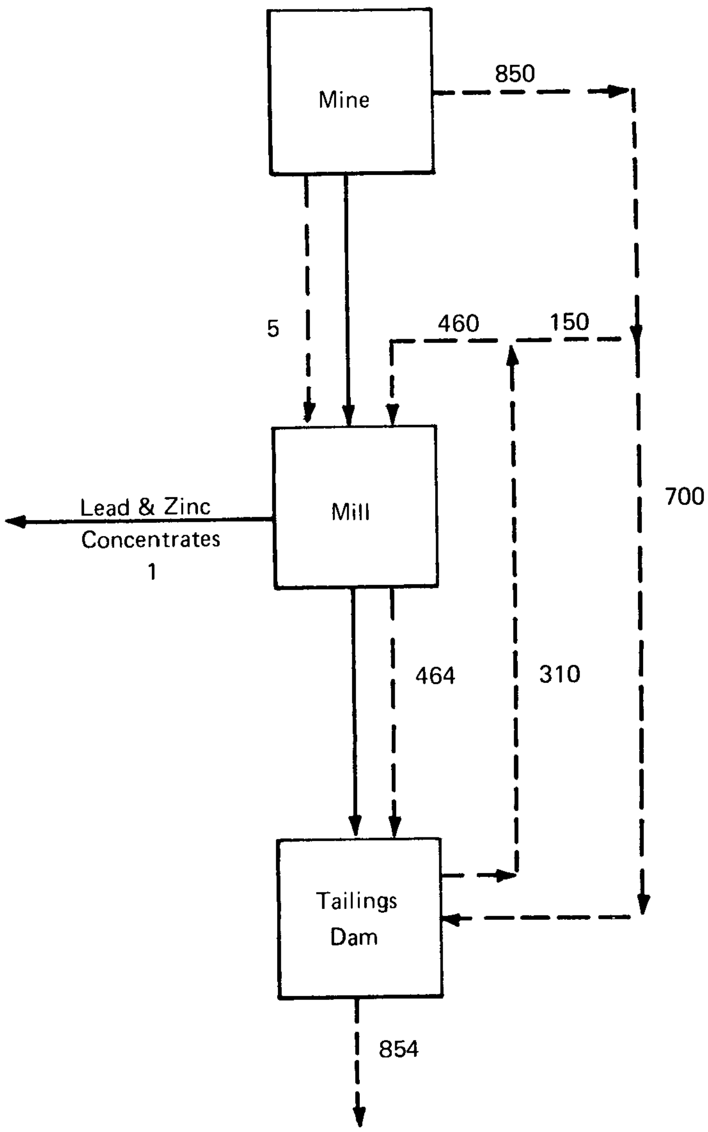


FIGURE V–2 WATER BALANCE TYPICAL ZINC OPERATION



Legend:

Solids

Water (Figures are Gallons Per Ton of Ore)

FIGURE V–3 WATER BALANCE TYPICAL FLOWSHEET – MISSOURI LEAD DISTRICT

also in small amounts from copper ores. In addition some copper is produced from the lead and zinc ores. There is, therefore, an interdependence between the copper, lead and zinc industries particularly in the smelting and refining operations.

In addition to the lead and zinc concentrate major products, lead and zinc ores contain other valuable and recoverable metals: antimony, arsenic, bismuth, cadmium, gallium, germanium, indium, manganese, silver, and thallium. Sulfur is a valuable by-product since substantial amounts of sulfuric acid are produced from the sulfide concentrates.

All the above by-products leave the lead and zinc mining and milling industry as constituents of the lead and zinc concentrates. They are not recovered until later stages of the smelting and refining part of the industry.

C. INDUSTRY OVERVIEW

The bulk of lead and zinc production is from large, integrated companies, many of them having many plants. The lead and zinc industries are closely allied and to a large extent lead and zinc have been considered as a single industry.

A few large, integrated firms do their own smelting and refining. Others which do not do any smelting and refining but do have their own marketing firms, pay toll smelters and refineries to process their concentrates. They then market the product themselves. The small firms, however, sell their concentrates to custom smelters and refineries, which in turn sell the zinc metal product.

Asarco, Amax, St. Joe, and Bunker Hill are integrated and operate mines, mills and smelters to produce lead. These same companies plus New Jersey Zinc and National Zinc are integrated with respect to zinc production.

All the production of primary lead and zinc in the United States comes from underground mines in about 20 states. These mines range in size from very small to modest; that is, from 200 tons per day of ore to about 6,000 tons per day for the largest. The typical size is 1,500 to 2,000 tons of ore per day. This is small in comparison with the large copper and iron ore mines.

Table V-1 lists the major U.S. zinc mines and mills and Table V-2 the major lead mines and mills. The information includes ore production for 1972 and 1973, the facilities, the mill size, and the employment.

The production of lead and zinc in 1972 by states and by type of ore is shown in Table V-3, the historic mine production of lead in Table V-4, the historic mine production of zinc in Table V-5, the lead production of U.S. companies in Table V-6, and the zinc production of U.S. companies in Table V-7.

TABLE V-1

MAJOR U.S. ZINC MINES AND MILLS

Company	Mine	Location	Thousands Tons Ore 1972	Thousands Tons Ore 1973	Facilities*	Mill Size T/Day	Employment
St. Joe Minerals	Balmat-Edwards	New York	869	1,058	MC	600	275
New Jersey Zinc	Flat Gap	Tennessee	246	NA	NA	NA	155
	Jefferson City	Tennessee	466	NA	MC	1,700	190
	Austinville	Virginia	639	NA	MC	2,500	292
	Friedensville	Pennsylvania	435	383	MC	2,400	200
	Sterling	New Jersey	211	NA	M	–	155
	Eagle	Colorado	249	226	MC	750	460
American Smelting	Coy, Immel, Mascot,	Tennessee	2,392	1,167	MC	7,500	850
& Refining Company	Young, New Market,				MC	3,600	
	Ground Hog	New Mexico	135	128	M	–	105
U.S. Steel	*Zinc Mines*	Tennessee	NA	±500	MC	NA	NA
Eagle-Picher	Shullsburg-Black Jack	Illinois-Wisconsin	839	447	MC	1,500	122
Cyprus Mines	Bruce	Arizona	96	93	MC	275	116
Standard Metals	Silverton	Colorado	187	191	NA	NA	140
U.V. Industries	Continental	New Mexico	763	710	MC	8,000	407
United Park City	Summit	Utah	NA	84	NA	NA	200
Day Mines	Dayrock-Grayrock	Idaho	85	88	MC	55	65
Resurrection Mining Co. (Newmont)	Resurrection	Colorado	NA	208	NA	NA	NA
Kerr American	Blue Hill	Maine	–	NA	MC	1,000	NA

*M = Mine
C = Concentrator

TABLE V-2

MAJOR U.S. LEAD MINES AND MILLS

			Thousands Tons Ore			Mill Size	
Company	Mine	Location	1972	1973	Facilities	T/Day	Employment
St Joe Minerals	Fletcher	Missouri	1,249	1,219	MC	4,900	140
	Viburnum	Missouri	1,815	1,846	MC	7,100	250
	Indian Creek	Missouri	655	621	MC	2,600	100
	Brushy Creek	Missouri	-	383	MC	5,000	NA
Cominco American	Magmont	Missouri	1,034	934	MC	2,900	240
Ozark Lead (Kennecott)	Sweetwater	Missouri	1,271	1,114	MC	6,000	192
Amax Lead Co of Missouri	Buick	Missouri	1,447	1,593	MC	6,000	247
Bunker Hill	Bunker Hill Star-Crescent	Idaho	724	793	MC	2,400	641
Hecla Mining Co.	Lucky Friday	Idaho	192	177	MC	800	290
	Star	Idaho	264	266	MC	1,000	380
Kennecott (Tintic)	Burgin	Utah	203	197	MC	500	340
Idarado (Newmont)	Idarado	Colorado	370	443	MC	1,700	355
Pend Oreille	Pend Oreille	Washington	217	212	MC	2,400	100
Camp Bird Mines	Camp Bird	Colorado	NA	104	MC	500	NA
American Smelting & Refining	Leadville	Colorado	190	201	MC	700	30
Minerals Engineering Co.	Creede	Colorado	NA	50	MC	300	25
Homestake Mining	Bulldog	Colorado	94	99	MC	320	120

TABLE V-3

PRODUCTION OF LEAD AND ZINC IN THE UNITED STATES IN 1972, BY STATE AND CLASS OF ORE, FROM OLD TAILINGS, ETC., IN TERMS OF RECOVERABLE METAL

(Short Tons)

State	Lead ore			Zinc ore			Lead-zinc ore		
	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content
Arizona	--	--	--	--	--	--	(1)	(1)	(1)
California	--	--	--	[2]14,560	[2]553	[2]1,010	2,617	600	192
Colorado	--	--	--	249,098	3,183	25,456	509,694	16,721	25,350
Idaho	256,793	25,237	2,273	--	--	--	683,401	35,166	35,821
Maine	--	--	--	50,850	85	3,783	--	--	--
Missouri	8,485,769	489,397	61,923	--	--	--	--	--	--
Montana	119	19	--	--	--	--	--	--	--
Nevada	--	--	--	--	--	--	--	--	--
New Jersey	--	--	--	210,768	--	38,096	--	--	--
New Mexico	--	--	--	--	--	--	138,273	3,571	12,421
New York	--	--	--	852,453	1,089	60,749	--	--	--
Pennsylvania	--	--	--	435,277	--	18,344	--	--	--
Tennessee	--	--	--	3,522,626	--	96,433	--	--	--
Utah	--	--	--	--	--	--	191,119	17,175	21,264
Virginia	--	--	--	638,929	3,441	16,789	--	--	--
Washington	--	--	--	--	--	--	217,383	2,566	6,483
Wisconsin	--	--	--	293,465	757	6,873	--	--	--
Other States	--	--	--	218,867	644	6,907	--	--	--
Total	8,742,681	514,653	64,196	6,486,893	9,752	274,440	1,742,687	75,799	101,531
Percent of total lead-zinc	--	83	14	--	2	57	--	12	21

State	Copper-zinc, copper-lead and copper-zinc-lead ores			All other sources [3]			Total		
	Gross weight (dry basis)	Zinc content	Lead content	Gross weight (dry basis)	Zinc content	Lead content	Gross weight (dry basis)	Zinc content	Lead content
Arizona	[1]100,172	[1]10,071	[1]867	63,194,607	40	1,096	63,294,779	10,111	1,763
California	--	--	--	(2)	(2)	(2)	17,377	1,202	1,153
Colorado	401,846	11,481	9,594	112,568	1,514	1,848	1,273,006	63,801	31,346
Idaho	--	--	--	331,046	653	1,004	1,271,240	38,847	61,407
Maine	107,952	2,037	--	--	--	--	158,802	5,820	85
Missouri	--	--	--	--	--	--	8,485,769	61,923	489,397
Montana	--	--	--	13,323	12	268	13,412	12	287
Nevada	--	--	--	159	--	(4)	159	--	(4)
New Jersey	--	--	--	--	--	--	210,768	38,096	--
New Mexico	--	--	--	2,176,670	314	11	2,314,943	12,735	3,582
New York	--	--	--	--	--	--	852,453	60,749	1,089
Pennsylvania	--	--	--	--	--	--	435,277	18,344	--
Tennessee	1,762,000	5,289	--	--	--	--	5,284,626	101,722	--
Utah	114,604	599	3,531	--	--	--	305,723	21,863	20,706
Virginia	--	--	--	--	--	--	638,929	16,789	3,441
Washington	--	--	--	66,131	--	1	283,514	6,483	2,567
Wisconsin	--	--	--	--	--	--	293,465	6,873	757
Other States	--	--	--	228,922	6,251	691	447,789	13,158	1,336
Total	2,486,374	29,467	13,792	64,123,426	8,684	4,919	76,682,061	478,318	618,916
Percent of total zinc-lead	--	6	2	--	2	1		100	100

[1] Zinc-lead, copper-zinc, copper-lead, and copper-zinc-lead ores combined to avoid disclosing individual company confidential data.
[2] Zinc ore and ore from all other sources combined to avoid disclosing individual company confidential data.
[3] Lead and zinc recovered from copper, gold, silver, and fluorspar ores, and from mill tailings and miscellaneous cleanups.
[4] Less than ½ unit.

SOURCE: U.S.B.M. Minerals Yearbook, 1972

TABLE V-4

MINE PRODUCTION OF LEAD IN THE UNITED STATES (a)

(In tons of 2,000 lb. Computed as the lead content of ore recoverable in smelting and by other metallurgical processes, thus including lead passing directly from ore into pigments and chemicals.)

	1965	1966	1967	1968	1969	1970	1971	1972	1973(b)
Alaska	(c)	14	..	(c)	2	.....	...	..	
Arizona	5,913	5,211	4,771	1,704	217	285	859	1,763	778
California	1,810	1,976	1,735	4,001	2,518	1,772	2,284	1,153	10
Colorado	22,495	23,082	21,923	19,778	21,767	21,855	25,746	31,316	27,796
Idaho	66,606	72,334	61,387	54,790	65,597	61,211	66,610	61,407	61,430
Illinois	3,005	2,285	2,384	1,467	791	1,532	1,238	1,335	503
Kansas	1,644	1,109	1,031	1,227	395	80		..	
Kentucky	756	484	845	(c)	(c)	.	.		
Maine	(c)	.	.	(c)		.		85	198
Missouri	133,521	132,255	152,649	212,611	355,452	421,764	429,631	489,397	481,871
Montana	6,981	4,409	898	1,870	1,753	996	615	287	166
Nevada	2,277	3,581	1,500	863	1,420	364	111	.	
New Mexico	3,387	1,596	1,827	1,363	2,368	3,550	2,971	3,582	2,579
New York	601	1,097	1,653	1,396	1,686	1,280	877	1,089	2,303
Oklahoma	2,813	2,999	2,727	2,387	605	797	..	..	.
South Dakota	(c)	(c)	(c)	(c)	1	3		.	
Tennessee	......	181	..	(c)	(c)	.	..	.	
Utah	37,700	64,124	53,813	45,205	41,332	45,377	38,270	20,706	13,870
Virginia	3,651	3,078	3,430	3,573	3,358	3,356	3,386	3,411	2,612
Washington	6,328	5,859	2,762	5,655	8,649	6,784	5,177	2,567	2,236
Wisconsin	1,645	1,694	1,596	1,126	1,102	761	752	757	845
Undistributed	14	....	..	140		..	20	..	.
Totals	**301,147**	**327,368**	**316,931**	**359,156**	**509,013**	**571,767**	**578,550**	**618,915**	**600,257**

(a) U. S. Bureau of Mines. (b) Preliminary. (c) Included in Undistributed, if any.

TABLE V-5

MINE PRODUCTION OF RECOVERABLE ZINC IN THE UNITED STATES

(In tons of 2,000 lb., as reported by U. S. Bureau of Mines.) Compiled on a basis of zinc content in ores and concentrates produced and adjusted to account for average losses in smelting. Includes zinc recovered as zinc pigments and salts directly from ore.

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973(a)
Arizona	24,690	21,757	15,985	14,330	5,441	9,039	9,618	7,761	10,111	8,421
California	143	225	335	441	3,525	3,327	3,514	3,003	1,202	18
Colorado	53,682	53,870	54,822	52,442	50,258	53,715	56,694	61,181	63,801	56,817
Idaho	59,298	58,034	60,997	56,528	57,248	55,900	41,052	45,078	38,647	45,442
Illinois	13,800	18,314	15,192	20,416	18,182	13,765	16,797	12,706	11,378	5,318
Kansas	4,665	6,508	4,769	4,765	3,012	1,900	1,186	...	...	...
Kentucky	2,063	5,654	6,586	6,317	(d)	(d)	4,189	5,268	1,780	270
Maine	...	...	...	...	(d)	(d)	9,114	5,850	5,820	19,672
Missouri	1,501	4,312	3,968	7,430	12,301	41,099	50,721	48,215	61,923	82,223
Montana	29,059	33,786	29,120	3,341	3,778	6,143	1,457	361	12	418
Nevada	582	3,858	5,827	3,035	2,104	941	127	71	...	...
New Jersey	32,926	38,297	25,237	26,041	25,668	25,076	28,683	29,977	38,096	33,027
New Mexico	29,833	36,460	29,296	21,380	18,686	24,308	16,601	13,959	12,735	12,290
New York	60,754	69,880	73,454	70,555	66,194	58,728	58,577	63,420	60,749	81,435
Oklahoma	12,159	12,715	11,237	10,670	6,921	2,744	2,650	...	...	...
Oregon	(c)	(c)	...	...	(d)	(b)	...	...	...	...
Pennsylvania	30,754	27,635	28,080	35,067	30,382	33,035	29,554	27,438	18,344	18,858
Tennessee	115,943	122,387	103,117	113,065	124,039	124,532	118,260	119,295	101,722	63,367
Utah	31,428	27,747	37,323	34,251	33,153	34,902	34,688	25,701	21,853	16,564
Virginia	21,004	20,491	17,666	18,846	19,257	18,704	18,063	16,829	16,789	16,682
Washington	24,296	22,230	24,772	21,540	13,884	9,738	11,956	5,782	6,483	6,359
Wisconsin	26,278	26,993	24,775	28,953	25,711	22,901	20,634	10,645	6,873	8,672
Other States	...	...	...	...	9,702	12,627	1	3	...	...
Totals	**574,858**	**611,153**	**572,558**	**549,413**	**529,446**	**553,124**	**534,136**	**502,543**	**478,318**	**475,853**

(a) Preliminary. (b) Less than ½ unit. (c) Figure withheld to avoid disclosing individual company confidential data. (d) Included in Other States, if any.

TABLE V-6

LEAD PRODUCTION OF SOME COMPANIES OF THE UNITED STATES (a)

BY MINING COMPANIES (b)

Company	1965	1966	1967	1968	1969	1970	1971	1972	1973
Amax Lead Co. of Missouri and Homestake Lead Co. of Missouri	...		...	.	...	.....	.	137,967	167,818
Anaconda (own mines)	3,189	2,142	150	27	......	. .		.	
Asarco (own mines)	8,888	7,090	3,218	3,592	6,362	5,442	7,166	11,275	9,930
Bunker Hill:									
Bunker Hill Mine (f) (i)	25,031	25,974	25,331	25,967	26,539	24,637	22,612	22,872	21,953
Star Mine	7,432	8,028	7,554	6,123	5,327	7,270	8,820	8,989	8,981
Day Mines	1,431	3,311	2,072	2,137	4,236	2,756	6,385	7,012	7,889
Eagle Picher Lead	5,104	5,052	4,601	4,329	3,428	2,189	1,476	1,425	1,136
Emperius	1,850	1,964	2,010	2,027	1,845	1,696	1,048		
Hecla (g)									
Lucky Friday Mine	20,106	21,079	15,467	9,390	19,183	19,192	23,526	19,530	19,372
Mayflower Mine	4,781	6,007	5,536	4,753	6,055	5,140	4,864	3,586	
Star Mine (i)	3,185	3,436	3,242	2,627	2,271	3,135	3,780	3,854	3,830
Sunshine Mine	113	74	198	79	133	.			
Kennecott Copper Corp.									
Ozark Lead Co. } Tintic Division }		18,337	10,321	19,800	41,200	66,900	55,300	69,100	59,200
					7,500	16,800	13,300	14,200	11,220
New Jersey Zinc Co	7,936	6,859	7,277	7,052	6,522	6,100	6,290	5,576	4,737
Pend Oreille	4,314	3,790	1,754	4,989	7,665	4,809	5,153	2,549	2,191
Rico Argentine	1,877	1,100	1,285	1,871	1,281	1,244	219	..	
St. Joe Minerals Corp.	138,718	136,713	157,427	190,641	246,958	222,752	220,186	223,731	206,433
Standard Metals Corp. (h)	3,585	3,921	4,486	3,396	4,644	4,550	5,366	5,020	4,346
Sunshine (c)	229	238	487	248	304	200	172	51	51
United Park City Mines	4,336	5,482	4,090	5,314	5,802	3,570	787		

BY SMELTING AND REFINING COMPANIES (e)

Amax-Homestake Lead Tollers	... .	.	. .	19,011	76,310	115,089	108,710	133,366	135,406
Asarco	221,701	227,489	120,978	153,106	207,275	225,068	188,997	220,446	247,433
Bunker Hill	93,753	113,194	122,247	124,134	123,980	123,106	129,119	131,804	130,208
International Sm. & Refining (j)	7,904	16,024	8,062	11,758	13,162	11,994	11,618	518	
St. Joe Minerals Corporation	133,601	118,354	124,480	175,717	233,160	206,343	222,213	207,877	215,012
UV Industries, Inc. (d)	37,931	39,745	40,038	35,486	30,992	20,988	N A	N A.	N A.

(a) In tons of 2,000 lb. (b) In general, figures show lead content of ore or concentrates. (c) Includes production for outside companies, except Hecla. (d) Chiefly refined metal; production from own mines and mines of controlled companies, also from purchased ores. (e) Refined lead output from ore or bullion received from all sources. These totals duplicate to some extent the reports of mining companies. (f) Pig lead equivalent. (g) Includes Hecla's share of production from each mining property since date of acquisition of such property. (h) All production from Sunnyside Mine, incl. Washington-Belle Creole, and Brennomar ore bodies—owned by Washington Mining Co. in which UV Industries, Inc. holds 100% interest—Standard Metals Corp. has long term lease. (i) Reflects only Bunker Hills 70% ownership of Star production. (j) International Smelting and Refining Company carries their operations through the smelting of their product which is then refined by the American Smelting and Refining Company

TABLE V-7

PRODUCTION OF ZINC IN CONCENTRATES BY SOME COMPANIES (a)

UNITED STATES

Company	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Amax Lead Co. of Missouri and Homestake Lead Co. of Missouri	...	.	.		...	..	...	...	...	...	45,771	67,636
Amer. Zinc Co. (p)												
Tennessee	44,846	58,162	58,811	63,791	51,143	55,733	66,414	67,186	58,632	49,008	(u)	(u)
Washington	6,365	6,342	3,827	..	3,133	13,212	10,341(l)	.	..	.	..	.
Oklahoma	2,207	2,171	817	1,281	675	..	.	...	...	...	.	..
Wisconsin	7,820	9,242	10,819	11,757	11,199	11,892	7,221	7,513	4,152	...	..	...
New Mexico	.		10,901	7,811	5,975	693	..	...	...	...	...	...
Anaconda (own mines)	25,265	18,921	19,386	21,201	22,345	2,795	.	...	..	..		...
Asarco (own mines) (u)	11,968	12,628	16,596	27,418	23,257	9,718	7,660	21,240	22,482	22,181	102,420	58,226
Bunker Hill												
Bunker Hill Mine (b)	18,378	17,691	16,817	16,885	21,968	21,803	25,215	25,028	19,901	23,437	20,282	25,690
Star Mine (o)	18,073	17,742	17,590	16,835	13,238	13,737	11,171	8,893	9,979	11,113	12,979	11,883
Cyprus Mines Corporation												
Bruce Division							1,286	7,650	7,618	6,953	8,721	7,901
Day Mines	2,367	2,185	2,737	2,735	1,613	1,984	1,506	2,556	2,230	2,588	2,116	2,185
Emperius	3,518	2,248	3,217	2,818	2,638	2,786	2,171	2,562	2,282	1,318		
Eagle-Picher Co.	27,221	30,516	38,073	13,107	41,192	43,663	35,374	32,068	26,111	20,085	15,093	11,864
Gold Fields American Corp.												
(Tennessee) (m)	...	...	7,513	9,937	6,159	9,992	12,802	13,196	18,798	9,857	...	..
Hecla (r)												
Lucky Friday Mine	...	..	1,931	1,730	1,927	1,319	792	1,662	2,017	2,849	2,313	1,981
Mayflower Mine	608	5,446	1,113	1,161	1,507	4,871	3,799	3,567	3,197	2,909	2,163	
Star Mine	7,745	7,603	7,539	7,215	5,672	5,893	1,916	3,818	4,265	4,765	5,558	5,093
Kennecott Copper Corp.												
Ozark Lead Co } Tintic Division }	...	.			1,610	2,230	12,500	15,300	21,700	17,400	26,400	23,065
Lucky Friday Silver-Lead	2,058	1,943	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)
New Jersey Zinc Co.	N.A.	N.A.	N.A.	N.A.	N.A.	145,346	146,920	154,134	154,816	144,138	131,362	112,494
New Park	.	(t)	(t)	(t)	(t)	(t)	(t)	(t)	(t)	(t)	(t)	(t)
Pend Oreille	15,630	16,532	16,995	13,572	12,281	5,542	4,580	4,133	4,559	5,845	6,639	6,525
Rico Argentine	1,252	1,180	1,526	3,101	1,174	1,725	2,972	1,812	1,529	329	.	..
St Joe Minerals Corp. (g)	58,118	54,785	62,192	75,614	79,715	78,958	77,919	79,059	71,735	77,649	75,718	93,052
Standard Metals Corp. (,)	1,053	4,287	7,056	8,773	8,364	8,902	8,205	8,263	7,512	10,169	7,766	6,260
United Park City Mines	6,210	6,551	5,333	6,481	7,790	5,952	7,816	8,168	5,278	1,176	.	.
UV Industries, Inc. (f)	21,461	20,465	22,997	29,513	32,362	27,244	21,490	23,333	20,039	N.A.	N.A.	N.A.

These tables show quite clearly the interrelationship of lead and zinc production and the substantial amount of lead and zinc produced from the complex copper, lead, zinc ores. They also indicate that the major production of lead is in Missouri but other important producers are in Idaho, Colorado, and Utah and minor production comes from Arizona, California, Illinois, Maine, Montana, New Mexico, New York, Virginia, Washington, and Wisconsin.

The major production of zinc is from Tennessee with other important production coming from Arizona, Colorado, Idaho, Illinois, New Jersey, New Mexico, New York, Pennsylvania, Utah, and Virginia. Minor production is reported from California, Kentucky, Maine, Nevada, Washington, and Wisconsin.

In 1972 the Bureau of the Census figures indicated the following employment in the lead and zinc mining and milling industry:

Total Number of Establishments	=	102
Total Number with Over 20 Employees	=	47
Total Employees	=	7,700
Total Employees in Production	=	6,200

Additional information on employment is given in Tables V-1 and V-2 for most of the major lead and zinc producers.

The total employment as we have summarized it in Table V-1 and V-2 comes to 7,382.

D. FINANCIAL PROFILES

Appendix A contains financial profiles of the following companies that are important to the lead-zinc mining and milling industry:

American Metal Climax
American Smelting and Refining Company
Cyprus Mines Corporation
Gulf Resources and Chemical Corporation
Kennecott Copper Corporation
National Zinc Company
New Jersey Zinc
St. Joe Minerals Corporation
Eagle-Picher Industries

E. PRICE EFFECTS

1. Determination of Prices

The major products of the lead and zinc mining and milling industry are lead and zinc concentrates. These concentrates are transferred to the appropriate smelter for further treatment to recover the valuable metals and by-products.

Because of the different smelting practice required for each, the lead concentrates go to lead smelters and the zinc concentrates to zinc smelters.

The value of the concentrate at the producing mine-mill complex is determined by the use of smelter schedules. If the freight charge from the mine to the smelter is deducted from the smelter value, the value at the mine is determined.

Because a large sector of the lead industry is vertically integrated it is difficult to discuss lead concentrate pricing when concentrates are transferred to captive smelters. Concentrates sold to custom smelters account for only a small fraction of lead value sales and are usually done on a long-term contract basis. "Open schedules" are typically used by only the smallest operators and generally reflect the high end of the range in smelting-refining costs. However, one can get an idea of the value of lead concentrates by deducting smelting-refining charges of approximately 4-6¢ per pound from quoted metal prices.

Zinc concentrates also are transferred to a smelter, if the mine and mill are captive operations, or are sold to a custom smelter on a delivered basis if the mine and mill are not captive. Since the cost for the conversion of zinc concentrate to refined zinc is about 8¢/lb, one can get an idea of the value of zinc concentrates by deducting this amount from the metal price.

Typical open smelter schedules for lead and zinc smelters are shown in Table V-8. In all cases the value is based on metal prices as quoted in some acceptable market. For example, the New York price has been considered as the most representative for lead, since the start of production in the United States. This is the delivered price to consumers in major consuming areas.

The large supply of lead derived from secondary sources and the dependence on imports has made the U.S. lead market subject to frequent price changes. In general, domestic prices are influenced by supply-demand balances, producer stock positions and foreign prices. Since 1960, lead prices have varied from a low of 8.25¢/lb (in 1962) to a current high of about 24.5¢/lb. The lead price is usually referred to in terms of common lead and modest premiums exist from other grades such as chemical and acid-copper lead. A high proportion of lead sales is made on the basis of an average price for the month of delivery, the sale having

TABLE V-8

TYPICAL SMELTER SCHEDULES

Schedule	**Lead Smelter**	**Zinc Smelter**
Treatment Charge	$35.00 per dry ton on lead content 25% wet assay plus 10¢ per ton for each unit under 25%.	$135.00 per dry ton based on 12¢ market price. Add $1.25 per net ton for each 1¢ or fraction above 12¢.
Payments		
Gold	If .02 troy oz. per ton or over pay for 95% less deduction of .015 oz.	If .03 troy oz. per ton or over pay for 95% less deduction of .015 oz.
Silver	If 1 troy oz. or more pay 95% of market price less 1¢ per oz.	If 1 oz. or over pay for 70% at market price.
Copper	Deduct 20 lbs. copper per ton and pay for 95% at market price less deduction of 10¢ per lb.	If 1% or more copper pay for 65% at market price less deduction of 8¢ per lb.
Lead	Deduct 30 lbs. lead per ton from wet assay and pay for 90% of balance at market price less 2.77¢ per lb.	Deduct 30 lbs. lead per ton from wet assay and pay for 65% at market price less 2¢ per lb.
Zinc	–	If 40% or over pay for 85% at market price less .583¢ per lb. If under 40% deduct 80 lbs. zinc per ton and pay as above.
Cadmium	–	Pay for 30% at 75% of market price.
Lime	Pay 5¢ per unit if 5% or more.	–
Deductions		
Moisture	5¢ per unit over 10%.	1% minimum deduction from total weight.
Zinc	30¢ per unit over 8%.	–
Iron	–	50¢ per unit over 6% Fe + Mn combined.
Lime and Magnesia	–	$1.00 per unit over 1% combined.
Sulfur	25¢ per unit over 3% $2.50 maximum.	–
Arsenic	50¢ per unit over 1%.	–
Antimony	$1.00 per unit over 1%	–
Bismuth	50¢ per pound over .05%	–

occurred in the previous month. The average price is usually that quoted in *Metals Week*. Most of the remaining sales are made on the prices prevailing on the date of sale.

Since the end of World War II, the New York price has ranged from 2 to 3¢/lb above the price prevailing at the London Metal Exchange (L.M.E.). This "traditional spread" is accounted for by the U.S. import duty (1.0625¢/lb), ocean freight (about 1¢/lb) and the cost of delivery to the consumer (usually below 0.5¢/lb).

Lead prices, New York basis, over the years are shown in Figure V-4. This price is the delivered price to consumers in major consuming areas. Caution should be used in evaluating present prices because a new pricing structure for lead was adopted in December 1971, the price being quoted as a delivered price to consumers anywhere in the United States. This price structure is the same as the U.S. producer pricing used in the copper industry.

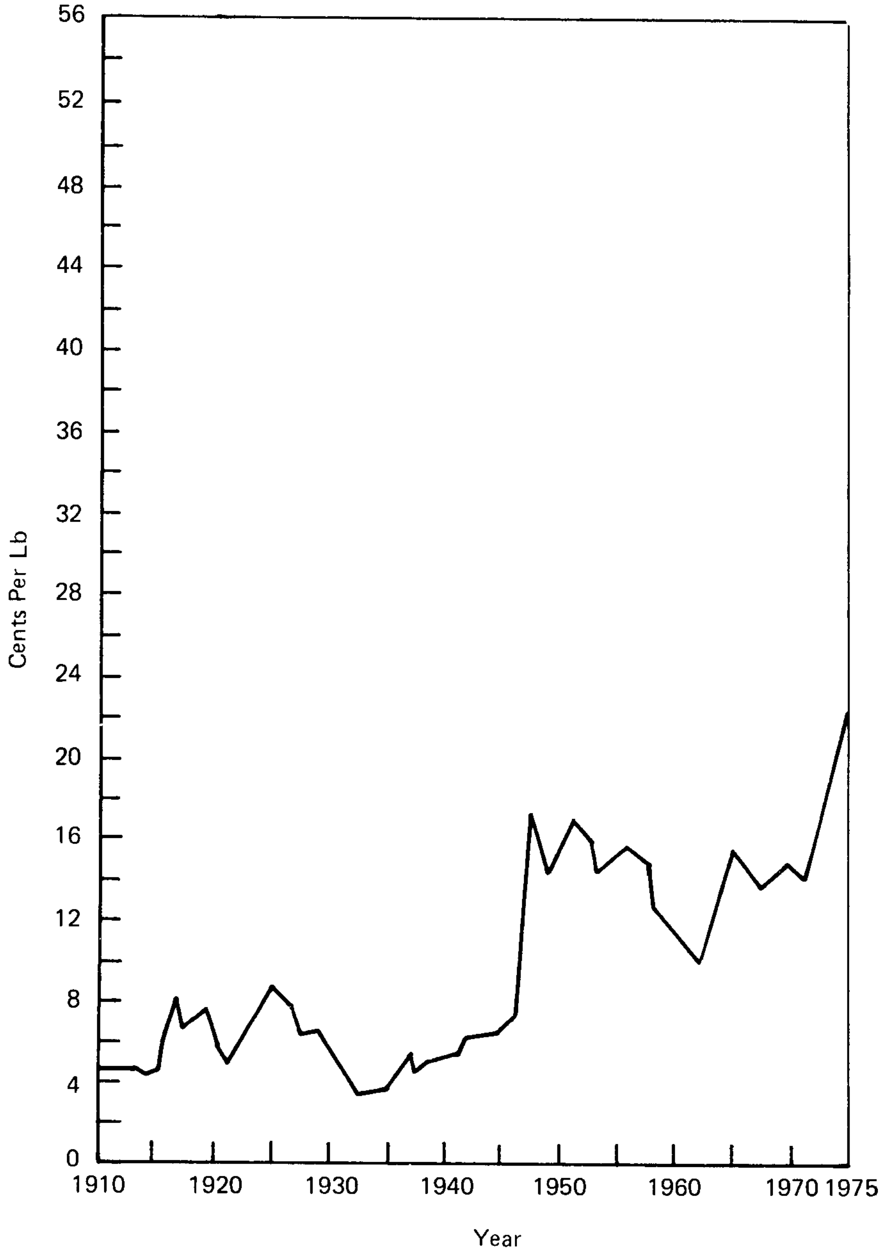
There are three major grades of zinc: Prime Western zinc, sold primarily to the galvanizing industry; Regular High Grade zinc, sold primarily to the brass trade; and Special High Grade zinc, sold primarily for the production of die-casting alloys.

Until recently pricing practices were not uniform with respect to these grades. Prime Western zinc was sold on the basis of a price at East St. Louis, Illinois, the freight from East St. Louis to consumer's destination being charged to the buyer. The origin of the East St. Louis basing point resulted from the fact that early in the century the bulk of U.S. mine production of zinc was obtained from the Tri-State district, now largely exhausted, which supplied zinc smelters in the area around St. Louis.

Both Regular High Grade and Special High Grade zinc have long been sold at a uniform price delivered to consumer's plant, regardless of location. Premiums for these higher qualities, however, were stated, in terms of a specified amount over the East St. Louis Prime Western zinc base price.

In early 1971, a new pricing structure was adopted, for zinc the price being quoted as a delivered price to consumers anywhere in the United States. This pricing structure is the same as the U.S. producer pricing used in the copper industry.

Recently, there has been pressure to change from a pricing system based on Prime Western (PW) zinc since the plants producing PW zinc are gradually closing down because of air pollution problems, obsolete facilities, higher operating costs, etc. Since Special High Grade (SHG) zinc is now the most common product,



Source: E/MJ March 1974

FIGURE V–4 AVERAGE ANNUAL U.S. LEAD PRICES (NEW YORK)

some groups have been pushing a plan to base the new pricing system on an SHG zinc basis. Others have favored a "product pricing" basis where each product is priced independently from the others. This has not yet been settled as an industry-wide practice. Until it is, prices are still being quoted on a PW zinc basis. Zinc prices (East St. Louis basis) over the years are shown in Figure V-5.

2. Costs of Production

There are basically two types of lead and zinc mines: those mining bedded type deposits with room and pillar systems, and those mining vein-type deposits, often using a cut-and-fill technique.

For illustrative purposes we have estimated the costs for these two types of operations. Typical room and pillar costs are shown in Table V-9 and cut-and-fill costs in Table V-10.

The room and pillar mine costs are for a 5,000-ton/day operation which is more or less typical of the Missouri lead district. For the cut-and-fill vein mining, the capacity is 2,000 tons/day which is perhaps the average size for this kind of operation.

3. Potential Constraints on Financing Additional Capital Assets

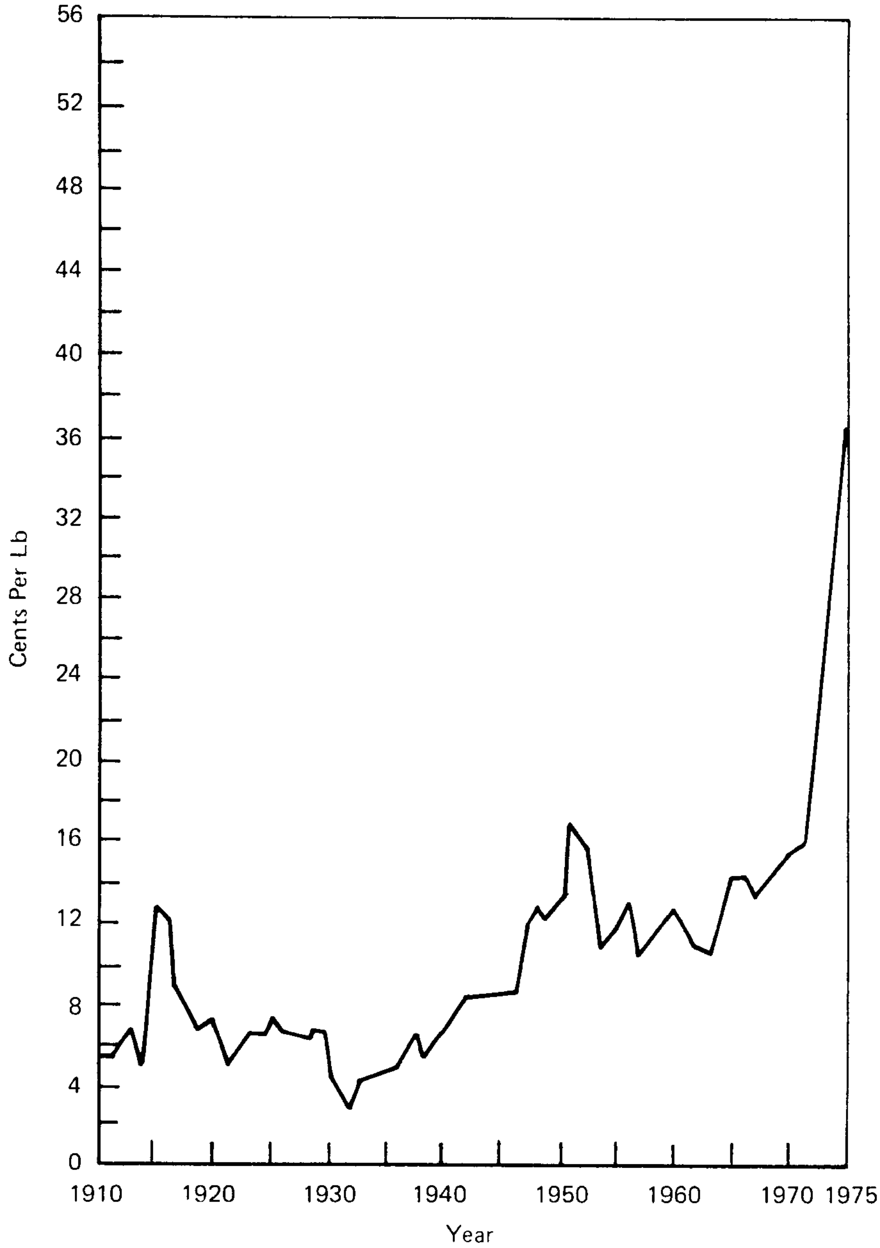
The constraints on financing additional capital investments in the lead and zinc industry are similar to those for the copper industry. See Section IV-E.

F. ASSESSMENT OF ECONOMIC IMPACT

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Document for the lead and zinc ore mining and processing industry. These guidelines are:

- Best Practical Control Technology Currently Available (BPCTCA) – to be met by industrial dischargers by 1977.
- Best Available Technology Economically Available (BATEA) – to be met by 1983.
- New Source Performance Standards (NSPS) – to be applied to all new facilities that discharge to navigable waters constructed after the promulgation of these guidelines.

For the purpose of recommending effluent guidelines, the Guidelines Contractor has categorized the lead and zinc ore mining and processing industry into the following groups:



Source: E/MJ March 1974.

FIGURE V–5 AVERAGE ANNUAL U.S. ZINC PRICES (E. ST. LOUIS)

TABLE V-9

TYPICAL ZINC AND LEAD MINING AND MILLING COSTS

Room and Pillar System – Flat Bedded Deposits – 8-90 ft. Thick Ore Bodies – Vertical Shaft Access – 500-1,000 Feet Deep – Dumping 2,000-5,000 gpm Water – Capacity – 5,000 Tons/Day = 1,500,000 Tons/Year – $5,000,000 in Mine Investment – $15,000,000 in Mill Investment.

Mining Costs	**$/Ton Ore**
Underground Development	0.29
Mining	1.58
Transportation	0.80
General Expense	0.60
Surface	0.03
Transportation to Mill	0.10
Depreciation (10 Years)	0.29
Interest Charges (6%)	0.19
	3.88

Milling Cost	**$/Ton Ore**
Crushing	0.08
Conveying and Screening	0.10
Fine Grinding	0.35
Flotation and Thickening and Filtration	0.45
Concentrate Handling	0.03
Tailing Disposal	0.08
Water Supply	0.06
Misc. – Maintenance	0.20
Supervision	0.20
Depreciation (10 Years)	0.86
Interest Charges (6%)	0.56
Total	2.97
Grand Total	6.85 P.T. Ore

TABLE V-10

TYPICAL LEAD AND ZINC MINING AND MILLING COSTS
(Cut-and-Fill System)

Vein-Type Deposit – Cut-and-Fill Mining – Vertical Shaft Access – Pumping Water – Capacity 2,000 Tons Ore/Day – ±3,000' Deep – 600,000 Tons/Year – $5,000,000 in Mine investment – $8,500,000 in Plant Investment

Mining Cost	**$/Short Ton Ore**
Materials and Utilities	1.30
Direct Labor	1.80
Maintenance Labor and Supplies	1.60
Payroll Overhead	0.60
Administrative Costs	0.55
Taxes and Insurance	0.15
Depreciation (10 Years)	0.78
Interest Charges (6%)	0.47
Total	7.25

Milling Cost	**$/Short Ton Ore**
Crushing	0.10
Conveying and Screening	0.12
Fine Grinding	0.40
Flotation and Thickening and Filtration	0.50
Concentrate Handling	0.05
Tailing Disposal	0.10
Water Supply	0.10
Maintenance	0.25
Supervision	0.25
Depreciation (10 Years)	1.25
Interest Charges (6%)	0.75
Total	3.97
Grand Total	11.22

1. Mines
2. Mills.

1. Effluent Guidelines

For the first sub-category above (mines) the recommended parameters and guidelines for BPCTCA and BATEA are given in Table V-11. The guidelines recommended for NSPS are the same.

For the second sub-category (mills), the recommended parameters and guidelines for BPCTCA are given in Table V-12. BATEA and NSPS requirements for this sub-category are zero discharge.

2. Cost of Compliance

The guidelines contractor has estimated the cost of compliance for both BPCTCA and BATEA guidelines. These costs for lead and zinc ore mining and milling are summarized in Table V-13 by sub-category and in Table V-14 by company. The costs summarized in these tables are investment costs which represent the amount of money needed to install the required treatment facilities and the annual costs which are the costs to operate the facilities. The annual costs include charges for amortization and interest. The fixed cost portion of the annual costs is about 20%.

In Table V-15 we have estimated the incremental cost to the ten companies involved on the basis of increase in cost per pound of total metal (combined lead and zinc) produced by each company. These costs are estimated for both BPCTCA and BATEA guidelines.

3. Basis for Impact Analysis

The basis used for analysis of the impact was discussed previously in the "Approach" section of this report.

4. Levels of Impact

The levels of impact are the same as those discussed previously.

5. Best Practical Control Technology Currently Available (BPCTCA)

a. Price and Production Effects. As is evident from Table V-16, 43% of the industry would not be directly affected by the guidelines. For the 40% that is directly affected, the product cost increase of \$.002 per pound of combined lead and zinc produced is small and could readily be passed on or absorbed under normal circumstances. The percentage increase of \$.002 per pound on a \$0.165-per-pound product (1972) is about 1.2%. There is virtually no impact on the whole industry.

TABLE V-11

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA AND BATEA – LEAD AND ZINC MINES

Parameter	Concentration (mg/ℓ) in Effluent	
	30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Cu	0.05	0.1
Hg	.001	.002
Pb	0.1	0.2
Zn	0.5	1.0

*Value in pH units

Source: Development Document

TABLE V-12

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – LEAD AND/OR ZINC MILLS

Parameter	Concentration (mg/ℓ) in Effluent	
	30-day Average	24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Cyanide	0.01	0.02
Cd	0.01	0.02
Cu	0.05	0.1
Hg	0.001	0.002
Pb	0.10	0.2
Zn	0.10	0.2

*Value in pH units

Source: Development Document

TABLE V-13

LEAD AND ZINC ORES – COST OF COMPLIANCE WITH BPCTCA AND BATEA GUIDELINES

			Costs – Thousands $			
			BPCTCA		BATEA	
Sub-Category	No.	1,000 M.T./Year	Investment	Annual	Investment	Annual
Mines	1-14	7,300	0	0	0	0
	15	873	194.7	82.0	194.7	82.0
	16	118	68.6	28.4	68.6	28.4
	17	545	923.1	628.8	923.1	628.8
	18	204	78.2	32.8	78.2	32.8
	19	544	433.3	251.5	433.3	251.5
	20	544	183.6	79.0	183.6	79.0
	21	495	150.3	21.8	150.3	21.8
	22	19	126.1	53.6	126.1	53.6
	23	116	107.0	43.6	107.0	43.6
	24	159	126.1	53.6	126.1	53.6
	25	62	22.6	15.5	22.6	15.5
	26	333	251.8	118.0	251.8	118.0
	27	1,450	100.6	13.9	100.6	13.9
	28	354	42.0	6.8	42.0	6.8
	29	998	234.0	35.5	234.0	35.5
Subtotal		14,114	3,042.0	1,464.8	3,042.0	1,464.8
Mills	1-18	–	0	0	0	0
	19	187	0	0	62.7	13.3
	20	1,450	0	0	137.0	32.5
	21	847	0	0	391.1	66.1
	22	873	0	0	143.1	33.2
	23	545	0	0	58.8	16.0
	24	495	106.1	19.6	175.0	37.7
	25	354	0	0	16.6	3.4
	26	998	0	0	79.7	23.8
	27	118	72.3	55.3	58.5	16.0
	28	159	41.8	29.2	38.6	8.9
	29	62	0	0	35.9	8.3
	30	333	0	0	89.3	25.8
	31	204	0	0	49.7	12.2
	32	544	851.3	282.6	918.7	301.4
	33	544	0	0	45.4	10.8
Subtotal		7,713	1,071.5	386.7	2,300.1	609.4
Total Industry		14,114	4,113.5	1,851.5	5,342.1	2,074.2

TABLE V-14

LEAD AND ZINC ORES – COST OF COMPLIANCE BY COMPANIES

Company	Division	1,000 M.T. Ore/Year	Costs – Thousands $ BPCTCA Investment	BPCTCA Annual	BATEA Investment	BATEA Annual
A	I	873	194.7	82.0	337.8	115.2
	II	118	140.9	83.7	127.1	44.4
	III	544	0	0	45.4	10.8
	Total	1,535	335.6	165.7	510.3	170.4
B	I	545	923.1	628.8	981.9	644.8
	II	204	78.2	32.8	127.9	45.0
	III	544	1,468.2	613.1	1,535.6	631.9
	IV	354	42.0	6.8	58.6	10.2
	Total	1,647	2,511.5	1,281.5	2,704.0	1,331.9
C	I	495	256.4	41.4	325.3	59.5
D	I	19	126.1	53.6	126.1	53.6
	II	116	107.0	43.6	107.0	43.6
	III	159	167.9	82.8	164.7	62.5
	Total	294	401.0	180.0	397.8	159.7
E	I	62	22.6	15.5	58.5	23.8
F	I	333	251.8	118.0	341.1	143.8
G	I	1,450	100.6	13.9	237.6	46.4
H	I	998	234.0	35.5	313.7	59.3
I	I	847	0	0	391.1	66.1
J	I	187	0	0	62.7	13.3
			4,113.5	1,851.5	5,342.1	2,074.2

TABLE V-15

LEAD AND ZINC ORES – INCREASE IN COST OF METALS PRODUCED
DUE TO BPCTCA AND BATEA GUIDELINES

	Thousands Short Tons 1972 Production			Increase in Costs Per Pound Combined Lead and Zinc	
Company	Lead	Zinc	Total	BPCTCA	BATEA
A	224	76	300	$.00028	$.00028
B	6	131	137	.0047	.0049
C	32	33	65	.00032	.00045
D	11	102	113	.00079	.00076
E	7	2	9	.00086	.0013
F	1	15	16	.0037	.0045
G	138	46	184	.000037	.00013
H	69	26	95	.00019	.00031
I	70*	25*	95*	0	.00035
J	–	9*	9*	0	.00074

Major effect on Company "B" and Company "F".

Within Company "B" the estimated cost increases for the various company units are as follows:

Unit I	45	$.0070	$.0072
Unit II	17	.0009	.0013
Unit III	45	.0068	.0070
Unit IV	30	.0001	.0002

*Estimated by Arthur D. Little, Inc.

TABLE V-16

SUMMARY OF DATA AND COSTS FOR BPCTCA GUIDELINES
LEAD AND ZINC ORE MINING AND MILLING (1972)

	Impact Group			Total
	"A"	"B"	"C"	Industry
Thousands M.T. Ore/Yr	7,300	6,814	0	16,900
% of Industry-Ore Basis*	43.2	40.3	0	100
Thousands S.T./Yr Metal Content	454	462	0	1,097
Number of Employees	2,606	3,824	0	7,700
% of Employees	33.8	49.7	0	100
Added Investment ($)	0	4,113,500	0	4,113,500
as % of Annual Capital Exp.	0	63.5	0	15.8
as % of Total Investment	0	3.0	0	1.2
Added Annual Cost ($)	0	1,851,500	0	1,851,500
$ per ton Ore	0	0.27	0	0.11
$ per lb Combined Lead and Zinc	0	.0020	0	.0008

*83.5% of industry tonnage covered.

b. Financial Effects. The capital outlays required to achieve compliance would total only 3.0% of the total invested capital of the impacted group ("B") of the industry. Annual capital expenditures for noncompliance purposes now average 4.7% of total invested capital in the impacted group. Thus if all of the capital outlays needed for compliance were to be concentrated in one year, total outlays in that year would be raised by almost two-thirds to 7.7% of invested capital. If, as is likely, the capital outlays for abatement can be distributed over two or more years, the burden can be less severe. While these outlays may appear sizable to some of the companies in the impacted group, we believe they can be accommodated without significant adverse effect.

c. Balance of Payment Effects, Employment Effects, and Community Effects. Consideration of the price and production, and financial effects indicates that there will be no output curtailments or plant shutdowns in the lead and zinc ore mining and milling industry because of BPCTCA effluent limitations. As a result there will be no employment or community effects and no balance of payments effects.

6. Best Available Technology Economically Available (BATEA)

Table V-17 lists the data for and costs of meeting the BATEA guidelines. These are only slightly higher than the BPCTCA data and costs shown in Table V-16.

TABLE V-17

SUMMARY OF DATA AND COSTS FOR BATEA GUIDELINES
LEAD AND ZINC ORE MINING AND MILLING (1972)

	Impact Group			Total Industry
	"A"	"B"	"C"	
Thousands M.T. Ore/Yr	6,266	7,848	0	16,900
% of Industry-Ore Basis	37.1	46.4	0	100
Thousands S.T. Metal Produced (Combined Lead and Zinc)	376	540	0	1,097
Number of Employees	2,316	4,114	0	7,700
% of Employees	30.1	53.4	0	100
Added Investment ($)	0	5,342,100	0	5,342,100
as % of Annual Capital Exp.	0	72.4	0	20.6
as % of Total Investment	0	3.4	0	1.6
Added Annual Cost ($)	0	2,074,200	0	2,074,200
$ per ton of Ore	0	0.26	0	0.12
$ per lb Combined Lead and Zinc	0	.0019	0	.0009

For meeting BATEA guidelines, therefore, the effects and impacts are the same as for BPCTCA. Thus, there will be no significant impact on the industry or any impact group of it in meeting BATEA standards.

7. New Source Performance Standards (NSPS)

The guidelines contractor has recommended that for new lead and zinc mills the NSPS guideline should be zero discharge. For lead and zinc ore mines the NSPS standards should be identical to BATEA limitations.

The Effluent Guideline Development Document provided no cost estimates for the NSPS analysis. Therefore, any statements about the effect of the NSPS requirement on the construction of new plants within the United States must be qualitative.

However, it can be said with some degree of confidence that the costs for a "grass roots" plant to meet the NSPS standards are no more than the costs for an existing plant in the impacted group (impact group "B") to meet the BPT and BAT recommended effluent limitations. In the construction of a new plant, in-process modifications can oftentimes be made which may be more efficient and economical than add-on treatment technologies for existing plants.

For the above reasons, a new plant designed with the NSPS effluent limitations in mind could be constructed without much difficulty. Therefore, the cost of water pollution control due to the NSPS standards alone will have minimal effect on the decision of the U.S. lead and zinc ore mining and milling industry to expand domestic production capacity through the construction of new plants.

VI. GOLD ORES (SIC 1041)

A. INTRODUCTION

Gold was first mined in the United States in 1799 in the southeastern states, but it was not until the 1848 discovery of placer gold in California that the industry really started to develop. The industry's production grew to about 4 million troy ounces per year in the 1905-1917 period. After a drop in production in the 1920's the industry produced its all-time record of about 5 million ounces in 1940. In recent years total annual production has been about 1.5 million ounces.

Gold occurs not only in straight gold and gold-silver lode and placer ores but also in small but economically recoverable amounts in many base metal ores. The major production today from the gold ores in the United States is from the vein type deposit at Lead, South Dakota, and the two operations in Nevada mining carboniferous gold containing shales by open pit methods.

B. INDUSTRY DESCRIPTION

The Gold Ores Industry includes establishments engaged primarily in mining gold ores from lode deposits or in the recovery of gold from placer deposits by any method. In addition to ore dressing methods such as crushing, grinding, gravity concentration, and froth flotation, this industry includes amalgamation, cyanidation, and the production of bullion at the mine, mill, or dredge site.

1. Reserves

The Bureau of Mines has estimated (1968) that total domestic reserves of gold amount to 237 million ounces, available at prices up to $145 per ounce. An additional 60 million ounces was estimated to be recoverable as a by-product from base metal ores.

2. Mining

Gold ores are mined by placer, open pit, and underground methods. Not much gold is produced by placer methods (±13,000 ounces in 1972), but the practice goes on in a number of small operations in the western states and Alaska. Placer mining involves digging the surface material by hand or machine and feeding it to a sluice box or other concentrating device where the gold settles out and is recovered. Dredging is a type of placer operation where the dredge floats on a pond and digs the ore with a bucket line. Most dredges also concentrate the ore right on the dredge using regular gravity concentration equipment. Dredge spoils are then discharged over the back end of the dredge by conveyor belt to fill in the pond.

Regular open pit mining, consisting of overburden removal and ore mining and hauling, is practiced by the two gold producers in Nevada. Standard equipment is used for drilling, blasting, shovel loading and truck haulage.

Underground mining is carried out by the major gold producer (from a gold ore) in the United States (Homestake – Lead, South Dakota). In this mine a cut and fill system is generally used which involves stoping out the ore then filling the space with sized tailings from the milling operation. Shafts are used to gain access to the mine and to remove ore.

3. Beneficiation

Processing of the gold ores to recover the gold values can be simple (gravity separation and amalgamation) or complex (cyanidation or carbon adsorption).

Gravity processing equipment such as sluice boxes, blanket tables, vibrating tables, jigs, and gold traps relies on the great difference in specific gravity between gold particles and the waste particles to make a separation. Such processes are the sole separation method used at small operations, and some of them are often a part of more complex processes used at larger gold milling plants.

Amalgamation relies on the great affinity of gold for mercury to separate free gold particles. Mercury is simply added to the ore slurry or gold concentrate, mixed, and then recovered for retorting and separation of the gold. The mercury is recovered and reused. Until recently amalgamation was practiced at Homestake but we understand this has recently been stopped because of the pollution hazard.

The cyanidation process is used at the three gold producing plants in the United States and at many gold-ore processing plants around the world. The basic process involves the dissolution of gold (and silver, if present) in cyanide solution, the separation of the pregnant solution from the waste solids, and the precipitation of the gold (and silver) from the solution by using zinc dust.

An adaptation of the cyanide process that has been used in the past and has recently been installed at Homestake is the carbon cyanidation process. Coarse particles of activated charcoal are added to the cyanide-ore slurry. The carbon particles adsorb the gold from solution and then are removed from the pulp by a simple screening operation. The loaded carbon is processed in a small electrolytic cell to remove the gold and the char is recycled. The process has advantages for the fine, slimy, ore fraction since it precludes the need for large thickening circuits.

4. Water Use

The 1967 Census of Mineral Industries lists the water usage of gold and silver ores together as 11 billion gallons of gross water per year with 7 billion gallons per year being discharged.

Of the three major gold mines in the United States, the two in Nevada (Carlin and Cortez) have zero discharge of water or plant effluents. In these mines, tailings go to tailings dams where the solids settle out, and the clear water is decanted and reused. Nothing is discharged. At Homestake, however, water is discharged and meeting water quality standards will have some impact on the operation.

The water consumed at Carlin has been reported as 144 gallons per ton of ore processed. This is water lost in evaporation, seepage, etc. The total water used at Homestake has been reported at 850 gallons per ton of ore but there is no estimate of water consumed.

5. Products and By-products

The gold ore mining and processing industry produces gold bars (usually about 1,000-ounce) for shipment to the buyer. The bars are rarely pure gold but often contain some silver as well which is separated and recovered in later refining steps.

Gold bars produced at the mine refineries are often 850 to 990 fine. That is, 850 to 990 parts out of 1,000 are gold, with the rest being silver. Silver is the major by-product but in the final refining stages a significant amount of platinum group metals also is recovered.

Some gold ores in other parts of the world yield valuable by-products, e.g., uranium, osmium and iridium from ores in South Africa, and platinum from the gold placer mines in Colombia.

C. INDUSTRY OVERVIEW

1. Types of Firms

The gold mining and milling industry is made up of a diverse group of companies that can be divided into three principal sections:

- Large base metal mining companies which produce gold as a by-product. These are large integrated companies such as Asarco, Anaconda, Kennecott, and Phelps Dodge where the principal production is copper, lead, and zinc, but where gold is recovered in the final refining stages.

- A large number of very small mines, usually placer mines where only a few people are employed and where only small amounts of gold are produced.

- The true gold mines. There are three of these: Carlin, Cortez, and Homestake, which produce about 60% of the gold in the United States.

These major gold producing companies can be described as follows:

- Homestake Mining Company is a large diversified company with about $115 million in total annual metal sales. It operates the famous Homestake gold mine at Lead, South Dakota; the Buick lead mine in Missouri (jointly owned with AMAX); a small silver mine at Creede, Colorado; a uranium operation in New Mexico; a copper mine in Peru; and a forest products company in South Dakota. The company is very active in exploration for mineral resources with an exploration budget of approximately $1.5 million per year.

- Carlin Gold Mining Company is a wholly owned subsidiary of Newmont Corporation. Newmont is a very large holding company whose major holdings are: Magma Copper (100%), Carlin Gold (100% owned), O'Okiep Copper (57.5%), Tsumeb Corp. (29.2%), Idorado Mining (80.1%), Dawn Mining Co. (51%), Newmont Oil (100%), Resurection Mining (100%), Granduc (100%), Swailkameeu (100%), Palbora Mining Co. (28.6%), Southern Peru Copper (10.25%), Sherritt Gordon (39.4%), Foote Mineral (32.8%), and Atlantic Cement (50%). Numerous other investments are also held.

- Cortez Gold Mines is owned by Placer Amex, Inc. and Bunker Hill. It is managed and operated by Placer Amex, a subsidiary of Placer Development, a large Canadian company. Bunker Hill also is a large diversified mining company.

2. Types of Plants

The three major gold-ore mining and processing companies and two smaller U.S. firms are listed in Table VI-1. The three large companies account for about 80% of the gold produced from siliceous gold ores and produce gold bullion as their finished product.

TABLE VI-1

GOLD ORE PRODUCERS

Company	Mine	Type	Location	1973 Tons Ore/Year	Employees	Mill	Age (Years)
Carlin Gold	Carlin	O.P.	Nevada	729,000	160	Cyanide	10
Cortez Gold Mine	Cortez	O.P.	Nevada	803,000	100	Cyanide	8
Homestake Mining	Lead	U.G.	South Dakota	1,578,021	±500	Cyanide	75
Knob Hill Mines	Knob Hill	U.G.	Washington	69,000	68	Gravity Flotation Cyanide	N.A.
Sunnyside	Silverton	U.G.	Colorado	170,000	N.A.	Amalgamation	N.A.

The remaining producers – small companies engaged in placer and underground mining – have simple gravity concentration plants.

The Cortez Gold Mine encountered a heavy flow of water into its pit which prevented full recovery of the remaining ore, and mining of the Cortez ore body terminated in February of 1973. The company, however, is milling 800,000 tons of ore (0.124 oz gold per ton) from a nearby property and will continue heap-leaching of 2 million tons of low grade ore (0.041 oz per ton).

Tables VI-2 and VI-3 list the production of gold in the United States, the production by companies and the production by types of ore. In 1972, 41% of the gold produced was a by-product from the base metal ores, and 59% came from true gold ores. Placer production was very small, less than 1% (0.9%), so the dry and siliceous gold ore production was 58% of the total.

The U.S. is a minor factor in world gold production, accounting for only 3.3% of the total.

The 1972 Census statistics on employment in the gold-ore segment of the industry can be summarized as follows:

Total Number of Establishments	=	81
Total Number with Over 20 Employees	=	5
Total Number of Employees	=	1,800
Total Number in Production	=	1,500

TABLE VI-2

MINE PRODUCTION OF RECOVERABLE GOLD IN THE UNITED STATES (a)

(Troy Ounces)

By State	1969	1970	1971	1972	1973(b)
Alaska	21,227	34,776	13,012	8,639	6,500
Arizona	110,878	100,853	91,048	102,996	101,791
California	7,004	4,990	2,066	3,071	2,977
Colorado	25,777	37,114	42,031	61,100	50,136
Idaho	3,403	3,128	3,506	2,881	2,520
Maine					
Michigan					
Missouri					
Montana	24,159	22,456	15,614	23,725	26,284
Nevada	456,291	480,141	371,878	419,718	261,181
New Mexico	8,952	8,710	10,081	11,897	13,117
New York					
South Dakota	593,146	578,716	513,127	407,130	359,516
Tennessee	126	124	192	176	15
Utah	433,385	408,029	368,996	362,114	308,781
Other States	47,805	55,261	55,678	11,791	29,175
Total	**1,733,176**	**1,743,322**	**1,495,108**	**1,449,776**	**1,166,858**

(In fine ounces in terms of the metal recovered from the several classes of ore)

Year	Placers	Dry and Siliceous Ores	Copper Ores	Lead and Zinc Ores	Lead-Copper Ores	Other Ores	Total
1964	125,232	795,907	430,528	6,026	96,835	1,780	1,456,308
1965	99,441	927,924	567,409	6,321	100,439	3,656	1,705,190
1966	91,827	1,038,426	516,491	5,754	116,194	4,728	1,803,420
1967	61,835	1,085,511	321,217	3,111	105,508	3,972	1,584,187
1968	37,102	934,522	405,723	2,239	95,599	3,107	1,478,292
1969	25,418	1,035,833	579,171	4,126	84,742	3,886	1,733,176
1970	38,713	1,049,122	552,969	554	98,907	3,057	1,743,322
1971	16,351	891,488	478,932	1,862	104,566	1,909	1,495,108
1972	12,922	841,425	170,964	1,959	421,518	1,155	1,449,943
1973							

(a) As reported by U.S. Bureau of Mines. (b) Preliminary.

TABLE VI-3

GOLD PRODUCTION IN THE UNITED STATES

By Year	Fine Ounces
1967	1,525,500
1968	1,539,250
1969	1,716,850
1970	1,743,322
1971	1,495,108
1972	1,449,776
1973	1,165,858

By Company	1972	1973
Anaconda*	22,278	20,856
Asarco*	45,976	44,288
Carlin	±200,000	±200,000
Cortez Gold	190,629	75,660
Hecla*	48,037	1,271
Homestake	407,462	357,634
Kennecott Corp.*	350,080	342,284
Phelps Dodge*	69,722	68,151

*By-product producer

D. FINANCIAL PROFILES

Financial profiles for the major non-ferrous metal producers who produce gold as a by-product (Anaconda, Asarco, Kennecott, Phelps Dodge, Hecla) are given in the Appendix. Also included are profiles for Newmont Corp., which is the owner and operator of one of the major true gold producers (Carlin Gold Mining), and the Homestake Mining Co.

E. PRICE EFFECTS

1. Determination of Prices

Because of its monetary function, the price of gold (1,000 fine) was set by the U.S. Treasury in 1934 at $35 per troy ounce.

The U.S. policy of purchasing all gold offered and redeeming dollars offered by foreign central banks and governments at $35 per ounce established the official world price for gold. Devaluation of the pound sterling on November 18, 1967, sparked an upsurge in gold speculation and hoarding; prices for gold at the end of 1967 in gold markets outside the United States ranged from $35.95 at Beirut to $57.50 at Bombay. In March 1968, a two-tier price system was established by the seven-nation "Gold Pool" under which internal monetary transactions remained at the official price of $35 per ounce; purchases and sales by the "Gold Pool" countries in the private market were terminated, and a floating price for all private transactions began. During the remainder of the year the U.S. price for gold fluctuated between $37.50 and $42.05 per ounce. The average upper-tier price in 1968 was $39.26 per ounce.

The two-tier agreement was abrogated in November of 1973 and since then the freedom to sell gold bullion was restored to monetary authorities.

Recent important developments in the gold price area have been policy changes in the valuation of monetary gold by nation-states and international monetary institutions, legalization of gold ownership for U.S. citizens, and the commercial auction of gold by the U.S. Treasury early in 1975.

The "Metals Week" gold price averages for the last several years have been as follows:

	$/troy oz
1971	41.05
1972	58.40
1973	97.58
1974	140.02
1975 (April)	169.84

2. Costs of Production

The production costs for the three major gold mines and mills have been reported* as follows:

	Dollars per Short Ton of Ore		
	Homestake	**Carlin**	**Cortez**
Mining	7.13	0.75	0.25
Milling	1.50	2.35	1.38
Total	8.63	3.10	1.63

These costs are direct operating costs; they do not include depreciation or amortization, home office expense, cost of sales, capital charges, etc.

*F.W. McQuiston, Jr. and R.S. Shoemaker, "Gold and Silver Cyanidation Plant Practice," *AIME,* 1975.

3. Potential Constraints on Financing Additional Capital Assets

Constraints on financing additional capital assets for gold mining and milling plants are similar to those already discussed in previous chapters of this report.

F. ASSESSMENT OF ECONOMIC IMPACT

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Document for the gold ore mining and processing industry. These guidelines are:

- Best Practical Control Technology Currently Available (BPCTCA) – to be met by industrial dischargers by 1977.
- Best Available Technology Economically Available (BATEA) – to be met by 1983.
- New Source Performance Standards (NSPS) – to be applied to all new facilities that discharge to navigable waters constructed after the promulgation of these guidelines.

For the purposes of recommending effluent guidelines and estimating the cost of implementing these guidelines, the Guideline Contractor for metallic ore mining and milling has categorized the gold ore industry into the following groups:

a. Mines
b. Mills using Cyanidation process
c. Mills using Amalgamation process
d. Mills using Flotation process
e. Mills using Gravity separation

For category "b" zero discharge is recommended, and operations using this process are now at zero discharge.

For categories "a," "c," "d" and "e," effluent guidelines are recommended, and costs of implementation have been estimated for plants in these categories for both BPCTCA and BATEA standards.

1. Effluent Guidelines

For the mines category, which includes both open-pit and underground mines, the recommended parameters and BPCTCA guidelines are given in Table VI-4. The BATEA guidelines are the same as BPCTCA for mines.

For category b (Mills – Cyanidation Process) zero discharge is recommended and hence no parameters or guidelines are proposed for either BPCTCA or BATEA.

For category c (Mills – Amalgamation) the recommended parameters and BPCTCA guidelines are those given in Table VI-5. Zero discharge is recommended for BATEA standards.

For category d (Mills – Flotation) the recommended parameters and BPCTCA guidelines are those given in Table VI-6. Zero discharge is recommended for BATEA for this category.

For category e (Mills – Gravity Separation) the recommended parameters and BPCTCA guidelines are those given in Table VI-7. For this category, BATEA guidelines are the same as BPCTCA guidelines.

2. Costs of Compliance

The guidelines contractor has estimated the costs of compliance for both BPCTCA and BATEA guidelines. These costs for gold ore mining and milling are summarized in Table VI-8 by category and in Table VI-9 by company. The costs summarized in these tables are investment costs, which represent the amount of money needed to install the required treatment facilities, and the annual costs, which are the yearly costs to operate the facilities. The annual costs include a charge for amortization which is based on a useful life of 20 years for facilities and ten years for equipment. They also include a charge for capital recovery computed with an 8% interest rate.

In this category of the mineral industry the fixed cost portion of the annualized costs is about 20%. That is, 20% of the total annual cost is fixed cost (amortization plus interest charges in this case).

In Table VI-10 we have estimated the incremental cost to the three companies' final product (gold metal) that is due to compliance with both BPCTCA and BATEA guidelines. These are added costs for the particular company unit where effluent treatment is required.

3. Basis for Analysis

The impact analysis for gold ores was carried out on the same basis as that described in Section I. However, because of the singular position of gold as a monetary metal, the impact of altered gold mining costs and output on the U.S. balance of payments must be considered from a unique standpoint. Increased imports (or decreased exports) of gold are not seen as tendencies toward deficit,

TABLE VI-4

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – GOLD MINES

Parameter	Concentration (mg/ℓ) in Effluent 30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Cu	0.05	0.1
Hg	0.001	0.002
Zn	0.50	1.0
Pb	0.10	0.20

*Value in pH units

Source: Development Document

TABLE VI-5

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – GOLD MILLS USING AMALGAMATION PROCESS

Parameter	Concentration (mg/ℓ) in Effluent 30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Cu	0.05	0.1
Hg	0.001	0.002
Zn	0.2	0.1

*Value in pH units

Source: Development Document

TABLE VI-6

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – GOLD MILLS USING FLOTATION PROCESS

	Concentration (mg/ℓ) in Effluent	
Parameter	**30-day Average**	**24-hour Maximum**
pH	6* to 9*	6* to 9*
TSS	20	30
Cyanide	0.01	0.02
Cu	0.05	0.1
Hg	0.001	0.002
Zn	0.2	0.1
Pb	0.1	0.2
Cd	0.01	0.02

*Value in pH units

Source: Development Document

TABLE VI-7

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – GOLD MINES OR MILLS USING GRAVITY-SEPARATION METHODS

	Concentration (mg/ℓ) in Effluent	
Parameter	**30-day Average**	**24-hour Maximum**
pH	6* to 9*	6* to 9*
TSS	30	50

*Value in pH units

Source: Development Document

TABLE VI-8

GOLD ORES – COST OF COMPLIANCE WITH BPCTCA AND BATEA STANDARDS

		1,000 M.T. Ore	Cost (Thousands $)			
			BPCTCA		BATEA	
Category	No.	Per Year	Investment	Annual	Investment	Annual
Mines	1-4	3,330	0	0	0	0
	5	170	110.2	47.2	110.2	47.2
Mills – Cyanide	1-2	1,450	0	0	0	0
	3	1,430	3,469.1	856.8	3,469.1	856.8
Mills – Amalgamation	1	170	45.3	31.4	254.5	54.5
Mills – Flotation	1	69	20.3	16.6	31.1	18.1
Placer Mines	(50-60 - No Cost Estimates)					
Total Industry		6,619	3,644.9	952.0	3,864.9	976.6

TABLE VI-9

COSTS BY COMPANIES

Company	1,000 M.T. Ore Per Year	Costs (Thousands $) BPCTCA Investment	BPCTCA Annual	BATEA Investment	BATEA Annual
A	170	155.5	78.6	364.7	101.7
B	69	20.3	16.6	31.1	18.1
C	1,430	3,469.1	856.8	3,469.1	856.8
Total	1,669	3,644.9	952.0	3,864.9	976.6
Rest of Industry	1,831	0	0	0	0

TABLE VI-10

ADDED COST PER OUNCE OF GOLD PRODUCED

Company		Estimated Gold Production (1972) (troy ounces)	Added Cost ($/Troy Ounce) For BPCTCA	For BATEA
A		30,000*	2.62	3.39
B		14,000*	1.19	1.29
C		407,462	2.10	2.10
Gold Price Average 1972	=	$ 58.40/Troy Ounce		
Price June 1975	=	$ 169.80/Troy Ounce (H&H)		

*Estimated by Arthur D. Little, Inc.

nor are increased exports (decreased imports) regarded as tendencies toward surplus. Moreover the volume of gold production in the United States is small relative to U.S. international transfers of gold.

4. Levels of Impact

The three levels of impact used in the following analysis were described in Section I.

a. Best Practical Control Technology Currently Available (BPCTCA)

In Table VI-11 we have summarized the information and costs to comply with the BPCTCA guidelines. Shown in Table VI-11 for the three impact groups discussed above and for the total industry are the data on tonnage and number of employees, the added operating costs, and the added investment costs as a percentage of capital expenditures and total investment.

(1) Price and Production Effects. As is evident from the table, 52% of the industry would not be directly affected by the guidelines. For the 48% that is directly affected, the product cost increase of \$2.11 per troy ounce of gold produced is small and could readily be either passed on or absorbed under normal circumstances. The percentage increase of \$2.11 per ounce on a \$58.40-per-ounce product (1972) is 3.6%. The percentage increase in product cost for the total industry is 1.9%.

(2) Financial Effects. The added capital investment required for the impacted group of the industry is 218% of the estimated annual capital expenditures and 9.5% of the total invested capital. The percentage of annual capital expenditures is calculated on the assumption that the investment for pollution control will be accomplished in one year. In actuality, however, this investment would likely be made over a period of several years so the annual percentage would actually be less than indicated.

Despite the softening of the impact by spreading the outlays over the years, the amounts are still sizable and, in an industry other than gold mining and milling, would have a notable effect. In gold, however, because of the current prosperity of the industry, the additional capital cost can be financed without evident strain.

(3) Balance of Payment Effects, Employment Effects, and Community Effects. Consideration of the price and production, and financial effects indicates that there will be no output curtailments or plant shutdowns in the gold ore mining and milling industry because of BPCTCA effluent limitations. As a result there will be no employment or community effects and no balance of payments effects.

b. Best Available Technology Economically Available (BATEA)

Table VI-12 lists the costs for meeting the BATEA guidelines. These are only slightly higher than the BPCTCA costs in Table VI-11.

For meeting BATEA guidelines, therefore, the effects and impacts are the same as for BPCTCA, as discussed above.

c. New Source Performance Standards (NSPS)

The guidelines contractor has recommended that for new gold mills using flotation, cyanidation or amalgamation, the NSPS guideline should be zero discharge. For gold ore mines and mills using gravity separation, the NSPS standards should be identical to BPCTCA limitations.

The Effluent Guidelines Development Document provided no cost estimates for the NSPS analysis. Therefore, any statements about the effect of the NSPS requirement on the construction of new plants within the United States must necessarily be qualitative.

However, it can be said with some degree of confidence that the costs for a "grass roots" plant to meet the NSPS standards are no more than the costs for an existing plant in the impacted group (impact group "B") to meet the BPCTCA and BATEA recommended effluent limitations, because in the construction of a new plant, in-process modifications can oftentimes be made which may be more efficient and economical than add-on treatment technologies for existing plants.

For the above reasons, a new plant designed with the NSPS effluent limitations in mind could be constructed without much difficulty. Therefore, the cost of water pollution control due to the NSPS standards alone will have minimal effect on the decision of the U.S. gold ore mining and milling industry to expand domestic production capacity through the construction of new plants.

TABLE VI-11

SUMMARY OF DATA AND COSTS FOR BPCTCA GUIDELINES GOLD ORE MINING AND MILLING (1972)

	Impact Group			Total
	"A"	"B"	"C"	Industry
Thousands M.T. Ore/Year	1,831	1,669	0	3,500
% of Industry – Ore Basis	52.3	47.7	0	100
Ounces Gold Produced/Year (thousands)	403	451	0	854*
Number of Employees	830	670	0	1,500
% of Employees	55.3	44.7	0	100
Added Investment ($)	0	3,644,900	0	3,644,900
as % of Annual Capital Expenditure	0	218	0	104
as % of Total Investment	0	9.5	0	4.5
Added Annual Cost ($)	0	952,000	0	952,000
$ per Ton Ore	0	0.57	0	0.27
$ per Ounce of Gold	0	2.11	0	1.11

*Only production from true gold ores (dry siliceous ores). By-product gold production from other base metal ores not included.

TABLE VI-12

SUMMARY OF DATA AND COSTS FROM BATEA GUIDELINES GOLD ORE MINING AND MILLING (1972)

	Impact Group			Total
	"A"	"B"	"C"	Industry
Thousands M.T. Ore/Year	1,831	1,669	0	3,500
% of Industry – Ore Basis	52.3	47.7	0	100
Thousand Ounces Production/year	403	451	0	854
Number of Employees	830	670	0	1,500
% of Employees	55.3	44.7	0	100
Added Investment ($)	0	3,864,900	0	3,864,900
as % of Annual Capital Expenditure	0	232	0	110
as % of Toal Investment	0	10.1	0	4.8
Added Annual Cost ($)	0	976,600	0	976,600
$ per Ton Ore	0	0.59	0	0.28
$ per Ounce Gold	0	2.17	0	1.14

VII. SILVER ORES (SIC 1044)

A. INTRODUCTION

In 1972, mines in the United States produced 37,233,000 troy ounces of silver. Of this amount about 75% was produced as a by-product from base metal ores, and 25% came from dry and siliceous ores.

Silver normally occurs in deposits associated with other metals such as copper, lead, zinc, and gold. The principal silver minerals are argentite (Ag_2S), argentiferous tetrahedrite (Cu_3Sb, AsS_3) and argentiferous galena (PbS). The last two have part of their crystal lattices replaced with silver atoms.

The major silver occurring location in the United States is the Coeur d'Alene district in Idaho where silver ores occur in fault zones and fissures. These are usually steeply dipping and narrow (6-8') veins. In this district ores contain from 3 to 45 ounces of silver per ton.

B. INDUSTRY DESCRIPTION

The Silver Ores Industry includes establishments engaged primarily in mining, milling, or otherwise preparing silver ores. The production of bullion at the mine or mill site is included also.

1. Reserves

Domestic resources of silver have been estimated at 4.9 billion ounces, of which 1.3 billion are classified as reserves. Most of the reserves are present as a potential by-product from base metal ores. About 75% of the reserves are in the western states of Arizona, Idaho, Nevada, Montana, and Utah.

2. Mining

The true silver ores are all mined by underground methods through shafts, some of which are very deep (5,000-6,000'). From the shafts ore is developed through a series of drifts, cross-cuts, and raises with stoping commonly being done by cut and fill methods. In this procedure mined-out areas are filled with the sand fraction from the milling operation.

3. Beneficiation

Silver ores are almost universally processed by the flotation process which produces a concentrate for further refining by smelting or leaching techniques.

In flotation, reagents are added to condition the valuable mineral particles so they can be collected in a froth product. Since silver commonly occurs with base metals it is quite common to beneficiate the ore to produce two flotation concentrates. In Idaho, for example, they often produce a zinc concentrate and a lead concentrate with most of the silver going along with the lead.

4. Water Use

In processing the silver ores by flotation, water is used in a ratio of about four tons of water to one ton of ore. Most of the water leaves the operation in the tailings, which are collected in tailings dams from which water is recycled for reuse.

No information is available on water consumption or discharge by the silver mining industry. The census data combines gold and silver and their combined usage in 1968 was as follows:

Gross Water Used	–	11 Billion Gallons
Total Water Discharged	–	7 Billion Gallons

5. Products and By-products

The silver mining and processing industry's major product is usually a sulfide metal concentrate containing the silver. The ores in which silver is the major valuable component also usually contain lead, zinc, copper, and iron sulfides. The processing by flotation produces a high-grade silver concentrate that contains some lead or other base metals which require further refining to recover the silver.

By-products can be considered to be copper, lead, zinc and at times small amounts of gold.

C. INDUSTRY OVERVIEW

1. Types of Firms

The major silver producing companies are all subsidiaries of large integrated metal mining companies.

For example, the largest single silver producing mine is the Galena mine in Idaho owned and operated by ASARCO, a large diversified metal producer. (See Appendix A.)

The Sunshine mine, 33.25% owned by Hecla Mining Co., is also a major producer. Hecla operates four lead-silver-zinc mines in Idaho, a mine in Utah, and mines in British Columbia, Canada, and is developing a large copper project in Arizona. They produce about $20 million of copper, lead, zinc, silver, and gold per year.

The other two major mines, the Bulldog mine in Colorado and the Crescent mine in Idaho, are owned by Homestake and Bunker Hill, respectively. Both Homestake and Bunker Hill are large integrated mining companies.

The Clayton silver mine in Idaho also produces appreciable amounts of silver. Clayton is a small privately owned mining company that produces lead, zinc, and silver concentrates which it sells to nearby smelters.

2. Types of Plants

The major silver producing companies are listed in Table VII-1. This list includes only those companies whose major product is silver. The by-product silver producers are considered in the lead-zinc section of this report.

TABLE VII-1

SILVER PRODUCING COMPANIES – FROM SILVER ORES

Company	Mine	Location	Tons Ore Per Year (1973)	Ounces Ag/Year	No. Employees	Age
Asarco	Galena	Idaho	200,911	4,220,000	200	NA
Sunshine Mining Co. (Hecla – 33%)	Sunshine	Idaho	123,539	3,070,000	580	91
Bunker Hill	Crescent	Idaho	33,359	595,326	75	23
Homestake	Bulldog	Colorado	86,693	2,091,483	120	6
Clayton Silver Mines	Clayton	Idaho	80,976	121,407	25	41

Note: All companies operate underground mines and flotation milling plants.

Source: Compilation by ADL from industry publications.

Of the listed companies, ASARCO, Bunker Hill and Homestake are large integrated opera⁺⁻ons; they mine, mill, smelt and refine silver.

U.S. mine production of silver for 1968 through 1972 was as follows:

	1968	1969	1970	1971	1972
Thousands Troy Ounces	32,729	41,906	45,006	41,564	37,233
Percentage from:					
Gold and Silver Ores	39	36	33	37	25
Base Metal Ores	61	64	67	63	75

About 87% of the total production in 1972 came from five western states:

State	Thousands Troy Ounces
Idaho	14,251
Arizona	6,653
Utah	4,300
Colorado	3,664
Montana	3,325
Missouri	1,972
New Mexico	1,017
Michigan	785
Nevada	595
California	175
South Dakota	100
Tennessee	83
New York	25
Oregon	2
Others	286
Total	37,233

The historic production by U.S. companies is shown in Table VII-2. The major producers are: ASARCO, Anaconda, Kennecott, Phelps Dodge, Hecla, and Bunker Hill.

Bureau of Census figures for silver ores are:

Number of Establishments	=	53
Number of Establishments with over 20 Employees	=	7
Number of Employees	=	1,000
Number of Employees in Production	=	800

Total employment for the true silver mines is 1,000 (Table VII-1).

TABLE VII-2

SILVER PRODUCTION OF SOME COMPANIES
(In fine ounces)

UNITED STATES

Company	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
naconda (own mines)	1,456,016	4,430,276	4,607,719	1 873 658	1,752,678	2,557,984	4,739 634	3,491,615	[illegible]	[illegible]
rco (own mines) (g)	9,050,513	9 148,145	8,005,170	5,121,820	5,186,605	6,467,979	6 838,228	6,658,181	[illegible]	[illegible]
ker Hill										
nker Hill Mine	1,741,181	1,589,007	1,525 229	1,440,171	1,504,198	1,490,293	1,585,069	1,614,117	[illegible]	[illegible]
Crescent Mine	525 740	664,211	816,771	1,393,171	1,400,719	1,461,454	1 421,260	1,663,417	[illegible]	[illegible]
Star Mine (h)	385,237	439,954	156,649	391,405	268,543	244 285	347 579	453,053	[illegible]	182 284
Mines	55,414	68,900	285,562	157,253	550,267	407 516	258,673	642,255	[illegible]	[illegible]
erius	366,835	238,717	173,837	158,159	130,114	151,191	160 522	55,182		
na Mine (c)	4,340,514	4,358,345	4,205,644	2,032,522	1,900,233	2 958,707	3,619,630	3,900,797	4 221 990	4 191 878
cla (f)										
Lucky Friday Mine	3,472,011	3,152 612	3,189,180	2,114,191	1,467,727	2,936,110	2,814,459	3,313,075	2 718 662	2 688 517
Mayflower Mine	395,368	432,921	639,192	535,131	543,600	686 972	552,031	570,663	620,024	
lver Summit Mine	357,784	658,470	668,880	528,594	391,018	98 390				
ar Mine	165,101	188,552	195,652	168 022	115,054	105,200	118 520	194,202	208 132	205,116
Sunshine Mine	1,550,432	2,124,699	2,380,869	2 500 978	2,454,051	2 731 721	2 730 077	2,255,974	842 171	960 306
nnecott	2,077,592	3 280,131	4,763,318	2,769,292	3,229,258	3,863,239	4 338 730	3,711,111	[illegible]	[illegible]
ky Friday Silver-lead	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
ma Copper Company (a)										
n Manuel Division	282,334	273,610	316,099	166,893	215 316	323 866	328 989	255 586	539 842	833 171
Superior Division	306,269	408,366	466,334	197 119	317,119	508,663	509 196	357,319	266 254	490 764
elps Dodge (b)	2,001,575	2,091,565	2,125,080	1,202,651	1,780,100	2,125 078	2 616 810	2,125 280	2,381 714	2 361 370
loe Minerals Corp (a)		340,289		260,774	410,110	525,312	531,849	388,854	167 117	195,327
dane (d)	3,102,857	4,312,521	4,928,579	5,210,365	5,116,786	5,644,054	5,739,325	4 791,489	1 880,612	2 109,523
ed Park City Mines	252,754	271,758	357,153	260 105	324,002	444,155	325,184	80 858		

(a) Includes silver produced from purchased ores (b) Total production of all branches, also includes silver produced from purchased ores (c) Owned by Callahan Mining Corp and operated under lease by American Smelting & Refining Co (d) Includes production for outside companies, except Hecla (e) Effective January 1, 1964, Lucky Friday merged into ... (f) Includes Hecla's share of production from each mining property since date of acquisition of such property (g) Includes production in U S A , Canada and Peru Includes ... Mines production (h) Bunker Hill's 70% ownership of total production

Source: 1973 Year Book – American Metal Statistics

D. FINANCIAL PROFILES

The major silver-ore processing companies are: ASARCO, Anaconda, Kennecott, Phelps Dodge, Hecla, and Homestake. Financial profiles for these are given in Appendix A.

E. PRICE EFFECTS

1. Determination of Prices

Silver was the first monetary standard established in America when the first financial law passed by the Continental Congress in 1776 made the silver dollar the unit of value. The dollar was defined by Congress in 1792 as 371.25 grains of fine silver and the silver monetary value of $1.2929 per ounce, although not defined in such terms in the law, could be derived by dividing the number of grains in a troy ounce (480) by the number of grains of pure silver in the silver dollar (371.25).

At the end of 1933, with the market price of silver at about $0.44 per ounce, Congress enacted legislation authorizing U.S. Treasury purchase of newly mined domestic silver with a seigniorage deduction of 50% thus fixing the price at $0.6464 per ounce. In 1934 the Silver Purchase Act directed the Secretary of the Treasury to purchase silver at home and abroad until the market price reached the mint price of $1.2929 per ounce or until the monetary value of Treasury's stock reached one-third of the monetary value of gold stock. During the next decade the support price changed on several occasions and eventually was set at $0.9050 in 1946. In the late 1950's world-wide industrial and coinage demand exceeded world-wide production. Consequently, U.S. Treasury stocks not earmarked for currency backing or coinage were sold. In November 1961, by Presidential order, U.S. Treasury sales were suspended, the use of free silver for coinage was suspended, and silver required for coinage was to be obtained by retiring from circulation $5 and $10 certificates.

Public Law 88-36, June 1963, repealed the Silver Purchase Act of 1934; this new policy provided for the eventual demonetization of silver except for subsidiary coinage.

In 1964 foreign demands actually comprised a drain on Treasury stocks and this country became a net exporter of silver for the first time since lend-lease in World War II. The sharp upsurge in silver usage in the early 60's took place in spite of a 40% increase in silver price between November 1961 and June 1963. The mint was not able to keep up with demand for coins by vending machines, coin collectors and speculators. This expansion of silver usage in coinage was the largest drain on U.S. Treasury stocks.

To meet the growing demand and rising price of silver, Congress passed the Coinage Act of 1965. Under the act, some 90% of silver formerly used for coinage was available for industrial use; the melting, treating, or exporting of any U.S. coin was prohibited, and a Joint Commission on Coinage was established. On July 14, 1967, the Treasury, upon recommendation by the Joint Commission, halted all Government sales of silver at the old monetary value of $1.2929 and announced it would sell only 2 million ounces per week, with the General Services Administration (GSA) handling sales.

Demonetization was, in effect, completed on June 24, 1968, when the right to redeem silver certificates for silver was terminated.

The actual silver price history since 1967 is shown in Figure VII-1 where the large increase in price in 1973 and 1974 is evident. As of June 1, 1975, the Metals Week price was 420.9 cents per troy ounce.

Silver is believed by knowledgeable people to have a promising future market and there should be a continuing upward trend in the price.

2. Costs of Production

The silver mines discussed in this section are all small, deep underground mines that work vein type deposits.

We have estimated the basic costs for a mine and mill producing 500 tons of ore per day (160,000 tons/year) and milling the same amount to produce concentrates that are the final product. The mine is assumed to be 2,500-3,000 feet deep and to use a cut and fill system. The mill is a conventional flotation mill producing two concentrates.

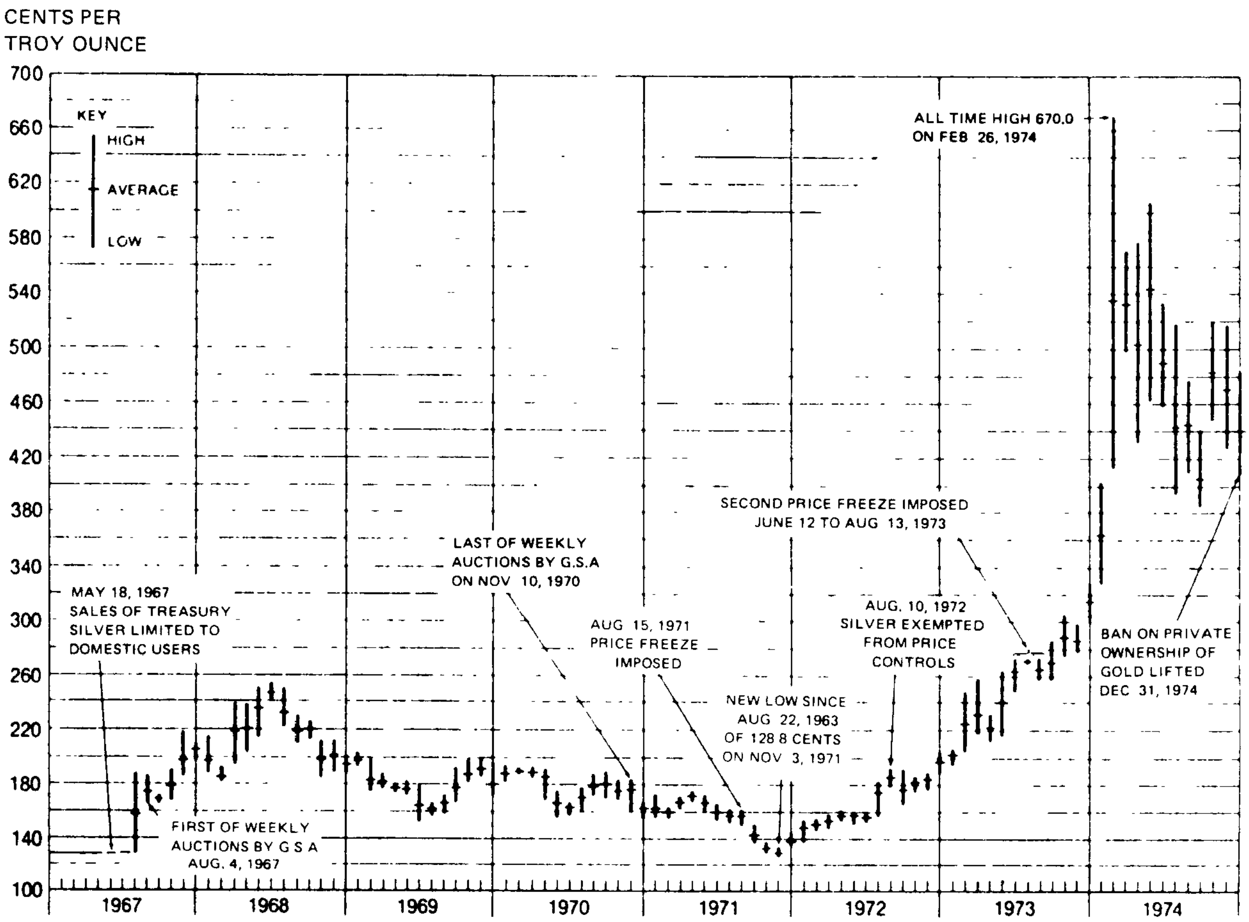
Our cost estimate for this kind of operation is as follows:

a. Investment

Mine	$5,500,000
Mill	2,500,000
Total	$8,000,000

b. Operating Cost

	$/Ton Ore
Mine	$13.50
Mill	5.35
Total	$18.85 (Includes amortization and depreciation.)



Source: Engineering and Mining TI—McGraw Hill – January, 1975

FIGURE VII–1 NEW YORK SILVER PRICE, MONTHLY RANGES

3. Potential Constraints on Financing Additional Capital Assets

The financing constraints on companies that mine and process silver ores are the same as those of other ore mining companies as discussed in Chapter III.

F. ASSESSMENT OF ECONOMIC IMPACT

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Document for the silver ore mining and processing industry. These guidelines are:

- Best Practical Control Technology Currently Available (BPCTCA) – to be met by industrial discharges by 1977.

- Best Available Technology Economically Available (BATEA) – to be met by 1983.

- New Source Performance Standards (NSPS) – to be applied to all new facilities that discharge to navigable waters constructed after the promulgation of these guidelines.

For the purpose of recommending effluent guidelines, the Guidelines Contractor has categorized the silver ore mining and processing industry into the following groups:

a. Mines
b. Mills – Flotation Process
c. Mills – Cyanidation Process
d. Mills – Amalgamation Process
e. Mills – Gravity Separation

For category "c" zero discharge is recommended and plants in these groups are now at zero discharge.

For categories "a," "b," "d," and "e" effluent guidelines are recommended and costs are estimated for those plants requiring additional control.

1. Effluent Guidelines

The recommended parameters and BPCTCA guidelines for category "a," which includes only underground mines in this case, are given in Table VII-3. The recommended BATEA guidelines are the same as those for BPCTCA.

TABLE VII-3

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – SILVER MINES (ALONE)

Parameter	Concentration (mg/ℓ) in Effluent 30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Cu	0.05	0.1
Pb	0.1	0.2
Zn	0.5	1.0
Hg	0.001	0.002

*Value in pH units

For category "b" (Mills – Flotation) the recommended parameters and BPCTCA guidelines are given in Table VII-4. The recommended BATEA guidelines are the same as those for BPCTCA.

For category "c" (Mills – Cyanidation Process), zero discharge is recommended and hence no parameters or guidelines are proposed.

The recommended parameters and guidelines for category "d" (Mills – Amalgamation Process), are given in Table VII-5. For these mills the recommended BATEA guideline is zero discharge.

TABLE VII-4

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – SILVER MILLS USING FLOTATION PROCESS

Parameter	Concentration (mg/ℓ) in Effluent 30-day Average	24-hour Maximum
pH	69	6 - 9
TSS	20	30
Cu	0.5	0.1
Zu	0.10	0.2
Pb	0.10	0.2
Hg	0.001	0.002
Cd	0.01	0.02
Cn	0.01	0.02

TABLE VII-5

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS
RECOMMENDED FOR BPCTCA – SILVER MILLS USING AMALGAMATION PROCESS

	Concentration (mg/ℓ) in Effluent	
Parameter	**30-day Average**	**24-hour Maximum**
pH	6* to 9*	6* to 9*
TSS	20	30
Cu	0.05	0.1
Hg	0.001	0.002
Zn	0.10	0.20

*Value in pH units

Source: Development Document

The recommended parameters for category "e" (Mills – Gravity Separation), are given in Table VII-6. BATEA guidelines for this category are the same as those for BPCTCA.

TABLE VII-6

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS
RECOMMENDED FOR BPCTCA – SILVER MILLS USING GRAVITY SEPARATION

	Concentration (mg/ℓ) in Effluent	
Parameter	**30-day Average**	**24-hour Maximum**
pH	6* to 9*	6* to 9*
TSS	30	50

*Value in pH units

Source: Development Document

2. Costs of Compliance

The guidelines contractor has estimated the investment costs and annual operating costs of compliance for both BPCTCA and BATEA guidelines. These costs for silver ore mining and milling are summarized in Table VII-7 by category and in Table VII-8 by companies. The annual costs include charges for amortization. The amortization charge includes an interest cost (at 8%), and is based on a useful life of 20 years for facilities and ten years for equipment.

In this silver ore group of the mineral industry about 20% of the total annual cost is fixed cost (amortization plus interest charges in this case).

TABLE VII-7

SILVER ORES – COST OF COMPLIANCE WITH BPCTCA AND BATEA STANDARDS

Category	No.	1,000 M.T. Ore/Year	Costs (Thousands $)			
			BPCTCA		BATEA	
			Investment	Annual	Investment	Annual
Mines	1	183	54.3	25.8	54.3	25.8
	2	75	128.2	45.7	128.2	45.7
	3	182	31.3	19.9	31.3	91.4
		440	213.8	91.4	213.8	91.4
Mills-Flotation	1	75	0	0	0	0
	2	183	55.0	35.0	33.4	7.0
	3	182	55.0	35.0	48.0	11.3
		440	110.0	70.0	81.4	18.3
Total Industry		440	323.8	161.4	295.2	109.7

Source: ADL Summary of data from Development Document.

TABLE VII-8

COSTS BY COMPANIES

Company	1,000 M.T. Ore/Year	Costs (Thousands $)			
		BPCTCA		BATEA	
		Investment	Annual	Investment	Annual
A	183	109.3	60.8	87.7	32.8
B	75	128.2	45 7	128.2	45.7
C	182	86.3	54.9	79.3	31.2
Total Industry	440	323.8	161.4	295.2	109.7

Source: ADL Summary of data from Development Document.

In Table VII-9 we have estimated the incremental cost to the three companies' final product (silver, metal) due to compliance with both BPCTCA and BATEA guidelines. The table shows the added costs for the particular company unit where effluent treatment is required and for the companies' total silver production. Two companies are multi-unit companies, and the third is a large single unit silver producer.

TABLE VII-9

INCREASE IN COST OF SILVER DUE TO BPCTCA AND BATEA GUIDELINES FOR COMPANIES AFFECTED (1972)

Company	Unit	Estimated Silver Content of Production (M troy oz)	Cost Increase per Ounce Silver ($)	
			BPCTCA	BATEA
A	1	4,222	0.014	0.008
	Total Co.	7,688	0.008	0.004
B	1	1,962	0.023	0.023
	Total Co.	2,577	0.018	0.018
C	Total Co.	1,890	0.029	0.017

Source: ADL Calculations.

3. Basis for Analysis

For the silver ore mining and processing category the basis for analysis is identical to that described in Section I of this report.

4. Levels of Impact

The levels of impact for the silver ore impact analysis are the same as those described in Section I of this report.

a. Best Practical Control Technology Currently Available (BPCTCA)

In Table VII-10 we have summarized the costs for compliance with the BPCTCA guidelines. Shown in Table VII-10 for the three impact groups discussed above and for the total industry are the data on tonnage and number of employees, the added operating costs, and the added investment costs as a percentage of capital expenditures and total investment.

(1) Price and Production Effects. As is evident from the table, 20% of the industry would not be directly affected by the guidelines. For the 80% that is directly affected the product cost increase of $0.020 per ounce of silver is small and could readily be passed on or absorbed under normal circumstances. The percentage increase of $0.020 per ounce on a $1.68-per-ounce product (1972) is less than 1%. There is virtually no impact on the whole industry.

TABLE VII-10

SUMMARY OF DATA AND COSTS FOR BPCTCA GUIDELINES
SILVER ORE MINING AND MILLING (1972)

	Impact Group "A"	Impact Group "B"	Impact Group "C"	Total Industry
Thousands M.T. Ore/Year	113	440	0	553
% of Industry-Ore Basis	20.4	79.6	0	100
Thousands Ounces Silver Produced	716	8,074	0	8,790
Number of Employees	100	900	0	1,000
% of Employees	10.0	90.0	0	100
Added Investment ($)	0	323,800	0	323,800
as % of Capital Expenditure	0	17.0	0	17.0
as % of Total Investment	0	1.4	0	1.2
Added Annual Cost ($)	0	161,400	0	161,400
$ per Ton Ore	0	0.37	0	0.29
$ per Ounce Silver	0	0.020	0	0.018

(2) Financial Effects. The added capital investment required for the impacted group of the industry is 17.0% of the estimated annual capital expenditures and 1.4% of the total invested capital. The percentage of annual capital expenditures is calculated on the assumption that the investment for pollution control will be accomplished in one year. However, in actuality this investment would likely be made over a period of several years so the effect would actually be less than indicated.

(3) Balance of Payment Effects, Employment Effects, and Community Effects. Consideration of the price and production, and financial effects indicates that there will be no output curtailments or plant shutdowns in the silver ore mining and milling industry because of BPCTCA effluent limitations. As a result there will be no employment or community effects and no balance of payments effects.

b. Best Available Technology Economically Available (BATEA)

For meeting BATEA guidelines the effects and impacts are given in Table VII-11. These are very similar to the BPCTCA effects and there will be no significant impact on the industry or any group in meeting BATEA standards.

TABLE VII-11

SUMMARY OF DATA AND COSTS FOR BATEA GUIDELINES
SILVER ORE MINING AND MILLING (1972)

	Impact Group "A"	"B"	"C"	Total Industry
Thousands M.T. Ore/Year	113	440	0	553
% of Industry-Ore Basis	20.4	79.6	0	100
Thousands Ounces Silver Produced	716	8,074	0	8,790
Number of Employees	100	900	0	1,000
% of Employees	10.0	90.0	0	100
Added Investment ($)	0	295,200	0	295,200
as % of Capital Expenditure	0	15.5	0	15.5
as % of Total Investment	0	1.3	0	1.1
Added Annual Cost ($)	0	109,700	0	109,700
$ per Ton Ore	0	0.25	0	0.20
$ per Ounce Silver	0	0.014	0	0.012

c. New Source Performance Standards (NSPS)

The guidelines contractor has recommended that for new silver ore mills using flotation, cyanidation, or amalgamation processes, the NSPS guideline should be zero discharge. For silver ore mines and mills using gravity separation the NSPS standards should be identical to BPCTCA limitations.

The Effluent Guideline Development Document provided no cost estimates for the NSPS analysis. Therefore, any statements made with regard to the effect of the NSPS requirement on the construction of new plants within the U.S. must necessarily be qualitative.

However, it can be said with some degree of confidence that the costs for a "grass roots" plant to meet the NSPS standards are no more than the costs for an existing plant in the impacted group (group "B") to meet the BPCTCA and BATEA recommended effluent limitations, because in the construction of a new plant, in-process modifications can oftentimes be made which may be more efficient and economical than add-on treatment technologies for existing plants.

For the above reasons, a new plant designed with the NSPS effluent limitations in mind could be constructed without much difficulty. Therefore, the cost of water pollution control due to the NSPS standards alone will have minimal effect on the decision of the U.S. silver ore mining and milling industry to expand domestic production capacity through the construction of new plants.

G. LIMITS OF THE ANALYSIS

The limits of this analysis are the same as those discussed in Section I of this report.

VIII. BAUXITE (SIC 1051)

A. INTRODUCTION

Bauxite is a naturally occurring material composed of hydrated aluminum oxide minerals. The principal ores are gibbsite, the trihydrate (65.4% Al_2O_3), and boehmite, the monohydrate (85% Al_2O_3). Bauxites are rarely pure and usually contain impurities – principally iron oxides, clays (aluminum silicates), and titanium oxides.

Bauxites are not common or extensive in the United States and the bulk of the needs for alumina (from which aluminum is made) is imported from such places as Jamaica, Guyana, and Surinam. In the United States bauxite occurs primarily in Arkansas but there are some small operations in Alabama and Georgia. The Arkansas bauxites are used to make alumina but the small mines in Alabama and Georgia produce principally refractory bauxite products. Additional small amounts are used for activated alumina and abrasives.

B. INDUSTRY DESCRIPTION

The Bauxite and Other Aluminum Ores Industry includes establishments engaged primarily in mining, milling, or otherwise preparing bauxite and other aluminum ores. Associated activities such as drying, calcining, activating, and sintering are also included.

1. Reserves

U.S. reserves of bauxite are very small and have been estimated by the Bureau of Mines (1972) as 45 million long tons of 50% Al_2O_3 ore. This is only 0.3% of the world's total and it is clear that most U.S. needs for bauxite will have to be met by imports. Large reserves are located in Africa, Australia, Jamaica and Surinam. A summary of world reserves is given in Table VIII-1.

2. Mining and Beneficiation

Bauxite mining in the United States will be carried out entirely by open pit techniques when Reynolds' underground operation in Arkansas closes later this year. The open pit mines use conventional equipment such as scraper-loaders, shovels, front-end loaders, and trucks. The two principal operations in Arkansas strip a considerable amount of waste overburden to reach the ore (stripping ratio about 4/1 but it varies considerably).

TABLE VIII-1

WORLD BAUXITE RESERVES, 1972

(Thousand Long Tons)

Country	Grade ($\%\ Al_2O_3$)	Quantity	Percent of Total
United States	50	45,000	0.3
Australia	50	4,500,000	29.8
France	58	60,000	0.4
Greece	54	150,000	1.0
Guinea, Republic of	54	4,000,000	26.8
Guyana	58	100,000	0.7
Jamaica	50	800,000	5.4
Surinam	58	600,000	4.0
Other Free World	55	4,000,000	26.8
Communist Countries (Except Yugoslavia)	50	700,000	4.6
World Total		15,000,000[1]	100.0[1]

1. Totals may not add because of independent rounding.

Source: Commodity Data Summaries, Bureau of Mines, 1973

The mined bauxite is generally beneficiated in a simple process involving crushing, grinding and washing although more complex processes such as gravity separations and flotation are used sometimes. The object of beneficiation is to reduce the amount of waste silica as much as possible. Finished beneficiated bauxite is usually dried before shipment to alumina plants for the further steps in producing alumina.

Bauxite is also often calcined before it is used to manufacture refractory shapes.

3. Water Use

Water use in bauxite ore mining and processing has not been tabulated in the Bureau of Census data. However, since there are only a few operations, the industry is not an important discharger of water-borne pollutants.

In the washing operation the primary effluent problem would probably be the control of suspended solids. The major water problem in the aluminum industry is in the handling, discharge and storage of the "red mud" resulting from the production of alumina from bauxite. This was not a part of this study.

4. Products and By-products

The only product of the bauxite mining and milling industry is a washed, sized, and dried bauxite ore which is the feed to alumina production for the production of aluminum metal or for other uses.

No by-products are associated with the bauxite mining industry.

C. INDUSTRY OVERVIEW

1. Types of Firms

Until 1940 the Aluminum Company of America (Alcoa) was the only primary aluminum producer and bauxite refiner in the United States. The domestic bauxite refining industry presently consists of only five large corporations, all of which are fully integrated from bauxite mining through to, and including, fabrication of aluminum products. These companies, their dates of entry into alumina production, and their respective capacities for domestically produced alumina are shown in Table VIII-2. Of these, Alcoa, Kaiser, and Reynolds are 100% self-owned, Ormet is owned 50% by Olin Corporation and 50% by Revere Copper and Brass, Inc., and Martin Marietta Aluminum, Inc., is owned 82.7% by Martin Marietta Corporation.

TABLE VIII-2

BAUXITE REFINING COMPANIES IN THE UNITED STATES

Company	Date of Entry	Alumina Capacity, 1973 (Short Tons/Year)
Aluminum Company of America	1888	2,750,000
Kaiser Aluminum & Chemical Corp.	1942	1,935,000
Martin Marietta Aluminum, Inc.	1967	400,000
Ormet Corporation	1958	618,000
Reynolds Metals Company	1942	2,300,000
Total		8,003,000

Source: Arthur D. Little, Inc., estimates.

There are nine bauxite refining plants in the United States. These are distributed fairly equally among the five large corporations (see Table VIII-3). Seven of the plants produce alumina primarily for the eventual production of aluminum metal. The alumina produced at each plant is consumed by the parent company for that specific purpose.

TABLE VIII-3

BAUXITE REFINING PLANTS IN THE UNITED STATES, 1972

Company and Plant	Alumina Capacity (Annual Short Tons)	Date Built	Employment
Aluminum Company of America (Alcoa)			
Bauxite, Ark.	375,000	1951-52	1,375
Mobile, Ala.	1,025,000	1937	650
Point Comfort, Tex.	1,350,000	1957-58	650
Totals	2,750,000		2,675
Kaiser Aluminum & Chemical Corp.			
Baton Rouge, La.	1,040,000	1941-42	720
Gramercy, La.	895,000	1959	500
Totals	1,935,000		1,220
Martin Marietta Aluminum, Inc.			
St. Croix, V.I.	400,000	1966	430
Ormet Corporation			
Burnside, La.	618,000	1957	430
Reynolds Metals Company			
Corpus Christi, Tex.	1,460,000	1952-54	900
Hurricane Creek, Ark.	840,000	1941	1,000
Totals	2,300,000		1,900
Grand Totals	8,003,000		6,655

Source: Arthur D. Little, Inc., estimates.

The other two plants, both located in Arkansas, produce a variety of products for industries other than the aluminum metal industry. These two plants process primarily low-grade Arkansas bauxite using the Combination process. This process utilizes a sintering step which results in a very pure, low-organic product. This alumina is purer than that needed for aluminum production and is also a higher cost product than alumina produced by the American and Modified Bayer processes and, therefore, may not be competitive as a raw material for the aluminum reduction industry. Products from these two plants are marketed world-wide for numerous applications in such areas as chemicals, refractories, and cements.

Of the five companies involved in domestic alumina production, Alcoa and Reynolds can be considered as being involved solely in the aluminum industry. The other three companies either are diversified or are owned by diversified companies. Kaiser is perhaps the most diversified of the five, with about 80% of its sales in aluminum but with appreciable interests in refractories, chemicals, fertilizers, and nickel. A portion of Martin Marietta's aluminum volume is in non-aluminum products such as titanium and special metals. The parent company, Martin Marietta Corporation, is a diversified conglomerate with interests in chemicals, metals, and construction among others. Ormet is not itself diversified but is owned by two well-diversified companies: Olin Mathieson Chemical Corp. and Revere Copper and Brass, Inc. Olin's primary interests are in the chemical industry, while Revere is one of the largest U.S. fabricators of copper, brass, and aluminum mill products.

2. Types of Plants

Table VIII-4 lists the bauxite mines in the United States together with their production and estimated number of employees. The major producers by far are Alcoa and Reynolds, both of which operate mines in Arkansas. Both are large companies integrated from raw material to finished metallic aluminum and to the production of alumina for many other uses. The other listed companies produce bauxite for refractories and for other minor uses such as activated bauxite and abrasives.

The Bauxite, Arkansas, plant of Alcoa was built in 1951-1952. The plant was designed to use a combination Bayer process to refine the domestic bauxite supplied by the nearby mines. It has had a fairly constant production of about 400,000 tons of alumina per year. About 85% of the output of this plant is marketed around the world for various uses other than the production of aluminum metal.

The Reynolds Hurricane Creek Plant in Arkansas was built for the Government and operated by Alcoa during World War II. Production began in July 1942. After operating the facilities under lease for three years, Reynolds purchased the plant in 1949, subject to a modified National Security Clause. The plant employs the Combination process on locally-mined ore. It uses a small amount of imported bauxite from company-owned operations in Guyana to bring the silica content of the overall ore within practicable processing tolerances. Similar to Alcoa's Bauxite, Arkansas, plant, it has experienced very little growth because of its heavy reliance on limited domestic reserves. It produces about 800,000 tons of alumina per year. Also, like Alcoa's plant, it produces only about 15% of its alumina for eventual use in the production of aluminum metal. It has over 300 customers and produces more than 30 products.

TABLE VIII-4

BAUXITE MINES IN THE UNITED STATES

Company	Mine	Type	Location	(1973) Tons Ore/Year	Process	Employees
Alcoa	Bauxite	O.P.	Bauxite, Arkansas	750,000	Alumina	1375***
American Cyanamid	Benton	O.P.	Benton, Arkansas	N.A.	Calciner	20
Engelhard Min. and Chem.	Porocil	–	Little Rock, Arkansas	N.A.	Calciner	29
Reynolds	Arkansas	O.P. + U.G.**	Hurricane Creek, Arkansas	765,000	Alumina	1000***
Stauffer Chem. Co.	–	O.P.	Little Rock, Arkansas	25,000	Conc.	17
A.P. Green	Barbour	O.P.	Alabama*		Mine	12
Harbison Walker	Barbour	O.P.	Alabama*	41,967	Mine	27
Wilson Snead Co.	Eufaula	O.P.	Alabama*	64,000	Mine & Conc.	36 1974
General Refractories	Southern	O.P.	Georgia	35,000	Mine and Calcine	50

*Annual Report 1974 – State Div. Mines

**Reynolds – U.G. mining production about 10% or 76,000T/year will be discontinued Nov. 1975
O.P. production will continue

***Includes employment in bauxite refinery.

Each alumina plant, in our opinion, is utilizing the best known technology available for the particular ore it is processing. Efficiencies range from 70 to 90% recovery of the alumina from the bauxite depending on the difficulty of the ore.

U.S. production of crude bauxite in the last several years has been as follows:

Thousands of Long Tons (Dry Equivalent)

Year	Alabama & Georgia	Arkansas	Total
1968	83	1,582	1,665
1969	88	1,755	1,843
1970	213	1,869	2,082
1971	207	1,781	1,988
1972	319	1,493	1,812

About 90% of the bauxite mined is used for alumina production, as can be seen from the figures for crude and processed bauxite consumed in 1972:

Type	Thousands of Long Tons (Dry Equivalent)
Crude	1,748 (for alumina)
Dried	18
Activated	7
Calcined	178
Total	1,950

The 1972 Census of Mineral Industries has summarized the general statistics for bauxite and other aluminum ores as follows:

Number of Establishments	=	10
Number with 20 or More Employees	=	5
Number of Employees	=	500
Number of Employees in Production	=	300

D. FINANCIAL PROFILES

Financial data for the three major primary aluminum producers are given in Tables VIII-5, VIII-6, and VIII-7. Financial profiles for the two largest, Alcoa and Reynolds, are given in Appendix A.

TABLE VIII-5

REFERENCE DATA ON MAJOR PRIMARY ALUMINUM PRODUCERS

	Alcoa	Kaiser	Reynolds
Percent Change in Earnings			
Due to Aluminum price change	high	med. – high	high
Reported Income Tax Rate			
1971	32%	31%	nil
1970	40%	31%	32%
Estimated Breakdown of Revenue			
Primary	10 – 15%	5 – 10%	23 – 27%
Fabrication	65 – 70%	60 – 70%	62 – 66%
Other Sales	10 – 15%	5 – 10%	10 – 12%
All Other, n.e.c.	5%	23 – 29%	–
	100%	100%	100%

Note: While reasonable care was taken in compiling this data and presenting it in as consistent a fashion as is possible, we cannot guarantee absolute comparability from one company to the next, due to differences in the nature of earnings, and differences in their accounting for certain balance sheet and income statement items. To the best of our knowledge the above data present an accurate and meaningful basis for selective comparisons.

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed.

TABLE VIII-6

FINANCIAL PERFORMANCE DATA ON MAJOR PRIMARY ALUMINUM PRODUCERS

Company	Net Sales for the Year	Operating Income Before Depreciation	Net After-Tax Earnings (before Extraordinary Items)	Capital Expenditures		Operating Ratio: Op. Income Sales ÷	Net After-Tax Return on Stockholder's Equity	Ratio of Capital Expenditures to Gross Plant at Year End
	$ million					Percent		
Alcoa								
1971	1,441.2	251.2	55.30	199.4				
1970	1,522.4	323.5	114.30	284.9				
1969	1,545.2	330.8	122.40	247.3				
1968	1,352.8	308.7	104.70	177.2				
						av. 20.7%	av. 8.8%	av. 8.6%
Reynolds								
1971	1,093.2	114.6	5.89	79.7				
1970	1,035.2	171.3	47.46	112.7				
1969	1,012.7	173.3	57.07	128.6				
1968	843.8	121.5	31.09	127.4				
						av. 14.8%	av. 7.3%	av.7.1%
Kaiser								
1971	904.5	104.2	27.00	107.4	Includes			
1970	880.9	122.3	50.80	121.6	Avg. of			
1969	925.8	148.9	60.20	158.1	$37.6/yr.			
1968	850.1	138.2	52.00	132.8	Investments			
						av. 14.5%	av. 9.0%	av. 9.7%

Note: While reasonable care was taken in compiling this data and presenting it in as consistent a fashion as is possible, we cannot guarantee absolute comparability from one company to the next, due to differences in the nature of earnings, and differences in their accounting for certain balance sheet and income statement items. To the best of our knowledge the above data present an accurate and meaningful basis for selective comparisons.

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed.

TABLE VIII-7

SELECTED FINANCIAL DATA: MAJOR U.S. ALUMINUM COMPANIES

1971	Alcoa	Kaiser Aluminum	Reynolds
Sales (in millions of dollars)	1,462.1[a]	904.5	1,106.5[a]
Pre-Tax Profit (in millions of dollars)	76.7	39.2	5.5
Net Income (in millions of dollars)	52.0	27.0	5.9[b]
Cash Flow from Operations and Holdings (in millions of dollars)	187.9	69.0	72.9
Increase (Decrease) in debt	71.5	85.9	70.3
Dividends Paid	41.2		18.0
Current Ratio: Assets/Liabilities	3.2	1.6	3.2
Net Working Capital	520.0	189.0	408.0
Capital Expenditures	199.4		79.7
Long-Term Debt, year end	954.0	589.0	878.0[c]
Equity, year end	1,268.6	631.6	699.1
Debt ÷ (debt and equity) Percent based on book values	43.0	48.1	55.5
Scheduled Dept Repayment (1972 payment excluded from long-term debt at year end 1971)			
1972	21.9	35.9	50.4
1973	40.3	31.7	64.1
1974	28.0	31.3	52.7
1975	42.0	33.1	66.7
1976	36.3	53.1	92.9
Long-Term Financing (in millions of dollars, 1971)	203.9	123.1	122.0
Employment, year end	44,064	24,500[d]	35,900

a. Includes other revenues and/or income, as reported.
b. $47.5 for 1970.
c. Includes $125.0 of convertible debentures.
d. Estimated.

Note: While reasonable care was taken in compiling this data and presenting it in as consistent a fashion as is possible, we cannot guarantee absolute comparability from one company to the next, due to differences in the nature of earnings, and differences in their accounting for certain balance sheet and income statement items. To the best of our knowledge the above data present an accurate and meaningful basis for selective comparisons.

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed.

E. PRICE EFFECTS

1. Determination of Prices

It is very difficult to determine a market price for either bauxite or alumina since both are sold almost exclusively to company-owned plants and, therefore, are not readily available on the open market. However, alumina is becoming more available, one reason being that economies of scale require alumina plants to be very large in order to be competitive. This need for large plants has brought with it a need to form worldwide consortia to exploit new bauxite deposits and produce alumina. The participation of different aluminum producers and of interests other than aluminum producers in alumina investments has led to a greater readiness on the part of alumina plants to sell their product under long-term contracts to non-participants in the venture.

The two Arkansas plants produce a variety of products, each with its own market price, which tends to make price determination very complicated.

Table VIII-8 shows the domestic mine production of bauxite and the f.o.b. value in dollars per short ton for a ten year period. Also shown are similar data for Arkansas mine production of bauxite. The Arkansas values are considered to be the most accurate representation of the f.o.b. cost of domestic bauxite to an alumina plant since 90% of the domestic bauxite production and essentially all of the domestic supply for alumina production in 1971 came from Arkansas mines.

TABLE VIII-8

DOMESTIC MINE PRODUCTION OF BAUXITE

	Quantities (Thousand Long Tons)		Total Value (Thousand Dollars)		Average Value f.o.b. (Dollars/Long Ton)	
Year	**Arkansas**	**Total U.S.**	**Arkansas**	**Total U.S.**	**Arkansas**	**Total U.S.**
1962	1,270	1,369	14,606	15,609	11.50	11.40
1963	1,478	1,525	16,701	17,234	11.30	11.30
1964	1,562	1,601	17,431	17,875	11.16	11.16
1965	1,593	1,654	17,974	18,632	11.28	11.26
1966	1,718	1,796	19,439	20,095	11.31	11.19
1967	1,571	1,654	18,269	19,079	11.63	11.54
1968	1,582	1,665	23,058	23,752	14.58	14.27
1969	1,755	1,843	24,706	25,725	14.08	13.96
1970[1]	1,869	2,082	26,293	30,070	14.07	14.44
1971	1,781	1,988	24,979	28,543	14.03	14.36
1972	1,624	1,812	21,010	23,238	12.86	12.82

1. Includes data for Oregon and Washington.

Source: Minerals Yearbook. (U.S. Bureau of Mines.)

2. Costs of Production

The cost of producing a washed and dried bauxite ready for alumina production is quite variable and depends to a large extent on the type of deposit being mined and in particular on the stripping ratio or the amount of waste that must be moved to reach the ore.

Direct mining costs for bauxite mines outside the United States are estimated to vary from $1.65 to $4.52 per short ton.

For a typical U.S. open pit mining operation producing about 750,000 tons of bauxite per year with a 4:1 stripping ratio and with sizing, washing, and drying of the bauxite, we estimate the cost as follows:

	$/ton
Stripping	1.25
Mining	.30
Hauling	.70
Road Maintenance	.05
Overhead & General	.35
Royalty	.25
Washing & Sizing	.95
Drying	1.30
Total	$5.15

Included in the cost for each item is amortization or depreciation of the investment.

3. Potential Constraints on Financing Additional Capital Assets

The aluminum industry is probably one of the most, if not the most, capital intensive manufacturing industries in the world. The capital expenditure programs as well as the long-term financing of the large aluminum producers have been massive. In general, aluminum properties have been financed largely with long-term mortgages secured by their assets. The companies have benefited in the early days from various forms of government financial assistance (both domestically and internationally); more recently in the U.S. community industrial revenue bond financing has been utilized by these companies.

Aluminum companies typically have relatively high debt-to-equity ratios. The companies thus are highly leveraged financially and, depending on the particular circumstances, may or may not be in a position to attract any additional capital at any given moment.

F. ASSESSMENT OF ECONOMIC IMPACT

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Document for the bauxite ore mining industry. These guidelines are:

- Best Practical Control Technology Currently Available (BPCTCA) – to be met by industrial discharges by 1977.
- Best Available Technology Economically Available (BATEA) – to be met by 1983.
- New Source Performance Standards (NSPS) – to be applied to all new facilities that discharge to navigable waters constructed after the promulgation of these guidelines.

For the purpose of recommending effluent guidelines, the Guidelines Contractor has categorized the bauxite ore mining industry into only one subcategory as follows:

1. Mines.

1. Effluent Guidelines

For the mines sub-category, which includes only open-pit mines in this case, the recommended parameters and guidelines for BPCTCA are given in Table VIII-9. The BATEA guidelines are shown in Table VIII-10.

2. Costs of Compliance

The guidelines contractor has estimated the costs of compliance for both BPCTCA and BATEA guidelines. These costs for bauxite ore mining are summarized in Table VIII-11 for nine companies – two large multi-unit companies that produce alumina, and seven small producers of refactory bauxite. The annual costs include charges for amortization, which in turn include an interest cost (at 8%), based on a useful life of 20 years for facilities and 10 years for equipment.

In this bauxite ore category of the mineral industry about 20% of the total annual cost is fixed cost (amortization plus interest charges in this case).

In Table VIII-12, we have estimated the incremental cost that Company 9 would have to add to its final product (alumina) because of compliance with both BPCTCA and BATEA guidelines. These are added costs for the particular company unit that must treat its mine effluent.

TABLE VIII-9

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – BAUXITE MINES (ACID OR ALKALINE MINE DRAINAGE)

	Concentration (mg/ℓ) in Effluent	
Parameters	**30-day Average**	**24-hour Maximum**
pH	6* to 9*	6* to 9*
TSS	20	30
Al	0.60	1.2
Fe	0.50	1.0
Zn	0.10	0.20

*Value in pH units

Source: Development Document

TABLE VIII-10

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR ALKALINE MINE DRAINAGE BATEA – BAUXITE MINES (ACID OR ALKALINE MINE DRAINAGE)

	Concentration (mg/ℓ) in Effluent	
Parameter	**30-day Average**	**24-hour Maximum**
pH	6* to 9*	6* to 9*
TSS	20	30
Al	0.5	1.0
Fe	0.3	0.6
Zn	0.1	0.2

*Value in pH units

Source: Development Document

TABLE VIII-11

BAUXITE MINING – COSTS FOR IMPLEMENTATION OF BPCTCA AND BATEA STANDARDS

Company No.	Thousand Metric Tons Ore/Year	Costs (Thousands $)			
		BPCTCA		BATEA	
		Investment	Annual	Investment	Annual
1-8	1,150	0	0	0	0
9	750	383.2	224.8	383.2	224.8
Total Industry	1,900	383.2	224.8	383.2	224.8

TABLE VIII-12

COST FOR COMPANY NO. 9 PER TON OF Al_2O_3 PRODUCT

Al_2O_3 Produced (1972)	=	341,000 Long Tons
BPT Cost Per Year	=	$224,800
Incremental Cost Per Long Ton	=	$0.66
% Increase in Product Value* (Same for BAT)	=	5.2
Total Production Company No. 9	=	2,500,000 Long Tons
Cost Per Long Ton of Total Production	=	$0.09

*Approximate Average Value Al_2O_3 = $12.82 Per Long Ton (U.S.B.M. – 1972)

3. Basis for Analysis

For the bauxite industry, the basis of analysis is the same as that discussed in section I of this report.

4. Levels of Impact

For the impact analysis of bauxite the same impact levels are used as those previously discussed in section I of this report.

5. Best Practical Control Technology Currently Available (BPCTCA)

In Table VIII-13, we have summarized the costs incurred to comply with the BPCTCA guidelines and data on tonnage, number of employees, added operating costs, and added investment costs.

TABLE VIII-13

DATA AND COSTS FOR MEETING BPCTCA AND BATEA GUIDELINES – BAUXITE ORE MINING INDUSTRY (1972)

	Impact Group			Total Industry
	"A"	"B"	"C"	
Thousands M.T Ore/Yr	1,150	750	0	1,900
% of Industry-Ore Basis	60.5	39.5	0	100
Thousands M.T. Alumina Equivalent in Ore	518	341	0	859
Number of Employees	300	200	0	500
% of Employees	60.0	40.0	0	100
Added Investment for Facilities ($)	0	383,200	0	383,200
as % of Annual Expenditure	0	10.6	0	10.6
as % of Total Investment	0	2.0	0	0.81
Added Annual Operating Cost ($)	0	224,800	0	242,800
$ per ton Ore	0	0.30	0	0.12
$ per ton Alumina Equivalent	0	0.66	0	0.26

a. *Price and Production Effects.* Sixty-one percent of the industry would not be directly affected by the guidelines. For the 39.5% that would be directly affected, the product cost increase of $0.66 per ton is small and could readily be either passed on or absorbed under normal circumstances. The percentage increase of $0.66 per ton on a $12.82-per-ton product (1972) is 5.2%. The cost increase on the whole industry is 2.0%.

b *Financial Effects.* The added capital investment required for the impacted group of the industry is only 11% of the estimated annual capital expenditures and only 2.0% of the total invested capital. The percentage of annual capital expenditures is calculated on the assumption that investment for pollution control will be completed in one year. In actuality, however, this investment would likely be made over a period of several years so the effect would actually be less than indicated.

c. Balance of Payment Effects, Employment Effects, and Community Effects. Consideration of the price and production, and of the financial effects indicates no output will be curtailed or plants shut down in the bauxite ore mining industry because of BPCTCA effluent limitations. As a result there will be no employment or community effects and no balance of payments effects.

6. Best Available Technology Economically Available (BATEA)

For meeting BATEA guidelines, the effects and impacts are the same as those for BPCTCA (summarized in Table VIII-13). There will be no significant impact on the industry or on any group in meeting BATEA standards.

7. New Source Performance Standards (NSPS)

The guidelines contractor has recommended that for new bauxite mines the NSPS standards should be identical with BATEA limitations.

The Effluent Guideline Development Document provided no cost estimates for the NSPS analysis. Therefore, any statements about the effect of the NSPS requirement on the construction of new plants within the U.S. must necessarily be qualitative.

However, it can be said with some degree of confidence that the costs for a "grass roots" plant to meet the NSPS standards are no more than the costs for an existing plant in the impacted group (group "B") to meet the BPCTCA and BATEA recommended effluent limitations, because in the construction of a new plant, in-process modifications often can be more efficient and economical than add-on treatment technologies for existing plants.

For the above reasons, a new plant designed with the NSPS effluent limitations in mind could be constructed without much difficulty. Therefore, the cost of water pollution control due to the NSPS standards alone will have minimal effect on the decision of the U.S. bauxite ore mining industry to expand domestic production capacity through the construction of new plants.

G. LIMITS OF THE ANALYSIS

The limits of the analysis for bauxite are the same as discussed previously.

IX. FERROALLOYS (SIC 1061)

A. INTRODUCTION

The Ferroalloy Ores Industry includes establishments engaged primarily in mining, milling, or otherwise preparing ferroalloy ores.

The general group of metals commonly called ferroalloys includes chromium, manganese, molybdenum, tungsten, vanadium, nickel, and silicon.

In this section we have excluded vanadium that is produced as a by-product of uranium ores in the Colorado Plateau area. Vanadium produced as a mines major product is included in this ferroalloy section.

No chromium or manganese is mined in the United States. The mining of quartz, quartzite, and sandstones as a source of silicon is a domestic industry but is not considered as a metallic ore mining industry and is not a part of this study. We are therefore concerned here with nickel, tungsten, molybdenum, and (in part) vanadium.

B. INDUSTRY DESCRIPTION

1. Nickel

Hanna Mining Company, in Oregon, is the sole U.S. producer of ferronickel. Hanna operates an open pit mine and a smelter operation to produce ferronickel. In 1973, this company mined 2,125,000 tons of lateritic ore and employed 442 people.

Hanna's operation at Riddle produces about 13,000 tons of nickel per year as ferronickel. No water is used for milling and only a small amount for cooling purposes and general use.

2. Tungsten

In 1971 the Bureau of Mines reported 66 active tungsten mines in the United States, but the total annual production from 59 of them was less than 1000 metric tons. Most of the production comes from Union Carbide's California operation. The small properties operate intermittently and are very difficult to locate and contact.

Commercially important tungsten ores are scheelite ($CaWO_4$) and the wolframite series: wolframite ($(Fe,Mn)\ WO_4$), ferberite ($FeWO_4$), and huebnerite ($MnWO_4$). Most tungsten ores are mined underground in small mines and are processed by gravity concentration methods such as jigging, tabling and heavy media separation. In some cases flotation is also used. Concentrates sometimes are treated with acid to improve the grade and reduce the phosphorus content.

The tungsten mining and milling industry is rather small. In 1973, for example, 3,500 tons of tungsten in concentrates was produced and shipped with over 90% coming from Union Carbide in California and AMAX in Colorado (produced as a by-product from molybdenite mining).

The tungsten mining companies are listed in Table IX-1.

3. Molybdenum

In the United States molybdenum is recovered through the processing of molybdenum ores and also as a by-product or even a co-product from the large open pit copper mines in the southwestern states.

There are two major operating molybdenum mines today: one in Colorado (AMAX) and one in New Mexico (Moly Corp.). Information on these is listed in Table IX-2, while production information is listed in Table IX-3.

The total production of molybdenum concentrates in 1973 was 115,859,000 pounds of contained molybdenum (approximately equal to 100,000 tons of molybdenite – MoS_2). Of this amount 58% was from the two molybdenum mines and the remaining 42% was from approximately 12 by-product producers.

a. Reserves

The United States has reserves of about 6.3×10^9 pounds of molybdenum or about 60% of the estimated world total. It is estimated that 80% of these reserves are in deposits in Colorado and New Mexico; these are deposits in which molybdenum is the principal product. The remaining 20% occurs in the porphyry copper ores in Arizona, New Mexico, Nevada and Utah. Molybdenum is produced as a by-product from these latter ores.

b. Mining and Processing

Molybdenite ores are mined by both underground and open pit methods. The AMAX operation in Colorado produces most of its ore by block caving, an underground technique in which large blocks of ore are undercut to cause them to cave. Caved and broken ore is withdrawn from underneath in a series of ore passes and haulage systems. AMAX has also a small open pit operation at Climax that uses conventional equipment. The Moly Corp. mine is entirely an open pit mining operation.

TABLE IX-1

U.S. TUNGSTEN MINING COMPANIES

Company	Location	Tons Ore Per Year	Employees	Comments
Union Carbide	Bishop, Calif.	720,665	N.A.	Moly By-product
Bullion Monarch	Nevada	240,000	20	Custom Milling
Tungsten Prop. Ltd.	Nevada	120,000	7	–
Ranchers Expl.	North Carolina	N.A.	N.A.	On Standby Not Operating
Union Carbide	Austin, Nevada	– New Planned Tungsten Mine		–
Rawhide Mining Co.	Nevada	20	N.A.	–

All mines are underground.

Source: ADL compilation from published data.

TABLE IX-2

MOLYBDENITE MINES IN U.S. (1973)

Company	Mine	Type	Location	Tons Ore Per Year	Employees
Climax Molybdenum	Climax	O.P.	Colorado	153,506	2,351
		U.G.		13,142,788	
Moly Corp.	Questa	O.P.	New Mexico	5,351,008	410

Source: ADL compilation from published data.

TABLE IX-3

U.S. PRODUCTION OF MOLYBDENUM CONCENTRATES
(Thousands of Pounds of Contained Molybdenum)

Year	Production
1966	90,532
1967	88,930
1968	93,447
1969	99,807
1970	111,352
1971	109,592
1972	112,138
1973	115,859
1974 (estimated)	125,000

Source: U.S. Bureau of Mines – Mineral Yearbooks

TABLE IX-4

PRINCIPAL U.S. PRODUCING COMPANIES
(Production in Thousands of Pounds Contained Molybdenum)

Company	1971	1972	1973
American Metal Climax	61,273	59,832	56,194
Anamax Mining	1,208	2,119	3,244
ASARCO	1,659	2,031	814
Bagdad (Cyprus)	459	418	500
Miami Copper (Cities Service)	208	164	200
Duval Corp *	5,485	3,503	7,160
Duval Sierrita	9,846	11,677	14,297
Inspiration	230	28	105
Magma Copper	3,165	4,954	4,542
Moly Corp.	10,062	10,975	10,866
Kennecott	13,353	13,980	14,288
Pima Mining	1,429	1,021	1,876

Source: American Bureau of Metal Statistics.

These molybdenum ores commonly contain about 0.5% MoS_2 and are treated by the flotation process to produce relatively pure molybdenite (MoS_2) concentrates. Molybdenite concentrates are further treated (usually away from the mine site) to produce the various molybdenum compounds, alloys, or metal as desired.

c. Water Use

No separate or specific information is readily available on water use by the two molybdenum mines. Both companies have taken measures to control effluents to meet BPCTCA water quality standards but will incur additional costs to meet BATEA standards in their milling operations.

d. Employment

The total employment in this industry segment is 2,761, as indicated in Table IX-2.

4. Vanadium

Only Union Carbide's operation in Arkansas, near Hot Springs, mines and processes a straight vanadium ore. The ore occurs as vanadiferous clays with an average grade of about 1% V_2O_5. The operation, which started in 1965, consists of two open pit mines and a 1600-ton-per-day processing plant where a roasting-leaching-precipitation process is used to produce a black, powdered vanadium oxide. This product is shipped in steel drums to a plant in Ohio for further processing.

Mining is carried out with conventional open pit equipment. The region is subject to high annual rainfall and good surface drainage around the pits is essential.

Reserves in this region have not been reported but there are said to be some minor occurrences of similar ore that may eventually be mined.

C. INDUSTRY OVERVIEW

The firms in the ferroalloy mining and milling industry vary from small family type operations to large integrated corporations.

Hanna Mining Company, the only U.S. company to produce ferronickel, is a large iron ore producer with operations and interests in iron ore mining, concentrating and pelletizing in the United States, Canada, Australia, and Brazil. The company also produces manganese and trades in ores and concentrates around the world.

Firms in the tungsten mining and processing business consist of one major company and a series of small companies about which information is difficult to obtain. The major corporation, Union Carbide Corp., is a large integrated company that produces uranium, vanadium, tungsten, molybdenum, manganese, chromium, and copper. It has operations in Arkansas, California, Colorado, and Wyoming. Union Carbide is the owner and operator of the Arkansas vanadium mine. The company is also engaged in the exploration for and development of mineral resources.

Climax Molybdenum and Moly Corp. are the major producers of molybdenum. Climax Molybdenum is a 100% owned subsidiary of AMAX, which is a very large integrated corporation engaged in the world-wide exploration and development of mineral resources. AMAX produces aluminum, copper, nickel, cobalt, lead, zinc, iron ore, coal, potash and various chemicals and specialty metals.

Molybdenum Corporation of America is smaller than AMAX. It produces molybdenum, rare earths, columbium, tungsten, rhenium and boron, and also explores for, buys and sells ores and concentrates. Its U.S. operations are in California, Colorado and New Mexico.

For the ferroalloy group as a whole, the Census of Mineral Industries gives the following data:

Number of Establishments	=	42
Number of Establishments with over 20 Employees	=	14
Number of Employees	=	3,700
Number of Employees in Production	=	2,800

These figures very likely include the manufacture of ferroalloys from imported ores and concentrates and therefore probably are not representative of just the mining and processing of U.S. ores.

D. FINANCIAL PROFILES

Financial profiles for three of the major producers of ferroalloys, AMAX, Hanna, and Moly Corp., are given in Appendix A.

E. PRICE EFFECTS

1. Determination of Prices

a. Nickel

In 1949-1950 the price of nickel was about 75¢ per pound but by 1968 had increased to about $1.00 per pound. This increase was caused by the necessity of mining lower-grade sulfide ores and more lateritic ores to supply the demand. Since then the price has been adjusted to approximately parallel the inflation trend and cathode nickel is now $2.01 per pound at the major producers' plants.

b. Molybdenum

Prices of molybdenum products are quoted in dollars per pound of contained molybdenum. Usually the price for processed material depends upon the purity of the product and the form in which it is sold. Prices for particular products also vary slightly according to whether they are briquetted or packaged in bags or cans.

The price of molybdenum products has fluctuated very little in the past 25 years, but prices (in constant dollars) have followed a slight upward trend, reflecting the increased demand and relatively small number of supply sources. They reflect also a decline in the average grade of the ore mined. The most recent price increases by all major producers established an f.o.b. plant price of $2.43 per pound of contained molybdenum in molybdenite concentrate (May 1975).

The current quoted price of bagged molybdic-oxide and technical-grade molybdic-oxide in cans is $2.69 per pound of contained molybdenum. Ferromolybdenum is being sold at $3.25 per pound of contained molybdenum.

c. Tungsten

Government stockpiling of tungsten, and the potential of mainland China to supply substantial quantities of tungsten to Western Europe were the principal reasons for erratic fluctuations of world prices for tungsten concentrate from 1948 through 1965.* However, world prices have been relatively stable since then, because the U.S. Government has sold tungsten concentrate at a fixed price of $43 per short-ton unit of WO_3, equal to $2.71 per pound of contained tungsten. In terms of 1968 dollars, the price of tungsten concentrate is expected

*In constant 1968 dollars.

to remain relatively stable until 1980–85, unless the U.S. Government changes its sales policy. Present prices are quoted as \$84.21 per short ton unit of WO_3. Hydrogen-reduced tungsten metal is quoted at \$10.21-12.01 per pound.

d. Vanadium

From 1949 to 1951 the average annual price of technical grade vanadium pentoxide (V_2O_5) was about \$3.00 per pound of contained V_2O_5. From that point they declined to as low as \$1.70 per pound (in 1969). However, they have increased since then to, at present May 1975, \$2.45-3.06 per pound.

Ferrovanadium prices have also increased from \$2.90 per pound of contained vanadium in 1968 to a present quotation of \$6.35 per pound for standard grade and \$5.10 per pound for the "Carvan" and Ferrovan grades.

2. Costs of Production

In the ferroalloy mining and processing business as described above, there are a great variety of mining and processing systems with very diverse and different costs.

The larger operations such as Climax Molybdenum, Moly Corp. and Union Carbide will have costs similar to those estimated for copper, lead, and zinc mines and mills since they operate similar facilities.

Costs for the smaller operations can not be estimated.

3. Constraints on Financing Additional Investments

For the large companies in the ferroalloy business the constraints will be similar to those discussed in Chapter I.

The smaller companies have very little ability to finance any additional investment.

F. ASSESSMENT OF ECONOMIC IMPACT

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Document for the ferroalloy ore mining and processing industry. These guidelines are:

- Best Practical Control Technology Currently Available (BPCTCA) – to be met by industrial dischargers by 1977.

- Best Available Technology Economically Available (BATEA) – to be met by 1983.

- New Source Performance Standards (NSPS) – to be applied to all new facilities that discharge to navigable waters constructed after the promulgation of these guidelines.

For the purpose of recommending effluent guidelines, the Guidelines Contractor has categorized the ferroalloy ore mining and processing industry into the following groups:

a. Mines – producing over 5000 metric tons/yr.

b. Mines and Mills – processing less than 5000 metric tons/year by methods other than leaching.

c. Mills – processing over 5000 metric tons/year – physical processing.

d. Mills – processing over 5000 metric tons/yr – flotation.

e. Mills – processing ores by leaching.

For all these categories, effluent guidelines have been recommended and implementation costs estimated for these operations that do not meet the guidelines.

1. Effluent Guidelines

The recommended parameters and guidelines for BPCTCA for category "a" (mines over 5000 metric tons/yr) are given in Table IX-5. The guidelines for BATEA are given in Table IX-6.

The recommended parameters and guidelines for BPCTCA for the category "b" (mills – less than 5000 metric tons/yr) are given in Table IX-7 and those for BATEA in Table IX-8.

The recommended parameters and guidelines for BPCTCA for category "c" (mills – over 5000 metric tons/yr – physical processing) are given in Table IX-9 and those for BATEA in Table IX-10.

The recommended parameters and guidelines for BPCTCA for category "d" (mills – over 5000 metric tons/yr – flotation) are given in Table IX-11 and those for BATEA in Table IX-12.

TABLE IX-5

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA-FERROALLOY-ORE MINES PRODUCING OVER 5000 M.T./YR

Parameter	Concentration (mg/ℓ) in Effluent	
	30-Day Average	24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
As	0.5	1.0
Cd	0.1	0.2
Cu	0.05	0.1
Pb	0.10	0.2
Zn	0.5	1.0

*Value in pH units.

Source: Development Document.

TABLE IX-6

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BATEA-FERROALLOY-ORE MINES PRODUCING OVER 5000 M.T./YR

Parameter	Concentration (mg/ℓ) in Effluent	
	30-Day Average	24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
As	0.5	1.0
Cd	0.05	0.1
Cu	0.05	0.1
Mo	1.0	2.0
Pb	0.10	0.2
Zn	0.1	0.2

*Value in pH units.

Source: Development Document.

TABLE IX-7

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED
FOR BPCTCA-FERROALLOY-ORE MINES AND MILLS TREATING LESS THAN 5,000
METRIC TONS (5,512 SHORT TONS) PER YEAR
BY METHODS OTHER THAN LEACHING

Parameter	Concentration (mg/ℓ) in Effluent	
	30-Day Average	24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	30	50

*Value in pH units.

Source: *Development Document.*

TABLE IX-8

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED
FOR BATEA-FERROALLOY-ORE MINES AND MILLS TREATING LESS THAN 5,000
METRIC TONS (5,512 SHORT TONS) PER YEAR
BY METHODS OTHER THAN LEACHING

Parameter	Concentration (mg/ℓ) in Effluent	
	30-Day Average	24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	30	40

*Value in pH units.

Source: Development Document.

TABLE IX-9

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA-FERROALLOY-ORE MILLS TREATING MORE THAN 5,000 METRIC TONS (5,512 SHORT TONS) PER YEAR BY PHYSICAL PROCESSING

Parameters	Concentration (mg/ℓ) in Effluent	
	30-Day Average	24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
As	0.5	1.0
Cd	0.05	0.1
Cu	0.05	0.1
Zn	0.1	0.2

*Value in pH units.

Source: Development Document.

TABLE IX-10

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BATEA-FERROALLOY-ORE MILLS TREATING MORE THAN 5,000 METRIC TONS (5,512 SHORT TONS) PER YEAR BY PHYSICAL PROCESSING

Parameters	Concentration (mg/ℓ) in Effluent	
	30-Day Average	24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
As	0.5	1.0
Cd	0.05	0.1
Cu	0.05	0.10
Mo	1.0	2.0
Zn	0.1	0.2

*Value in pH units.

Source: Development Document.

TABLE IX-11

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA-FERROALLOY-ORE MILLS PROCESSING OVER 5000 M.T./YR USING FLOTATION PROCESS

Parameters	Concentration (mg/ℓ) in Effluent: 30-Day Average	Concentration (mg/ℓ) in Effluent: 24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
COD	50	100
Cyanide	0.05	0.1
As	0.5	1.0
Cd	0.05	0.1
Cu	0.05	0.1
Zn	0.1	0.2

*Value in pH units.

Source: Development Document.

TABLE IX-12

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BATEA-FERROALLOY-ORE MILLS PROCESSING OVER 5000 M.T./YR USING FLOTATION PROCESS

Parameters	Concentration (mg/ℓ) in Effluent: 30-Day Average	Concentration (mg/ℓ) in Effluent: 24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
COD	25	50
Cyanide	0.02	0.04
As	0.5	1.0
Cd	0.05	0.1
Cu	0.05	0.1
Mo	1.0	2.0
Zn	0.1	0.2

*Value in pH units.

Source: Development Document.

The recommended parameters and guidelines for BPCTCA for category "e" (mills – leaching) are given in Table IX-13 and those for BATEA in Table IX-14.

2. Costs of Compliance

The guidelines contractor has estimated the investment costs and annual operating costs of compliance for both BPCTCA and BATEA guidelines. These costs for ferroalloy ore mining and milling are summarized in Table IX-15 by category and in Table IX-16 by companies. The annual costs include charges for amortization. The amortization charge in turn includes an interest cost (at 8%), and is based on a useful life of 20 years for facilities and ten years for equipment.

In this ferroalloy ore category of the mineral industry about 20% of the total annual cost is fixed cost (amortization plus interest charges).

In Table IX-17 we have estimated the incremental cost added to the five companies' final product due to compliance with both BPCTCA and BATEA guidelines. These are added costs for the particular company unit where effluent treatment is required. Four companies are large multi-unit companies. The other category is called small companies of which there are approximately 15.

3. Basis for Analysis

The analysis of economic impact will be carried out in the same way as described in Section I.

4. Levels of Impact

The same impact levels or groups are used in this analysis as those described in Section I.

5. Best Practical Control Technology Currently Available (BPCTCA)

In Table IX-18 we have summarized the costs of complying with the BPCTCA guidelines. Shown in Table IX-18 for the three impact groups and for the total industry are the data on tonnage and number of employees, the added operating costs, and the added investment costs as a percentage of capital expenditures and total investment.

As shown in the table one large multi-unit company (group "B") is impacted to some extent and the small company group (group "C") is severely impacted.

TABLE IX-13

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED
FOR BPCTCA-FERROALLOY-ORE MILLS
USING LEACHING PROCESS

Parameters	Concentration (mg/ℓ) in Effluent: 30-Day Average	Concentration (mg/ℓ) in Effluent: 24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Ammonia	30	60
As	0.5	1.0
Cd	0.05	0.1
Cu	0.05	0.1
Zn	0.1	0.2

*Value in pH units.

Source: Development Document.

TABLE IX-14

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED
FOR BATEA-FERROALLOY-ORE MILLS
USING LEACHING PROCESS

Parameters	Concentration (mg/ℓ) in Effluent: 30-Day Average	Concentration (mg/ℓ) in Effluent: 24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Ammonia	5	10
As	0.5	1.0
Cd	0.05	0.1
Cr	0.05	0.1
Cu	0.05	0.1
Mo	1.0	2.0
Zn	0.1	0.2

*Value in pH units.

Source: Development Document.

TABLE IX-15

FERROALLOY ORES – COSTS OF COMPLIANCE WITH BPCTCA AND BATEA STANDARDS

			Costs (Thousands $)			
		1,000 M.T.	BPCTCA		BATEA	
Sub-Category	No.	Ore/Year	Investment	Annual	Investment	Annual
Mines	1-5	20,300	0	0	0	0
	6	20	1.1	0.2	1.1	0.2
	7	410	284.5	157.2	284.5	157.2
Mills – Flotation – over 5,000 M.T./yr.						
	1	600	0	0	0	0
	2	3,710	0	0	204.0	88.9
	3	15,100	0	0	734.4	209.3
Mills – Physical Processing – over 5,000 M.T./yr.						
	1	1,620	0	0	0	0
	2	20	135.4	20.1	135 4	20.1
Mills – Leaching						
	1	410	424.2	463.1	486.5	488.4
Mills – Less than 5,000 M.T./yr.						
	1-35	17	0	0	0	0
	15	8	101.0	24.0	125.0	48.0
Totals		–	946.2	664.6	1970.9	1012.1

TABLE IX-16

COST BY COMPANIES – FERROALLOY ORES

		Costs (Thousands $)			
	1,000 M.T.	BPCTCA		BATEA	
Company	Ore/Year	Investment	Annual	Investment	Annual
A	20	136.5	20.3	136.5	20.3
B	3,710	0	0	204.0	88.9
C	15,100	0	0	734.4	209.3
D	410	708.7	620.3	771.0	645.6
All others – small Co's	8	101.1	24.0	125.0	48.0
	19,248	946.2	664.6	1970.9	1012.1

TABLE IX-17

ESTIMATED INCREASE IN COST OF MAJOR PRODUCT TO MEET BPCTCA AND BATEA GUIDELINES FERROALLOY ORES (1972)

Company	Product	Amount/Year	Cost/Unit to Meet Guidelines ($)	
			BPCTCA	BATEA
A	Tungsten ore	20 000 M.T.	$1.02	$1.02
B	Moly Conc.	10,975,000 lb*	–	.008
C	Moly Conc.	59,832,000 lb*	–	.003
D	Vanadium Pentoxide	8,000,000 lb**	0.078	0.081
Small Companies	Tungsten ore	8,000 M.T.	3.00	6.00

*Contained molybdenum

**Estimated

Approximate product values:	1972	1975
Molybdenum Concentrate – FOB – per pound contained molybdenum	$ 1.72	$ 2.43
Tungsten Concentrate – FOB – per short ton unit	55.00	84.20
Vanadium Pentoxide – Technical grade – per pound contained V_2O_5	1.50	2.45-3.06

TABLE IX-18

SUMMARY OF DATA AND COSTS FOR MEETING BPCTCA GUIDELINES
FERROALLOY ORE MINING AND MILLING (1972)

	Impact Group			
	"A"	"B"	"C"	Total Industry
Thousands M.T. Ore/Yr	20,292	410	28	20,730
% of Industry – Ore Basis	97.9	2.0	0.1	100
Thousands Units Product				
Tungsten Ore – M.T.	N.A.	–	28	–
Moly Conc. – (Contained Mo) – lb	70,807	–	–	–
Vanadium Pentoxide – lb	–	8,000	–	–
Number of Employees	3,530	120	50	3,700
% of Employees	95.4	3.2	1.4	100
Added Investment for Facilities ($)	0	708,700	237,500	946,200
as % of Annual Capital Expenditures	0	27.6	238	2.6
as % of Total Invested Capital	0	6.9	33.9	0.2
Added Annual Cost ($)	0	620,300	44,300	664,600
$ per M.T. of Ore	0	1.51	1.58	.03
$ per Unit of Product Indicated	0	0.08	1.58	Negligible

(1) Price and Production Effects. As is evident from the table, 98% of the industry would not be directly affected by the guidelines. For the 2.0% that is directly affected (group "B") the product cost increase of \$0.08 per pound is small and could readily be passed on or absorbed under normal circumstances. The percentage increase of \$0.08 per pound on a \$1.50-per-pound product (1972) is 5%. There is virtually no impact on the whole industry.

For group "C" the impact is about the same, with a cost increase of \$1.58 per metric ton or 2.9% on a \$55-per-metric ton product.

(2) Financial Effects. The added capital investment required for impacted group "B" of the industry is 28% of the estimated annual capital expenditures and 6.9% of the total invested capital. The percentage of annual capital expenditures is calculated on the assumption that investment for pollution control will be accomplished in one year. In actuality, however, this investment would likely be made over a period of several years so the effect would be less than indicated. This impact is not considered severe and this group should be able to provide the funds and pay the costs without any significant impact.

However, group "C" is severely affected. The investment required for BPCTCA is about two and one half times its average annual capital expenditure and 35% of its total plant investment.

(3) Balance of Payment Effects, Employment Effects, and Community Effects Consideration of the price and production and financial effects indicates there will be no output curtailments or plant shutdowns in 99.9% of the ferroalloy ore mining and milling industry (groups "A" and "B") because of BPCTCA effluent limitations. As a result there will be no employment or community effects and no balance of payments effects on this portion of the industry.

For group "C", however, it appears that some 17 small operations will most likely be forced to close. This is, however, a very small portion of the industry (0.1%) and the lost production should have no impact on the ferroalloy market, on ferroalloy prices, or on the balance of payments.

Employment would be locally affected since about 50 jobs would be lost with consequent secondary impact on the communities around the operations.

6. Best Available Technology Economically Available (BATEA)

Table IX-19 summarizes the costs for meeting BATEA guidelines for the ferroalloy ore mining and milling industry.

For BATEA compliance, two large multi-unit companies are added to group "B", which substantially increases the investment and annual cost for that group. However, it would still not cause any important impact on the groups ("A" and "B") that represent 99.9% of the industry or on the industry itself.

The BATEA impact on group "C" would be severe and would reinforce the effect of the BPCTCA impacts discussed above.

7. New Source Performance Standards (NSPS)

The guidelines contractor has recommended that for new ferroalloy ore mines the parameters and guidelines should be as given in Table IX-20. For mills processing less than 5000 metric tons/yr by processes other than leaching, mills producing over 5000 metric tons/yr with physical processes, and mills processing by leaching, the contractor has recommended that standards be the same as BATEA guidelines.

For mills producing over 5000 metric tons/yr and using the flotation process, the NSPS guidelines proposed are those given in Table IX-21.

The Effluent Guideline Development Document provided no cost estimates for the NSPS analysis. Therefore, any statements about the effect of the NSPS requirement on the construction of new plants within the United States must necessarily be qualitative.

However, it can be said with some degree of confidence that the costs for a "grass roots" plant to meet the NSPS standards are no more than the costs for an existing plant in the impacted group (group "B") to meet the BPCTCA and BATEA recommended effluent limitations, because in the construction of a new plant, in-process modifications can often-times be made which may be more efficient and economical than add-on treatment technologies for existing plants.

For the above reasons, a new plant designed with the NSPS effluent limitations in mind could be constructed without much difficulty. Therefore, the cost of water pollution control due to the NSPS standards alone will have minimal effect on the decision of the ferroalloy ore mining and milling industry to expand domestic production capacity through the construction of new plants.

G. LIMITS OF THE ANALYSIS

These are the same as discussed in Section I of this report.

TABLE IX-19

SUMMARY OF DATA AND COSTS FOR MEETING BATEA GUIDELINES
FERROALLOY ORE MINING AND MILLING (1972)

	Impact Group			
	"A"	"B"	"C"	Total Industry
Thousands M.T. Ore/Yr	1,482	19,220	28	20,730
% of Industry – Ore Basis	7.2	92.7	0.1	100
Thousands Units Product:				
Tungsten Ore – M.T.	N.A.	–	28	–
Moly. Conc. (Contained Mo) – lb	–	70,807	–	–
Vanadium Pentoxide – lb	–	8,000	–	–
Number of Employees	770	2,880	50	3,700
% of Employees	20.8	77.8	1.4	100
Added Investment for Facilities ($)	0	1,709,400	261,500	1,970,900
as % of Annual Capital Exp.	0	22.2	262	5.4
as % of Total Invested Capital	0	0.4	37.3	0.4
Added Annual Cost ($)	0	943,800	68,300	1,012,100
$ per M.T. Ore	0	.05	2.44	.05
$ per Unit of Product Indicated	0	.01	2.44	Negligible

TABLE IX-20

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR NSPS-FERROALLOY ORE MINES

Parameters	Concentration (mg/ℓ) in Effluent	
	30-Day Average	24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
As	0.5	1.0
Cd	0.05	0.1
Cu	0.05	0.1
Pb	0.10	0.2
Zn	0.1	0.2

*Value in pH units.

Source: Development Document.

TABLE IX-21

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR NSPS-FERROALLOY ORE MILLS USING FLOTATION PROCESS

Parameters	Concentration (mg/ℓ) in Effluent	
	30-Day Average	24-Hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
COD	25	50
Cyanide	0.02	0.04
As	0.5	1.0
Cd	0.05	0.1
Cu	0.05	0.1
Zn	0.1	0.2

*Value in pH units.

Source: Development Document.

X. MERCURY ORES (SIC 1092)

A. INTRODUCTION

The Mercury Ores Industry includes establishments engaged primarily in mining, milling, or otherwise preparing mercury ores and mercury metal. This industry includes the production of metallic mercury by furnacing or retorting at the mine site.

The mercury mining and processing industry in the United States is very small and is subject to great fluctuations. The mines are small and open and close as the price goes up and down.

Most of the production is from numerous small undergound mines in California with minor production from Idaho, Nevada, Alaska, Oregon, and Texas.

The statistics for the last five years are as follows:

	1969	1970	1971	1972	1973
Producing Mines	109	79	56	37	24
Production – Flasks	29,640	27,296	17,883	7,333	2,171

Tentative figures for 1974 indicate a continued drop to only 1,700 flasks and only ten mines operating.

Production in 1973 by states was as follows:

	No. Mines	Flasks Produced
California	18	1,219
Nevada	3	698
Alaska, Oregon, Texas	3	254
	24	2,171

The principal operating mines in 1973, as reported by the Bureau of Mines, were:

					Flask/yr
Red Bird Mine	–	Nevada	–	500-1,000
Culver – Baer	–	California	–	100-500
Guadalupe	–	California	–	100-500
New Almaden	–	California	–	100-500
White Mountain	–	Alaska	–	100-500
(Retorted in Oregon)				

A recent announcement indicates that Placer Amax is planning to reopen the McDermitt mine in Nevada at a cost of $9.7 million. This deposit is said to contain 3 million tons of ore averaging 0.5% Hg. The operation will produce 20,000 flasks per year from an open pit mine, flotation plant, and furnace operation. Complete control of all water is planned and there will be zero discharge.

B. MINING AND PROCESSING

Mercury ores are mined by underground techniques (which are generally open stopes with some timbering) and also by open pit techniques. All the operations are small and the mine ores have an average mercury content of 5.9 pounds per ton of ore. A mine producing 500 flasks per year would mine about 7,000 tons of ore per year, or around 50 tons per day.

The major mercury mineral in the ores is cinnabar (HgS) although free mercury does occur at times. The common processing method is simply to mine, size, and retort the ore to vaporize the mercury and then collect it in water-cooled condensers. Water is used only in the condensing step and then only a very small amount.

There are ways to concentrate mercury ores, with flotation being the preferred procedure. In this process, water is used but at the dry locations involved we believe there is no discharge. The flotation process results in a concentrate that is retorted to recover the metal.

There is no readily available information on employment in the mercury industry.

C. ASSESSMENT OF ECONOMIC IMPACT

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Document for the mercury ore mining and processing industry. These guidelines are:

- Best Practical Control Technology Currently Available (BPCTCA) – to be met by industrial dischargers by 1977.

- Best Available Technology Economically Available (BATEA) – to be met by 1983.

- New Source Performance Standards (NSPS) – to be applied to all new facilities that discharge to navigable waters constructed after the promulgation of these guidelines.

For the purpose of recommending effluent guidelines, the Guidelines Contractor has categorized the mercury ore mining and processing industry into the following groups:

1. Mines.
2. Mills using gravity separation and/or flotation.

1. Effluent Guidelines

The recommended parameters and guidelines for BPCTCA (for both underground and open pit mines) are given in Table X-1. For BATEA limitations the recommendations are given in Table X-2.

For the milling sub-category for BPCTCA and BATEA zero discharge is recommended and hence no parameters or guidelines are proposed.

2. Cost of Compliance

The guidelines contractor has not estimated costs for any particular mercury ore mines or mills.

The mercury mining and processing industry in the United States is very small and both the numbers of mines operating and the amount produced fluctuate widely.

The contractor reports that the one known open-pit mercury mine has no effluent discharge. No mills currently use flotation; as noted, one is scheduled to be open in 1975 but it will have zero discharge. One mill employs gravity separation but this mill also has zero discharge.

In view of the above there will be no impact on the mercury ore mining and processing industry because of the imposition of BPCTCA or BATEA guidelines.

For NSPS guidelines mercury mines are required to meet BATEA guidelines and mercury mills are required to have zero discharge.

TABLE X-1

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA-MERCURY MINES

Parameter	Concentration (mg/ℓ) in Effluent	
	30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Hg	0.001	0.002
Ni	0.1	0.2

*Value in pH units

Source: Development Document

TABLE X-2

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BATEA-MERCURY MINES

Parameter	Concentration (mg/ℓ) in Effluent	
	30-day Average	24-hour Maximum
pH	6 to 9	6 to 9
TSS	20	30
Hg	0.0005	0.001
Ni	0.1	0.2

XI. URANIUM-RADIUM-VANADIUM (SIC 1094)

A. INTRODUCTION

In the United States uranium minerals occur in, and are recovered from, two types of deposits: stratiform or vein. Stratiform deposits are tubular masses with their length and width larger than their thickness. These masses usually lie parallel to the bedding planes of the host rocks, which are commonly sandstones. Vein deposits usually dip steeply and are localized along fractures or other structural features.

By far the most common in the United States are the stratiform deposits, which have accounted for 95% of the production and which also have about 95% of the reserves.

There are more than 100 known uranium minerals but the most common are uraninite, a primary uranium oxide, and coffinite, a hydrated uranium silicate. These minerals occur as the major constituents of most U.S. deposits. The one exception to this is in the Uravan Mineral Belt in the Colorado plateau where there are predominant vanadium bearing minerals which make this region a source of both uranium and vanadium.

Figure XI-1 shows the general location of major uranium producing districts in the U.S. Not shown are operations in Texas where there are two mines and mills.

B. INDUSTRY DESCRIPTION

The Uranium-Radium-Vanadium Ores Industry includes establishments engaged primarily in mining, milling, or otherwise preparing uranium-radium-vanadium ores.

1. Reserves

A great deal of work has been done by the A.E.C. in the past on uranium ore reserves. We have summarized the information in Table XI-1 (1970 data). It is evident that the major reserves occur in New Mexico and Wyoming.

2. Mining

Uranium deposits are mined by both open pit and underground techniques. Uranium open pit mines are operating in Wyoming, New Mexico and Texas while most of the underground mines are in Colorado, Utah and New Mexico.

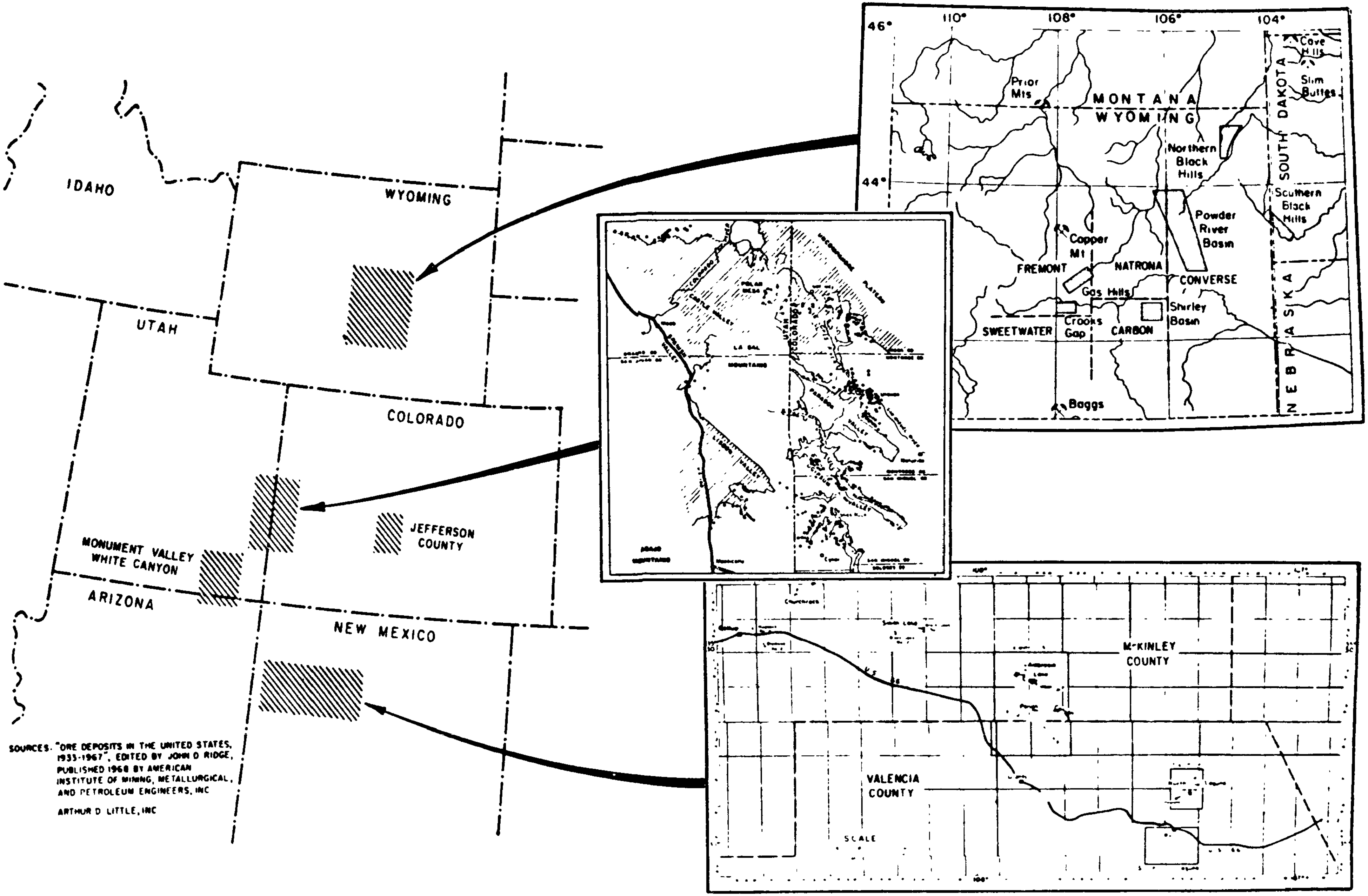


FIGURE XI-1 LOCATION OF MAJOR URANIUM MINING DISTRICTS OF INTEREST

TABLE XI-1

DISTRIBUTION OF U.S. URANIUM ORE RESERVES BY STATE

State	$6 Reserves				$8 Reserves				$10 Reserves			
	Ore (Tons)	U_3O_8 (Tons)	% Total Tons U_3O_8	Properties	Ore (Tons)	U_3O_8 (Tons)	% Total Tons U_3O_8	Properties	Ore (Tons)	U_3O_8 (Tons)	% Total Tons U_3O_8	Properties
New Mexico	19,177,461	66,181	44.38	64	34,905,227	86,042	42.16	74	51,444,246	101,112	40.86	80
Wyoming	21,028,825	53,566	35.92	93	44,020,039	82,275	40.31	138	70,868,073	103,879	41.98	205
Utah	2,129,353	8,070	5.41	166	2,952,856	9,483	4.65	205	3,677,602	10,540	4.26	219
Colorado	1,631,875	5,501	3.69	380	2,550,689	7,099	3.47	405	6,667,117	10,320	4.17	441
Texas	2,616,782	5,753	3.85	12	3,812,529	7,015	3.44	18	4,776,099	7,716	3.12	19
Others[1]	7,170,521	10,069	6.75	31	8,363,004	12,180	5.97	133	11,726,603	13,880	5.61	166
Totals	53,754,817	149,140	100	746	96,604,344	204,084	100	973	149,159,740	247,447	100	1,130

1. Include Arizona, Washington, South and North Dakota, California, Idaho, Montana, Nevada, Oklahoma, Oregon, and Alaska.

Sources: "Statistical Data of the Uranium Industry," AEC/GJO, 1 Jan. 1970, and informal communication, AEC, June 22, 1970.

a. Open Pit Mining

Open pits usually require a substantial amount of waste to be stripped to expose the first of the ore bodies constituting the reserves in the deposit. However, in a few uranium open pit mines that have been developed, the ore outcropped, so stripping and ore production started together.

In general, stripping ratios (cubic yards of waste moved to tons of ore mined) in uranium open pit operations are higher than the same ratios in pits operated for the recovery of other metals, such as copper or iron ore. The stripping ratios for these latter metals usually range from 2 to 4; whereas in uranium open pits, it is not uncommon to have stripping ratios of 30 to 35. For example, published information for one Wyoming open pit indicates the need to move 13.5 million cubic yards of waste per year to lay bare 400,000 tons of ore, a ratio of about 34. The higher stripping ratios prevailing for uranium open pits are principally a reflection of the greater value of the ore being mined.

Waste stripping and ore mining are carried out with conventional earthmoving equipment. In waste stripping, it is common practice to use scraper-loaders assisted by bulldozers for ripping and push loading. Ore can be mined using conventional shovel-truck equipment or smaller, more specialized equipment. For example, in the pits in some districts in Wyoming where ore bodies are small and variable in size and shape, backhoes have been found to be the most economic device for digging and truck-loading the ore.

b. Underground Mining

Several underground mining techniques are used. The best combination varies with the size, type, location, number, and position of the ore bodies to be mined. The techniques to be used are determined when the underground mine is planned.

Most of the presently operating important underground mines require shaft entry, and those that might be anticipated in the various regions, probably will also, although some ore no doubt will continue to be mined by inclines and adits. Circular concrete-lined shafts have become standard for many of the deeper deposits. Water is a problem in many mines and must be considered.

The stoping methods most commonly in use and planned for in new mines are various forms of room and pillar methods; there is also some minor use of modified long-wall retreat systems.

In general, ground support is provided in underground uranium mines by rock bolting wire mesh or steel plate to the back (i.e., roof) to stabilize the ground.

The ore is broken by conventional drilling and blasting. In general, the sandstone ores are soft and easy to drill and blast, although powder consumption can be as high as it is for hard rock mines.

Slusher scrapers are commonly used to pull the ore from stopes, particularly in the smaller ore bodies. Trackless diesel-operated front-end loaders and trucks equipped with exhaust scrubbers often are used when the ore bodies are thicker. For sub-ore haulage, electrically driven trains are standard, but for on-level ore, haulage trucks may be used.

Uranium can also be leached and recovered by solution mining from mined-out stopes and from passageways of abandoned mine areas. Uranium can also be recovered from mine water. Some mine waters contain 5-10 parts per million of uranium as U_3O_8, and this can be recovered profitably by ion exchange processing.

3. Uranium Milling

Uranium ores typically contain about 4 pounds of U_3O_8 per ton, and are rarely concentrated by the flotation or gravity procedures commonly used in dressing other ores. Usually all the ground uranium ore is subjected to the action of dissolving chemicals to produce the high-grade concentrate known as "yellowcake." First the raw ore is crushed and finely ground, and then leached to dissolve the uranium minerals from the rock. Next, the uranium-bearing solution that results from the leaching is separated from the undissolved material. Finally, the uranium is recovered as a chemically precipitated concentrate.

Uranium is separated from unwanted substances in the leaching solution by one of two well-known chemical processes: "ion exchange" or "solvent extraction." Both processes concentrate the uranium in a refined solution, from which it is precipitated in the form of a pure compound.

Ion exchange utilizes a property of certain organic resins to remove the uranium ions from either acid or alkaline leach solutions. In the process, an ionic component of the resin is exchanged for an ionic portion of the solution in which the resin is immersed. In this process virtually all uranium in solution can be transferred to the resin.

Solvent extraction is a similar chemical process. In this process an organic liquid solvent with a selective affinity for uranium is thoroughly mixed by agitation with the impure aqueous solution of leached uranium.

Processes now used in the domestic uranium milling industry can recover as much as 95% of the uranium content. Concentrates in the form of uranium oxides containing 75 to 98% uranium are shipped from the mill to central locations for processing to the hexafluoride.

Table XI-2 lists the operating U.S. uranium milling plants and indicates the type of process used at each.

4. Water Use

Many of the small uranium mines in the four corners region are dry and have no water problem. Other uranium mines are quite wet and must pump and provide for handling of mine water. The large underground mines in the Ambrosia Lake area of New Mexico are examples of mines below the water table and can be very wet.

Milling uranium and vanadium ores by the leaching processes described previously uses a considerable amount of water. For example, the Bureau of Census data for 1968 indicates the following (for uranium ores only):

	Gallons (Billions)
Total Water Intake	7
Mine Water Used	2
Other Water Used	5
Treated Prior to Use	2
Gross Water Used (includes recirculated)	11
Total Water Discharged	7
Mine Water Discharged	1
Water Treated Prior to Discharge	3

Mr. Kaufman's study (1967) indicated that for uranium and vanadium ores the gross water used was 8.3 billion gallons with a total water intake of 7.2 billion gallons.

In most cases all liquid and solid wastes from the uranium and vanadium mining and milling plants are completely contained in tailings ponds and no effluents are discharged. Where the climate permits, some evaporation ponds are used to get rid of the final effluent. There are, however, a number of wet mines and some milling operations that will require some effluent treatment additions.

5. Products and By-products

As indicated in the previous sections, the product from this industry is "yellowcake" which is shipped in drums to other locations for further processing.

The only by-product produced is vanadium, which is associated with uranium in the Colorado plateau ores.

TABLE XI-2

OPERATING U.S. URANIUM MILLING PLANTS

Company	Location	Rated Capacity (Tons/Day)	Ore From	Date Started	Process Used*
The Anaconda Co.	Bluewater – New Mexico	3,000	O.P.	1956	AL – RIP
Atlas Corp.	Moab – Utah	1,500	U.G.	1956	AL – CCD – SX ALKL – RIP
Conoco	Falls City – Texas	1,750	O.P.	1974	–
Cotter Corp.	Canon City – Colorado	450	U.G.	1958	AL – SX – ALKL – CPPT
Dawn Mining Co.	Ford – Washington	500	O.P.	1968	–
Exxon	Powder River Basin – Wyoming	2,000	O.P.	1972	–
Federal-American Partners	Fremont City – Wyoming	950	O.P.	1959	AL – RIP – ELUEX
Humble Oil	Powder River Basin – Wyoming	2,000	O.P.	1974	–
Kerr McGee Corp.	Grants – New Mexico	7,000	U.G.	1958	AL – CCD – SX
Mines Development, Inc.	Edgemont – S. Dakota	650	O.P.	1956	AL – RIP – ELUEX
Petrotomics	Carbon City – Wyoming	1,500	O.P.	1962	AL – CCD – SX
Rio Algom	La Sal – Utah	500	U.G.	1973	–
Susquehanna Western, Inc.	Falls City – Texas	1,000	O.P.	1961	AL – CCD – SX
Susquehanna Western, Inc.	Ray Point – Texas	1,000	O.P.	1970	–
Union Carbide	Rifle – Colorado	1,500	U.G.	1958	AL – CCD – SX
Union Carbide	Uravan – Colorado	1,500	U.G.	1950	AL – CCD – IX
Union Carbide	Natrona City – Wyoming	1,000	O.P.	1960	AL – RIP
United Nuclear – Homestake	Grants – New Mexico	3,500	U.G.	1958	ALKL – CPPT
Utah International	Fremont City – Wyoming	1,200	O.P.	1958	AL – CCD – IX – ELUEX
Utah International	Shirley Basin – Wyoming	1,200	O.P.	1972	–
Western Nuclear	Jeffrey City – Wyoming	1,200	O.P. U.G.	1957	AL – RIP – ELUEX

*AL = Acid Leach
ALKL = Alkaline Leach
CCD = Countercurrent Decantation
CPPT = Caustic Precipitation
RIP = Resin in Pulp
IX = Column Ion Exchange
SX = Solvent Extraction
ELUEX = H_2SO_4 Elution of Resin Followed by SX

C. INDUSTRY OVERVIEW

1. Types of Firms

This industry is made up of two types of firms, a large number of small uranium mines, and a group of medium and large companies integrated from uranium mining to the production of "yellowcake." Many of the large companies are also involved in numerous other mining activities. The major firms are as follows:

- *Anaconda:* Produces uranium in New Mexico but is also a producer of aluminum and large amounts of copper, from mines in Montana, Nevada and Arizona. It also has numerous foreign interests.

- *Atlas Minerals Corporation:* Atlas is a small company only operating uranium mines and a mill in Utah. It is a subsidiary of the Atlas Corporation.

- *Kerr McGee Corporation:* Kerr operates uranium mines and mills in New Mexico and Wyoming. It is a large diversified company producing petroleum and natural gas, manganese, potash, trona, soda ash, boron, and lithium. It is also involved in developing coal mines and in mineral exploration. Kerr's sales in 1974 were $1,550,348,620.

- *Utah International:* Utah operates uranium mines and mills in Wyoming. It is a large mining company producing copper concentrates, coal and iron ore in addition to uranium. Other byproducts produced are gold, silver, molybdenum and rhenium. It is also active in real estate developments and exploration for mineral resources around the world. Utah's sales in 1973 were $315,645,000.

- Humble Oil, Exxon and Conoco – all very large multi-national petroleum corporations – also operate uranium producing subsidiaries.

- Smaller companies in the business are Susquehanna Western, which operates two open pit uranium mines and mills in Texas; Cotter Corporation with a mine and mill in Colorado; Dawn Mining Company (Newmont subsidiary) with a mine and mill in Washington; Western Nuclear in Wyoming, mine and mill; Petrotomics Corporation in Wyoming, mine and mill; and Rio Algom which operates an underground mine and mill in Utah.

2. Types of Plants

As indicated above, the uranium and vanadium industry comprises a number of companies engaged in the exploration, mining and milling of ores to produce "yellowcake" and vanadium in some cases. These are the medium and large integrated companies listed in Table XI-2 whose plants consist of mines, ore transportation systems, and milling plants.

In addition to these companies, a number of small mines, particularly in the Colorado-Utah region, mine and supply ore to the two Union Carbide milling plants at Rifle and Uravan, Colorado.

A study completed in 1970* summarized information on the number of mines reporting uranium ore production in 1969 (Table XI-3) and on the number of employees in the uranium industry in that year (Table XI-4).

TABLE XI-3

URANIUM ORE MINES, 1969

State	Open Pit	Underground	Total
New Mexico	1	22	23
Wyoming	8	9	17
Utah	1	34	35
Colorado	0	78	78
Others	2	2	4
	12	145	157

TABLE XI-4

NUMBER OF EMPLOYEES IN URANIUM INDUSTRY, 1969

		Underground		
State	Open Pit	In Mines	Surface	Total
New Mexico	156	1,198	227	1,581
Wyoming	585	119	39	743
Utah	8	198	32	238
Colorado	8	612	150	770
Others	57	6	0	63
	814	2,133	448	3,395

*Assessment of Economic Impact of Radiation Standards, ADL Report C-72257, September 1970.

The Census of Mineral Industries for 1972 listed the following information:

Total Number of Establishments	=	145
Total Number of Establishments with Over 20 Employees	=	34
Total Number of Employees	=	5,900
Total Number of Employees in Production	=	4,600

These data include uranium and vanadium.

The mine production of recoverable U_3O_8 by states has been reported as follows:

	Thousands of Pounds of U_3O_8	
	1971	**1972**
Colorado	2,536	1,877
New Mexico	10,567	10,808
Utah	1,445	1,496
Wyoming	6,986	8,544
Other (Alaska, South Dakota, Texas and Washington)	2,981	3,033
	24,515	25,758

In 1971, 53% of the production came from the open pit mines, 45% from underground mines, and about 2% from heap leaching, in-situ processing and mine water recovery. A similar percentage would probably apply today.

Vanadium is produced as a by-product from the uranium ores and operations around Grand Junction, Colorado and also produced from a single vanadium open pit mine in Arkansas. Total production in recent years was as follows:

	Short Tons	
	Gross Wt.	**V_2O_5 Content**
1969	12,120	10,542
1970	11,035	9,986
1971	10,492	9,448
1972	10,410	9,367
1973	8,226	8,683

There is no breakdown of actual production as by-product or from the Arkansas mine; however, the production in Arkansas might be about 4,000 tons of V_2O_5 per year.

D. FINANCIAL PROFILES

Some of the important companies in the uranium mining and milling industry are: Anaconda, Newmont, and Homestake.

Profiles for these companies are given in Appendix A.

E. PRICE EFFECTS

1. Determination of Prices

The most important form of primary uranium that moves in commercial channels is the uranium oxide known as "yellowcake." Prices for this material are quoted in dollars/pound of U_3O_8. Prices have fluctuated from \$19.96/lb in 1953, to \$9.43 in 1968. The price buyers were willing to pay for spot delivery reportedly climbed steadily during 1974 and at year's end was reported at \$15/lb of U_3O_8. Likewise, the reported prices that buyers were willing to pay for 1980 delivery rose from \$12.30/lb U_3O_8 at the start of the year to \$25.35/lb U_3O_8 at the end of the year (prices estimated at time of delivery). For comparison, an AEC survey of contracts made during the years 1967 through mid-1974 reported prices in the year of delivery at \$7.65/lb U_3O_8 in 1974 and \$11.40/lb U_3O_8 in 1980. Several purchase contracts were reported to have included front money at the time of signing. While some buyers are interested in making firm contracts for post-1980, there does not appear to be much material being offered. Foreign buyers were unsuccessful in competing in the United States for available yellowcake to be delivered pre-1980.

2. Costs of Production

We have estimated the costs for two uranium ore mining and milling cases which we believe cover the major situations.

- A typical open pit mine in the Wyoming region, 1,200 tons ore/day, 400,000 tons/year, average grade 0.19% U_3O_8, 95% recovery in milling, 30/1 stripping ratio. Initial investment in mine development is \$4 million paid off in seven years. Hauls ore ten miles to mill.

	\$/Ton Ore
Stripping	2.90
Ore Mining	1.95
Overhead	1.15
Development (Amortized)	1.45
Royalty	1.40

Loading and Hauling	1.10
Milling (Includes Amortization)	7.50
Total	\$17.45
	= \$4.83/lb U_3O_8

- A typical medium to large underground mine, 600 tons/day, 150,000 tons/year, 0.20% U_3O_8 grade, 700 feet deep, sub-level development, ore hoisted.

	\$/Ton Ore
Labor – Direct	7.50
Labor – Administration	0.75
Operating Supplies	2.50
Maintenance Supplies	0.65
Haulage to Mill	0.60
Taxes – Insurance	0.55
Royalty	1.55
Amortization	1.75
Total	\$15.85
	= \$4.18/lb U_3O_8

Several mines like this often deliver to a single mill so milling costs are the same as above.

3. Potential Constraints on Financing Additional Capital Investments

Constraints on financing additional investments for the large companies in this industry are similar to those already discussed in previous sections of this report.

For the portion of the industry represented by the small individual uranium mines the situation is different. These small mines operate on a very limited financial base and any additional investment for effluent control and treating would likely be catastrophic. They also have a limited marketplace. That is, they have to sell their mined ore to the nearest milling plant that will accept it and that is usually only one company (Union Carbide). They cannot just pass on any additional cost.

F. ASSESSMENT OF ECONOMIC IMPACT

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Document for the uranium ore mining and processing industry. These guidelines are:

- Best Practical Control Technology Currently Available (BPCTCA) – to be met by industrial discharges by 1977.
- Best Available Technology Economically Available (BATEA) – to be met by 1983.
- New Source Performance Standards (NSPS) – to be applied to all new facilities that discharge to navigable waters constructed after the promulgation of these guidelines.

For the purpose of recommending effluent guidelines, the Guidelines Contractor has categorized the uranium ore mining and processing industry into the following groups:

a. Mines.
b. Mills with acid, alkaline or acid/alkaline leaching.

1. Effluent Guidelines

The recommended parameters and guidelines for BPCTCA for both open-pit and underground mines are given in Table XI-5 and the parameters and guidelines for BATEA in Table XI-6.

TABLE XI-5

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA – URANIUM MINES

	Concentration (mg/ℓ) in Effluent	
Parameter	**30-day Average**	**24-hour Maximum**
pH	6* to 9*	6* to 9*
TSS	20	30
COD	100	200
As	0.5	1.0
Cd	0.05	0.1
Zn	0.5	1.0
Ra 226	3**	10**
Total U	2	4

*Value in pH units
**Value in picocuries per liter

Source: Development Document

TABLE XI-6

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BATEA – URANIUM MINES

	Concentration (mg/ℓ) in Effluent	
Parameter	30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
COD	50	100
As	0.1	0.2
Cd	0.004	0.008
Mo	1.0	2.0
V	5	10
Zn	0.1	0.2
Ra 226	3†	10†
Total U	2	4

*Values in pH units
†Values in picocuries per liter

Source: Development Document

For both milling categories zero discharge is recommended for both BPCTCA and BATEA and hence no parameters or guidelines are proposed.

2. Costs of Compliance

The guidelines contractor has estimated the investment and annual operating costs of compliance for both BPCTCA and BATEA guidelines. These costs for uranium/vanadium ore mining and milling are summarized in Table XI-7 by category and in Table XI-8 by companies. The annual costs include charges for amortization. The amortization charge includes an interest cost (at 8%), and is based on a useful life of 20 years for facilities and 10 years for equipment.

In this uranium-vanadium group of the mineral industry about 20% of the total annual cost is fixed cost (amortization plus interest charges in this case).

In Table XI-9 we have estimated the incremental cost added to the seven companies' final product (yellowcake) due to compliance with both BPCTCA and BATEA guidelines. These are added costs for the particular company unit where effluent treatment is required.

3. Basis for Analysis

The analysis of economic impact for this group will be carried out in the same way as described in section I of this report.

TABLE XI-7

URANIUM – VANADIUM ORES – COST OF COMPLIANCE
WITH BPCTCA & BATEA GUIDELINES

			Costs (Thousands $)			
		1,000 M.T.	BPCTCA		BATEA	
Category	No.	Year	Investment	Annual	Investment	Annual
Mines	1-158	3,300	0	0	0	0
	159	145	75.7	(24.7)	164.8	0.9
	160-161	662	63.2	32.9	91.6	51.3
	162	182	199.8	12.4	336.6	44.0
	163-167	907	77.2	64.4	214.0	95.2
	168	154	571.6	(161.4)	1,049.7	(85.4)
	169	318	924.4	(368.3)	1,772.0	(253.6)
	170	454	145.7	(6.2)	247.5	20.9
	171-175	91	72.2	59.4	197.6	89.6
		6,213	2,129.8	(391.50)	4,073.8	(37.1)
Mills	1-17	5,142	0	0	0	0
	18	432	421.7	71.4	421.7	71.4
	19	324	1,101.8	207.7	1,101.8	207.7
	20	315	4.8	1.0	4.8	1.0
		5,113	1,528.3	280.1	1,528.3	280.1
Totals		12,426	3,658.1	(111.4)	5,602.1	243.0

TABLE XI-8

URANIUM – VANADIUM ORES – COST BY COMPANIES FOR BPCTCA & BATEA GUIDELINES

Company	1,000 M.T. Year	Costs (Thousands $) BPCTCA Investment	BPCTCA Annual	BATEA Investment	BATEA Annual
A	145	75.7	(24.7)	164.8	0.9
B	662	63.2	32.9	91.6	51.3
C	1,243	848.6	(84.6)	1,600.3	53.8
D	772	1,074.9	(373.5)	2,024.3	(231.7)
E	91	72.2	59.4	197.6	89.6
F	432	421.7	71.4	421.7	71.4
G	648	1,101.8	207.7	1,101.8	207.7
Totals		3,658.1	(111.4)*	5,602.1	243.0

*(111.4) Numbers in brackets indicate net gain due to recovery of uranium, vanadium, molybdenum by ion exchange from mine waters.

TABLE XI-9

ESTIMATED INCREASE IN COST OF PRODUCT (U_3O_8) DUE TO BPCTCA & BATEA GUIDELINES 1972 U_3O_8

Company	Production* (lb)	Added Cost/lb U_3O_8 \$ BPCTCA	BATEA
A	585,000	(.00004)	Negligible
B	2,700,000	.00001	.00002
C	5,012,000	(.00002)	.00001
D	3,113,000	(.0001)	(.00007)
E	367,000	.0002	.0002
F	1,742,000	.00004	.00004
G	2,613,000	.00008	.00008

*Estimated by ADL. Most companies do not reveal their actual production. (Yearly tons x .002 x .9 x 2240)

4. Levels of Impact

The levels of impact are the same as those described in section I of this report.

5. Best Practical Control Technology Currently Available (BPCTCA)

In Table XI-10 we have summarized the information and costs for compliance with the BPCTCA guidelines. Shown in Table XI-10 for the three impact groups discussed previously and for the total industry are the data on tonnage and number of employees, the added operating costs, and the added investment costs as a percentage of capital expenditures and total investment.

a. Price and Production Effects. As is evident from the table, 51% of the industry would not be directly affected by the guidelines. For the 45% that is directly affected there is no product cost increase, because for this impacted group there is actually a net gain from the recovery of uranium, molybdenum, and vanadium values from mine waters with ion-exchange. For the same reason, there is no impact on the whole industry.

TABLE XI-10

DATA AND COST FOR MEETING BPCTCA GUIDELINES URANIUM/VANADIUM ORE MINING AND MILLING (1972)

	Impact Group			Total Industry
	"A"	"B"	"C"	
Thousands M.T. Ore/Yr	3,300	2,913	0	6,430
% of Industry-Ore Basis*	51.3	45.3	0	100
Thousands lbs/Yr – U_3O_8**	13,235	11,687	0	25,800
Number of Employees	3,026	2,673	0	5,900
% of Employees	51.3	45.3	0	100
Added Investment for Facilities ($)	0	3,658,100	0	3,658,100
as % of Annual Capital Expenditure	0	41.8		8.6
as % of Total Investment	0	2.3	0	1.0
Added Annual Cost ($)	0	(111,400)***	0	(111,400)
$ per ton Ore	0	0	0	0
$ per lb Yellowcake	0	0	0	0

*96.6% of industry covered.

**Also produced some byproduct vanadium – not included.

***Indicates net gain due to recovery of uranium, molybdenum and vanadium by ion exchange from mine waters. Uranium valued at $8 per pound and molybdenum and vanadium at $1.60 per pound.

b. Financial Effects. The added capital investment required for the impacted group of the industry (group "B") is 42% of the estimated annual capital expenditures but only 2% of the total invested capital. The percentage of annual capital expenditures is calculated on the assumption that the investment for pollution control will be accomplished in one year. However, in actuality this investment would likely be made over a period of several years so the effect would be less than indicated.

c. Balance of Payment Effects, Employment Effects, and Community Effects. Consideration of the price and production, and financial effects indicates that there will be no output curtailments or plant shutdowns in the uranium ore mining and milling industry because of BPCTCA effluent limitations. As a result there will be no employment or community effects and no balance of payments effects.

6. Best Available Technology Economically Available (BATEA)

Table XI-11 lists the costs for meeting the BATEA guidelines. These are very similar to the BPCTCA costs in Table XI-10, but in this case there is an added annual cost increase of $0.02 per pound of yellowcake produced for the impacted group. This is not significant for a product selling for about $8.00 per pound (1972).

TABLE XI-11

DATA AND COSTS FOR MEETING BATEA GUIDELINES URANIUM/VANADIUM ORE MINING AND MILLING (1972)

	Impact Group			Total
	"A"	"B"	"C"	Industry
Thousands M.T. Ore/Yr	3,300	2,913	0	6,430
% of Industry-Ore Basis	51.3	45.3	0	100
Thousands lbs/Yr Product	13,235	11,687	0	25,800
Number of Employees	3,026	2,673	0	5,900
% of Employees	51.3	45.3	0	100
Added Investment for Facilities ($)	0	5,602,100	0	5,602,100
as % of Annual Capital Expenditure	0	64.0	0	13.2
as % of Total Investment	0	3.5	0	1.6
Added Annual Cost ($)	0	243,000	0	243,000
$ per ton Ore	0	0.08	0	.04
$ per lb Yellowcake	0	0.02	0	.009

For meeting BATEA guidelines, therefore, the effects and impacts are the same as for BPCTCA. That is, there will be no significant impact on the industry or any group in meeting BATEA standards.

7. New Source Performance Standards (NSPS)

The guidelines contractor has recommended that for new uranium ore mines the NSPS standards should be as given in Table XI-12. This table lists the recommended parameters and guidelines.

TABLE XI-12

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR NSPS – URANIUM MINES

	Concentration (mg/ℓ) in Effluent	
Parameter	**30-day Average**	**24-hour Maximum**
pH	6* to 9*	6* to 9*
TSS	20	30
COD	50	100
As	0.1	0.2
Cd	0.004	0.008
Zn	0.1	0.2
Ra 226	3†	10†
Total U	2	4

*Values in pH units
†Values in picocuries per liter

Source: Development Document

For uranium mills of both types the NSPS recommendation is zero discharge.

The Effluent Guideline Development Document provided no cost estimates for the NSPS analysis. Therefore, any statements about the effect of the NSPS requirement on the construction of new plants within the United States must necessarily be qualitative.

However, it can be said with some degree of confidence that the costs for a "grass roots" plant to meet the NSPS standards are no more that the costs for an existing plant in the impacted group (group "B") to meet the BPCTCA and BATEA recommended effluent limitations, because in the construction of a new plant, in-process modifications can oftentimes be made which may be more efficient and economical than add-on treatment technologies for existing plants.

For the above reasons, a new plant designed with the NSPS effluent limitations in mind could be constructed without much difficulty. Therefore, the cost of water pollution control due to the NSPS standards alone will have minimal effect on the decision of the U.S. uranium ore mining and milling industry to expand domestic production capacity through the construction of new plants.

G. LIMITS OF THE ANALYSIS

The limits of the analysis in this section are the same as those discussed in previous sections of this report.

XII. METAL ORES: N.E.C. (SIC 1099)

A. INTRODUCTION

For metal ores, not elsewhere classified, the guidelines contractor considered a group of ores which included antimony, beryllium, platinum group metals, rare earths, tin, titanium, and zirconium. The contractor presents a detailed discussion of these segments of the mining industry and the reader is referred to his report for details.

From this group of metal ores the guidelines contractor identified the following cases for which he recommended guidelines and estimated control costs:

- One antimony mine which is not now discharging effluent but may in the future.

- One titanium mine discharging 700,000 gpd of wastewater that would require an investment of $94,315 and an annual cost of $39,650 for level A control.

- One titanium mill discharging 9.45 million gpd that would require an investment of $12,000 and an annual operating cost of $1,700 for zero discharge.

- One platinum mine/mill that discharges 8.64 million gpd that would require an investment of $17,000 and an annual cost of $77,000 for level B control.

The guidelines set forth by the EPA, however, do not address antimony, rare earths or beryllium because of the limited number of these operations and because all of these operations are at zero discharge and no benefit to the environment can be shown by establishing effluent limitations. There are therefore no guidelines for those metals.

B. ASSESSMENT OF ECONOMIC IMPACT

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Document for the metal ores NEC mining and processing industry. These guidelines are:

- Best Practical Control Technology Currently Available (BPCTCA) – to be met by industrial dischargers by 1977.

- Best Available Technology Economically Available (BATEA) – to be met by 1983.

- New Source Performance Standards (NSPS) – to be applied to all new facilities that discharge to navigable waters constructed after the promulgation of these guidelines.

For the purpose of recommending effluent guidelines, the Guidelines Contractor has categorized the affected metal ore NEC mining and processing industry into the following groups:

1. Platinum and Tin Ores

   a. Mines or mines and mills combined (includes placer or dredge operations)

2. Titanium Ores

   a. Mines – (Lode)

   b. Mills – Electrolytic/magnetic and gravity/flotation.

   c. Mines and Mills – Physical processes with dredge mining.

1. Effluent Guidelines

The recommended parameters and guidelines for BPCTCA for platinum and tin mines and mills are given in Table XII-1. For BATEA they are the same.

The recommended parameters and effluent guidelines for titanium lode mines for BPCTCA are given in Table XII-2. BATEA recommendations are the same.

For titanium mills using electrostatic, magnetic, gravity or flotation processes the recommended parameters and guidelines for BPCTCA are given in Table XII-3. BATEA recommendations are the same.

The recommended BPCTCA guidelines for titanium mills associated with dredge mining are given in Table XII-4. BATEA recommendations are the same.

2. Costs of Compliance

The guidelines contractor has estimated the investment and annual operating costs of compliance for both BPCTCA and BATEA guidelines for the operations affected (Table XII-5). The annual costs include charges for amortization. The amortization charge includes an interest cost (at 8%), and is based on a useful life of 20 years for facilities and 10 years for equipment.

In this metal ores NEC segment of the mineral industry about 20% of the total annual cost is fixed cost (amortization plus interest charges).

In Table XII-5 we have also estimated the incremental cost added to the two companies' ore production due to compliance with both BPCTCA and BATEA guidelines. These added costs are not appreciable.

3. Levels of Impact

There will be no appreciable impact on the metal ores NEC mining industry because of the imposition of BPCTCA or BATEA guidelines.

For NSPS guidelines platinum and tin ore mines and mills will be required to meet BPCTCA and BATEA guidelines which are the same. NSPS for titanium lode mines will have to meet BPCTCA-BATEA guidelines. Titanium mills will be required to have zero discharge. Titanium dredge mines/mills will be required to meet BPCTCA-BATEA guidelines.

TABLE XII-1

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA AND BATEA PLATINUM AND TIN DREDGE MINES AND MILLS

Parameter	Concentration (mg/ℓ) in Effluent	
	30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	30	50

*Value in pH units

Source: Development Document

TABLE XII-2

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA AND BATEA TITANIUM MINES (Lode)

Parameter	Concentration (mg/ℓ) in Effluent	
	30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Fe	1.0	2.0

*Value in pH units

Source: Development Document

TABLE XII-3

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA AND BATEA TITANIUM MILLS

Parameter	Concentration (mg/ℓ) in Effluent	
	30-day Average	24-hour Maximum
pH	6* to 9*	6* to 9*
TSS	20	30
Fe	0.10	0.2
Ni	0.1	0.2
Zn	0.1	0.2

*Value in pH units

Source: Development Document

TABLE XII-4

PARAMETERS SELECTED AND EFFLUENT LIMITATIONS RECOMMENDED FOR BPCTCA AND BATEA TITANIUM DREDGE MINE WITH WET SEPARATION MILL

Parameter	Concentration (mg/ℓ) in Effluent	
	30-day Average	24-hour Maximum
pH	6† to 9†	6† to 9†
TSS	20	30
COD	15	30
Fe	1.0	2.0

†Value in pH units

Source: Development Document

TABLE XII-5

SUMMARY OF COSTS OF COMPLIANCE – METAL ORES NEC

		Thousands of Dollars			
		BPT		BAT	
Classification	M.T. Ore/yr	Investment	Annual	Investment	Annual
Titanium Mines (7)	±10,000,000	0	0	0	0
Titanium - Mine	1,180,000	94,315	39,650	94,315	39,650
- Mill	"	1,865	260	12,035	1,665
Platinum - Dredge	2,267,500	17,970	39,405	16,840	77,275
Rare Earth Mines	207,239	0	0	0	0
Beryllium Mines	N.A.	0	0	0	0
Antimony Mines	10,300	0	0	0	0
Zirconium Mines	N.A.	0	0	0	0
Totals	-	114,150	79,315	123,190	118,590

Increased Cost Per Unit of Production:

Titanium Mine & Mill:	$.03 per M ton ore for BPT $.04 per M ton ore for BAT
Platinum Dredge:	$.02 per M ton ore for BPT $.03 per M ton ore for BAT

APPENDIX A

FINANCIAL PROFILES OF SELECTED COMPANIES
IN THE ORE MINING AND DRESSING INDUSTRY

1. ALUMINUM COMPANY OF AMERICA (ALCOA)

Alcoa is the largest aluminum company in the world. Alcoa has probably the firmest raw material base, with large reserves in Jamaica, Surinam, Australia, and (still under development) Guinea, West Africa. The Company also has limited U.S. reserves, but most of its current raw material requirements are met by importing bauxite to supply domestic alumina plants. Over 80% of its smelter capacity is located in the United States.

BAUXITE AND ALUMINA

Alcoa mines bauxite from properties which it owns in Arkansas and from reserves held under mining rights in Surinam (expire 2033), the Dominican Republic (expire 2007 subject to renewal under conditions contained in the concession agreement), and Jamaica (expire 1982 and 1993, subject to renewals under conditions prescribed in the mining laws of Jamaica). The Company estimates that the bauxite contained in such properties and reserves is sufficient in the aggregate to supply its requirements for bauxite, at current consumption rates, for at least 40 years.

In Western Australia, the Company has certain mineral rights and also has options to acquire others. The Company's present mineral rights supply enough bauxite to produce 7% of the alumina required to operate its present domestic primary aluminum capacity. The Company can increase this supply to 42% of such requirement by exercising, in five increments, such options to acquire additional mineral rights. However, the exercise of any such option after December 30, 1986, is subject to the approval of the government of Western Australia. All such mineral rights are held subject to a mineral lease which expires in 1982 but may be extended to 2045 at the option of a 51%-owned subsidiary. All bauxite from such mineral rights is to be refined at an alumina plant or plants in Australia owned or to be owned by such subsidiary. The right to refine bauxite from the present mineral rights expires in 1988 but may be extended by the Company to 2008. Upon exercise of any option to acquire additional mineral rights, the right to refine the related bauxite has a basic 20-year term, which may be extended by the Company for an additional 20 years.

Alcoa also has alumina plants in Jamaica, Surinam, and Australia. It has a substantial planned surplus of alumina capacity over its own needs, which has allowed it to sign a number of long-term supply contracts.

Alcoa has a 27% interest in Halco (Mining), Inc., formed as a consortium to develop the extensive Boke-bauxite deposits in Guinea. (Martin Marietta has a 20% participation.) By 1980, these deposits will be supplying about one-third of Alcoa's demand. Alcoa is also constructing a $125 million alumina plant in Costa Rica, which may supply 15% of its needs at that time.

PRIMARY ALUMINUM

Most of the bauxite and alumina produced by Alcoa is used to make aluminum which is further processed into fabricated products. These fabricated products are used in various.manufacturing industries. The total production of primary aluminum by the Company during 1972, including all primary aluminum produced by nonconsolidated subsidiaries and affiliates, constituted approximately 15% of the free world's estimated primary aluminum production.

Primary aluminum is produced from alumina at smelting plants at Alcoa, Tennessee; Badin, North Carolina; Evansville, Indiana; Massena, New York; Point Comfort, Texas; Rockdale, Texas; Vancouver, Washington; Wenatchee, Washington; and Surinam. Alcoa's primary aluminum capacity as of December 31, 1972, including one-half of the capacity of two smelters in Norway in which the Company holds 50% interests, was 1,725,500 short tons. Its primary aluminum production during 1972 was 1,392,000 short tons. Capacity is based on normal operating conditions and does not represent maximum possible production. Primary aluminum shipments by Alcoa during 1972 were 388,000 short tons. Alcoa's fabricated aluminum products are produced at 26 domestic and three foreign plants. The annual capacity of fabricating facilities is dependent upon the product mix. In 1972, Alcoa's shipments of fabricated aluminum products totalled 1,178,000 short tons.

In response to the effects of over-capacity in the world aluminum industry, Alcoa has stated it reduced primary aluminum production so that in 1972 the Company's average operating rate was 87.1% of the capacity of its domestic smelters. In the latter part of 1972 and early 1973, as demand increased sharply, certain primary aluminum production units were started up. The Company's domestic primary aluminum operating rate on February 28, 1973 was 93.5%.

ALCOA SMELTING PROCESS

Alcoa has applied for patents on the "Alcoa Smelting Process," a new electrolytic method of producing primary aluminum from aluminum chloride, made from alumina, which it expects will reduce by as much as 30% the electricity required by the most efficient units of the Hall process (presently used worldwide in the production of primary aluminum) and result in lower operating costs. The new process, which involves electrolysis in a completely enclosed system, is expected to be essentially free of undesirable emissions and to afford a superior employee working environment. Moreover, the new process is reportedly more tolerant of power interruptions than the Hall process and will permit plants to be located on smaller sites, with greater location flexibility. The new process does not involve the need for fluoride chemicals, as does the Hall process, and thereby eliminates the expenses of containing fluoride emissions.

The Company has reportedly spent \$25 million in the development of the new process, which has been tested in a full-scale developmental unit. The first unit of an Alcoa Smelting Process plant, having an initial capacity of 15,000 tons per year of primary aluminum and an ultimate design capacity of 30,000 tons, is expected to be completed in 1975. Completion of the entire plant, presently conceived as a 300,000-ton facility, is contingent upon construction and operating experience with the first unit. The Company does not expect that the new process will result in any near-term obsolescence of its existing facilities for smelting aluminum.

OTHER BUSINESS

In addition to being the largest integrated producer of primary aluminum and fabricated aluminum products, Alcoa's operations also include the sale of engineering and construction services, shipping, and the fabrication of products from other metals.

Under the management of Alcoa Properties, Inc., a wholly owned nonconsolidated subsidiary, the Company acquires and develops land, develops and operates real estate properties, sells developed land and properties, and constructs and sells residential properties, including housing for low and middle income families. Such operations in real estate, housing, and land development are closely coordinated with the Company's operations in the manufacture and marketing of building products, components, and systems combining a variety of materials. The latter operations are conducted by the Alcoa Building Industries Division.

A recent important policy change is Alcoa's willingness to sell technical assistance (although the first sale was to Anaconda, hardly a newcomer to the industry). Alcoa has decided that technical assistance is now available from so many sources that it might as well take advantage of the profit opportunity represented by its own considerable expertise.

CONSOLIDATED INCOME

Table A-1.1 presents Alcoa's consolidated income statements for 1968-1972. Alcoa reported that income from operations for 1971 was adversely affected by lower shipments, price weaknesses, increased depreciation and interest expense, and June 1, 1971, labor contracts resulting in higher operating costs. During 1972, shipments increased but the other factors continued to affect adversely the Company's income from operations.

TABLE A-1.1

ALCOA AND CONSOLIDATED SUBSIDIARIES
STATEMENT OF CONSOLIDATED INCOME

	1968	1969	1970	1971	1972
	$Millions				
Income:					
Sales & Operating Revenues	1352.8	1545.2	1522.4	1441.2	1753.0
Interest, principally from entities not consolidated	8.6	10.3	13.1	12.7	12.1
Other Income	8.9	13.3	7.3	8.2	13.8
	1370.3	1568.8	1542.8	1462.1	1778.9
Costs & Expenses:					
Cost of goods sold & operating expenses, not including depreciation & depletion	882.3	1039.5	1022.5	1011.7	1269.8
Selling, gen'l admin. & other expenses	135.3	144.9	148.3	149.2	154.9
Provision for depreciation & depletion	113.0	121.9	127.8	137.5	150.9
Interest Expense	32.8	36.9	48.6	57.8	61.4
Taxes, not including social security & U.S. and foreign taxes on income	26.5	30.0	28.1	29.2	30.4
	1189.9	1373.2	1375.3	1385.4	1667.4
Income before U.S. & foreign taxes on income	180.4	195.6	167.4	76.7	111.5
Provision for U.S. & foreign taxes on income:					
U.S.:					
Current	52.4	49.8	27.3	(17.0)	7.7
Future	7.7	13.3	15.1	15.2	8.2
Foreign:					
Current	15.8	22.0	24.0	27.2	27.7
Future	4.2	2.8	.3	(.7)	(1.0)
	80.1	87.9	66.7	24.7	42.6
Income from Operations	100.3	107.7	100.7	52.0	68.9
Equity in earnings (losses) of entities not consolidated:					
Real Estate Developments	(1.3)	6.0	4.4	(5.2)	19.9
Other	5.7	8.6	9.2	8.5	14.0
	4.4	14.6	13.6	3.3	33.9
Income before Extraordinary Items	104.7	122.4	114.3	55.3	102.8
Extraordinary Items	--	--	(18.8)	--	--
Net Income	104.7	122.4	95.5	55.3	102.8

Source: Aluminum Company of America, Form 10-K annual report.

Net income for 1972 increased substantially over that for 1971, approximately \$29 million of such increase resulting from the sale of the Company's interest in three real estate developments. There were no substantial real estate development sales during 1968 or 1971, but two large properties were sold during each of the years 1969 and 1970.

Alcoa's cash flow from operations, including the effects of deferred credits and reserves and equity in non-consolidated entities, was \$238 million in 1972, compared to \$188 million for 1971.

ASSETS

Alcoa's consolidated balance sheet as of December 31, 1972, showed total assets of \$2.704 billion. Current assets were \$804 million, current liabilities \$240 million, providing \$564 million in net working capital. Total properties, plant, and equipment at cost was \$3.033 billion, almost twice 1972 sales; net property, plant and equipment, after accumulated depreciation, depletion and amortization, was \$1.495 billion.

LONG-TERM DEBT

Table A-1.2 summarizes Alcoa's outstanding long-term debt as of December 31, 1972. Long-term debt due after one year was \$904 million. Deferred items were \$221 million including \$197 million in deferred tax reserves. Equity consisted of \$66 million in preferred stock and \$1,119 million in common stock and retained earnings.

Alcoa is somewhat unique in that while it has a significant amount of long-term debt, it has a relatively low debt-equity ratio among the aluminum companies. It appears to be consistent with this financial position that its debt is in the form of debentures and notes instead of first mortgage bonds.

TABLE A-1.2

ALUMINUM COMPANY OF AMERICA – LONG-TERM OBLIGATIONS

(December 31, 1972)

	(In thousands of dollars)						
	Due						Total long-term debt
	1973	1974	1975	1976	1977	1978-96	
Sinking fund debentures:							
3% due 1979...........	--	--	$ 4,071	$ 4,150	$ 4,150	$ 8,700	$ 21,071
4 1/4% due in 1982....	--	$ 1,471	5,200	5,200	5,200	26,200	43,271
3 7/8% due in 1983....	--	3,032	5,200	5,200	5,200	31,400	50,032
6% due 1992...........	--	--	7,000	7,000	7,000	104,000	125,000
9% due 1995...........	--	--	--	--	--	150,000	150,000
7.45% due 1996........	--	--	--	--	--	150,000	150,000
Notes:							
3% due 1973...........	$12,000	--	--	--	--	--	12,000
4 3/8% due 1988.......	1,243	3,250	3,250	3,250	3,250	35,821	50,064
4.65% due 1989........	2,699	5,200	5,200	5,200	5,200	82,608	106,107
6% due 1977-89........	2,205	2,247	2,296	2,352	2,416	35,311	46,827
5 1/4% Convertible Subordinated debentures due 1991	--	--	--	--	6,250	118,750	125,000
6 1/2% bonds due 1986...	--	--	--	--	--	20,048	20,048
Other..................	9,276	3,930	10,014	4,061	801	3,642	31,724
	$27,423	$19,130	$42,231	$36,413	$39,467	$766,480	$931,144
Less amount due within one year included in current liabilities..........................							27,423
Noncurrent long-term debt..							$903,721

2. AMERICAN METAL CLIMAX, INC. (AMAX)

AMAX is engaged in the exploration for the mining of ores and minerals and the smelting, refining, and other treatment of minerals and metals. Its principal products are molybdenum, aluminum, iron ore, coal, copper, lead, zinc, and potash. AMAX also fabricates and markets various aluminum products. The company has substantial foreign operations and investments in other mining companies, particularly in Zambia, Canada, Australia, Southwest Africa, South Africa, and Botswana.

AMAX is the leading producer of molybdenum in the United States, through Climax Molybdenum Company and subsidiaries. In 1972, AMAX's production of molybdenum sold in the United States represented approximately 45% of total U.S. sales of molybdenum.

In July 1972, AMAX said it would enter the copper mining business in the United States in a two-step transaction in which it would acquire Banner Mining Company, which owned the Twin Buttes/Pima County, Arizona, property then leased to and mined by Anaconda; and then enter into a partnership with Anaconda to develop and expand operations at Twin Buttes and in Pima County, with an expected expenditure exceeding $200 million over the period 1973-1976. Banner Mining was acquired in 1973, by merger into AMAX Copper Mines, Inc., a wholly owned AMAX subsidiary, in accordance with the plan of merger and partnership.

AMAX has substantial U.S. lead and zinc operations, through Blackwell Zinc Company, Inc., and Missouri Lead Smelting Company, wholly owned subsidiaries. It is also participating in a joint venture for the operation of a lead, zinc, and copper mine and mill in New Brunswick, Canada, through Heath Steele Mines, Ltd., of Canada, another subsidiary.

In October, 1969, AMAX became a coal producer through the acquisition of Ayrshire Collieries Corporation. In 1972, AMAX ranked among the ten major bituminous coal producers in the United States.

Table A-2.1 shows the approximate relative contribution to consolidated sales revenues and consolidated income of AMAX's lines of business for 1972. AMAX's consolidated financial statements include the accounts of all subsidiaries in which a voting control of 51% or more is owned, except AMAX Credit Corp., a wholly owned finance subsidiary, and RST International, Inc. They also include AMAX's portion of AMAX-Homestake Lead Tollers, a 50%-owned partnership. In the table, revenue and income from base metals includes transactions involving the purchase and sale of metals, the sale of metals processed from concentrates and scrap, materials, and tolling services. Information concerning dividend

TABLE A-2.1

AMAX: SELECTED FINANCIAL DATA

	1972 Breakdown $ Millions	%
AMAX Sales Revenue:		
Molybdenum & Specialty Metals	114	13
Aluminum	311	36
Base Metals (Cu, Pb, Zn, etc.)	256	30
Fuels & Chemicals (Coal, etc)	137	16
Iron Ore	45	5
	863	100
Income Before Taxes & Extraordinary Items:		
Molybdenum & Specialty Metals	28	22
Aluminum	16	13
Base Metals	16	13
Fuels & Chemicals	23	18
Iron Ore	25	20
Dividends; and Equity in Before-Tax Earnings of RST	18	14
	126	100
Less Exploration Expense, Unallocated Corporate Charges, and Interest Expense	(35)	
Earnings Before Provision for Federal and Foreign Income Taxes and Extraordinary Items	$91	

Source: AMAX Annual Report 1972.

income, investments in other companies, and RST International, Inc., is presented in subsequent paragraphs.

In summary, AMAX has substantial investments in companies and derives substantial revenues and earnings from operations outside the United States. In 1972, approximately 16% of consolidated sales and 22 percent of consolidated income were derived from operations outside of the United States, primarily in Australia, Western Europe, Japan, and Canada. Approximately 14% of its consolidated income was derived from dividends from foreign investments, primarily in Africa, and equity in before-tax earnings of RST International, Inc. (Table A-2.1).

AMAX produces primary and secondary aluminum ingot and has extensive facilities for the manufacturing and producing of a wide selection of aluminum products. These products include items such as sheet, which are principally sold for further manufacturing and in AMAX's case, much is sold to the mobile home industry; and items such as architectural aluminum which are finished products and marketed under the Kawneer name. AMAX has a 50% interest in the Intalco primary reduction plants near Bellingham, Washington, which in 1972 accounted for 6% of the total primary aluminum produced in the United States, making Intelco one of the largest facilities in the United States.

AMAX is one of the largest suppliers of secondary aluminum ingot throughout the United States casting industry and also produces zinc casting alloys.

In respect to base metals, AMAX operates a custom copper smelter and refinery at Carteret, New Jersey, which treats blister copper originating largely from foreign sources, purchased for AMAX's own account and on toll for others. It also processes a large volume of scrap and treats precious metal-bearing secondary material and precious metal from primary sources both for its own account and for others. In 1972, silver and gold production was approximately 21 million ounces and 900,000 ounces, respectively. A program to modernize the Carteret production facilities was initiated in 1968 and is continuing. Programs have been submitted in respect of the Carteret plant to the New Jersey Department of Environmental Protection and the Federal Environmental Protection Agency involving the design and construction of additional environmental control facilities. These programs were expected to be approved and to involve the expenditure of up to $7 million over the next four to five years. Of the $256 million of base metals' sales shown in Table A-2.1, copper sales, exclusive of trading transactions on commodity exchanges and charges for toll refining of copper for others, accounted for approximately $90 million.

In May 1972, AMAX announced its intention to shut down its custom zinc smelter and refinery at Blackwell, Oklahoma, in late 1973 because of the economic inability of the plant to meet Oklahoma's air quality standards. However, variances were obtained from the state that will permit continued operation until the planned shutdown date.

In July 1972, two months after this announcement, AMAX purchased for $3 million the electrolytic zinc refinery of American Zinc Company near St. Louis. Rehabilitation and reactivation of this plant cost an estimated $20 million and will provide AMAX with annual designed capacity of 84,000 tons of special high-grade zinc by 1975. (Note that in comparison, the Blackwell plant produced 77,000 tons of slab zinc in 1972, such production representing 67 percent of its rated smelting capacity.)

AMAX and Homestake Mining Company are equal partners in a joint venture to mine their lead deposits with zinc content in Southeastern Missouri. They sell a portion of their lead concentrates under long-term and spot contracts. Such sales amounted to approximately 60,000 tons in 1972. All zinc concentrates produced by the mine and mill are sold to AMAX for treatment at its Blackwell zinc smelter in Oklahoma. After the Blackwell smelter is closed, the zinc concentrates will be treated at the smelter acquired from American Zinc Company. AMAX and Homestake, as equal partners, also own a lead smelter in Southeast Missouri with a designed annual capacity of 140,000 tons of refined lead. Half of the capacity is used for smelting AMAX-Homestake concentrates and the other half is committed under long-term tolling contracts to smelting concentrates produced by others.

On December 31, 1972, ore reserves of the project were estimated to be 60 million tons with an average grade of 4.7% lead and 1.7% zinc. The principal areas to be mined are held under long-term federal mineral leases which call for royalty payments to the United States Government of 4% to 5% of the actual sales of concentrates and 4% to 5% of the quoted refined metal price, less smelting, refining, shipping, and selling costs.The profitability of this mine has been high due to the mining of ore with lead and zinc grades substantially above average. Future profitability may be unfavorably affected when the ore mined is of average or below average grade.

As mentioned previously, AMAX has a participation through Heath Steele Mines in lead, zinc, and copper production in Canada. All of the properties of copper concentrates are sold in Canada, and its zinc and lead concentrates are sold in Europe and in the United States. In 1972, a $10 million mine and mill expansion program was initiated to increase production by approximately one-third. AMAX's share of the cost of this program will be approximately $8 million.

AMAX's capital expenditures in the aggregate have been increasing in recent years and during the five years ended December 31, 1972, amounted to approximately $550 million, excluding $83 million of additional investment in RST International, and $76 million of fixed assets acquired in the purchase of Ayrshire

Collieries Corporation. In 1972, AMAX's expenditures on capital projects totaled $135 million. Such capital expenditures are expected to continue to increase due to the expansion of AMAX's business both in the United States and abroad. To the extent that capital expenditures are not met by internally generated funds, AMAX has stated that it expects to finance such expenditures through a combination of debt, production payment, and possibly, equity financing.

AMAX's holdings in other mining and metal companies are summarized in Table A-2.2 and its dividends from these investments in Table A-2.3.

TABLE A-2.2

AMAX INVESTMENTS IN OTHER COMPANIES
(December 31, 1972)

Name of Securities	AMAX Equity	Cost (in $ Millions)
Australian Consolidated Minerals	33%	3.4
Botswana RST Ltd.	30%	15.9
Canada Tungsten Mining Corporation Ltd.	41%	3.5
Copper Range Company	20%	10.6
Kawecki Berylco Industries	6%	6.1
O'okiep Copper Co.	17%	0.4
Roan Consolidated Mines Ltd. (RCM)[1]	20%	34.9
Tsumeb Corporation Ltd.[2]	29%	0.8
Other	-	10.2
Total Investments in Other Companies		$85.8

[1] Sale of holdings in RCM is subject to restrictions of the Zambian Government.

[2] While there was no quoted market price for Tsumeb Corporation shares, that corporation's reported earnings in 1972 were $6.8 million, indicating that AMAX's holdings have value substantially in excess of its cost.

TABLE A-2.3

DIVIDENDS RECEIVED BY AMAX FROM INVESTMENTS IN OTHER MINING AND METAL COMPANIES AND FROM ROAN SELECTION TRUST LTD.

	Year Ended December 31,	
	1970	1972
Roan Selection Trust Limited[1]	$12,627,000	$ ----
Roan Consolidated Mines Limited[1]	4,250,000	6,125,000
O'okiep Copper Company Limited	2,397,000	747,000
Tsumeb Corporation Limited	7,108,000	1,209,000
Other	416,000	224,000
Gross Dividends	$26,798,000	$8,305,000
U.S. Income Taxes	2,403,000	760,000
Net Dividends	$24,395,000	$7,545,000

[1] Effective January 1, 1970, the Zambian operating properties of Roan Selection Trust Limited were combined into RCM and 51% of the shares of RCM were sold to an instrumentality of the Zambian Government. AMAX, through RST, Inc., owns 20% of the shares of RCM. Following receipt by AMAX in 1970 of two dividends in respect of the final two quarters of 1969, dividends from Roan Selection Trust Limited ceased, and AMAX now receives in their stead such dividends as RCM pays in respect of AMAX's 20% interest therein. The RCM dividends are included in equity in earnings of RST, Inc., on the AMAX Consolidated Statements of Earnings.

3. AMERICAN SMELTING AND REFINING COMPANY (ASARCO)

INTRODUCTION

The main business of ASARCO is the mining, smelting, and refining of nonferrous ores and concentrates, producing principally copper, lead, zinc, silver, and gold, and recovering related by-products. The business also includes buying and processing nonferrous scrap, and selling the alloys produced, producing and selling coal and asbestos, and producing chemical materials and manufacturing machinery for the metal-plating and finishing industry. ASARCO's operations are carried on principally in the United States with additional operations in Canada and Peru. In addition, ASARCO has substantial investments in other mining companies, principally in Australia, Peru, and Mexico, and holds a substantial interest in Revere Copper and Brass Incorporated.

Sales in 1972 totalled $814 million. Earnings before taxes and extraordinary items were $59 million, including $34 million in equity in earnings of nonconsolidated associated companies.

ASARCO accounts for between 10 and 20% of domestic sales of refined copper, lead, and zinc, and somewhat more than one-third of the sales of refined silver. Through its ownership of Lake Asbestos of Quebec, Ltd. in Canada, ASARCO has about 6% of the domestic market for asbestos. Coal is its other principal nonmetallic product, and ASARCO accounts for about 1% of the domestic market, through its Midland Coal Company Division, acquired in late 1970. ASARCO has approximately 15,000 employees.

Table A-3.1 shows, for the year ended December 31, 1972, the approximate amounts of ASARCO's consolidated sales of products and services and consolidated earnings (before income taxes and extraordinary items) attributable to its principal lines of business or other sources.

ASARCO has substantial equity in Southern Peru Copper Corporation, which is a 51.5%-owned, nonconsolidated associated company. In June, 1971, a new Peruvian mining law provided among other things that workers, through "mining communities," must be given increasing participation in profits and ownership (eventually to 50%) of mining enterprises. The Company's equity investment in Southern Peru Copper Corporation and in the net assets in Peru of the Company's wholly owned subsidiary, Northern Peru Mining Corporation, amounted to $106,757,000 and $8,871,000, respectively, on December 31, 1972. The Company believed the legislation will not have an adverse effect on its investments in Peru.

TABLE A-3.1

ASARCO: SELECTED FINANCIAL DATA

	1972 ($ Millions)
Sales[a]:	
Primary Metals	653.7
Secondary Metals[b]	107.7
Other Products	52.9
Total	814.3
Earnings:	
Primary Metals[c]	27.5
Secondary Metals[b]	1.0
Other Products	(.2)
Equity in Earnings of non-consolidated associated companies[d]	34.1
Non-operating[e]	(3.3)
Total	59.0
Sales of Metals, Minerals, and Other Products[a]:	
Copper	263.9
Silver	110.5
Lead	67.4
Zinc	56.2
Secondary Metals[b]	107.7
All other[f]	208.4
Total	814.3[g]

(a) Does not include sales of non-consolidated associated companies.

(b) Includes surface treatment chemicals.

(c) After deducting bulk of ASARCO's research and exploration expenses.

(d) Principally M.I.M. Holdings Limited (Australia, Southern Peru Copper Corporation (Peru) and ASARCO Mexicana, S.A. (Mexico).

(e) Primarily dividends and interest on investments other than those accounted for by the equity method; patent royalties and interest expense.

(f) Includes by-products, toll treatment charges, coal, asbestos, etc.

(g) Includes $173 million in sales of products and services to customers in foreign countries and operations in foreign countries.

Source: ASARCO Annual Report 1972.

Continued development of Southern Peru Copper Corporation's Cuajone open-pit copper mine and its infrastructure during 1972 required the expenditure of $37 million of that company's funds, bringing Southern Peru's total investment in Cuajone at the end of 1972 to about $83 million.

A work plan for Cuajone was filed with the Government calling for the expenditure or commitment of $47.6 million in 1973. Southern Peru has current construction plans to meet the requirement. Efforts to arrange financing to assure completion of this $500 million project were said to be promising. The bilateral agreement requires minimum annual expenditures, and the entire project must be completed by June, 1976, but may be extended by any additional time available by reason of force majeur. The bilateral agreement provides that failure to maintain the investment program or complete the project as scheduled, in the absence of force majeur, will result in termination of the concession for the Cuajone mine.

PROPERTIES

The location and general character of ASARCO's principal domestic mines and plants are shown below. In addition to the principal metals shown, ores also contain small quantities of other nonferrous metals.

Galena	– Wallace, Idaho – silver and copper – long-term lease
Ground Hog	– Vanadium, New Mexico – zinc and lead – primarily under long-term leases
Leadville	– Colorado – zinc and lead – primarily in fee
Mission*	– Sahuarita, Arizona – copper – primarily State mineral leases renewable at 20-year intervals, balance in fee under federal patented mining claims
San Xavier*	– Sahuarita, Arizona – copper – leases for ten years and so long thereafter as minerals are produced in paying quantities. (The primary ten-year term began September 18, 1959, and is now running under the indefinite secondary term.)

*Open-put mines

Silver Bell*	– Arizona – copper – primarily in fee
Coal Lands	– Illinois – primarily in fee, some under long-term leases
Tennessee Mines Division –	
American Limestone	– Sand – gravel – limestone – primarily in fee
Several Mines	– Zinc – primarily in fee

In Canada the Buchans (zinc and lead) and Granduc (copper) mines are held under long-term leases, and ownership in the Lake Asbestos (asbestos) mine is by way of a qualified fee.

Subsurface rights of mines in Peru, Mexico, and Nicaragua are held under concessions granted by the respective governments. In Australia, the M.I.M. Holdings Limited (52.7%-owned by ASARCO) ISA mines are held under government lease.

Smelters	**Refineries**
Hayden, Arizona[1]	Baltimore, Maryland[1]
El Paso, Texas[1,2]	Perth Amboy, New Jersey[1]
Tacoma, Washington[1]	Tacoma, Washington[1]
East Helena, Montana[2]	Omaha, Nebraska[2]
Glover, Missouri[2]	Amarillo, Texas[3]
Amarillo, Texas[3]	Corpus Christi, Texas[3]
Corpus Christi, Texas[3]	Denver, Colorado[4]

1. Copper
2. Lead
3. Zinc
4. Cadmium, high-purity metals

All plants are held in fee. ASARCO also operates two zinc oxide plants in Hillsboro, Illinois, and Columbus, Ohio.

Capacity utilization of the Company's primary metal plants during 1972 was 75% for copper smelters and refineries, 80% for lead smelters and refineries, and 90% and 80%, respectively, for zinc smelters and refineries.

*Open-pit mines

Installations of additional air quality control facilities are reducing the need to curtail production to protect air quality, and oil storage facilities have been constructed to supplement natural gas supplies.

Major new facilities were completed in the modernization program at the Corpus Christi electrolytic zinc refinery which will result in improved costs and increased capacity. The Amarillo zinc smelter, which has operated since 1923, will eventually be shut down because it cannot economically be made to comply with applicable air quality standards.

In March, 1973, ASARCO announced plans to phase out production at its Baltimore copper refinery after 1975. ASARCO will construct a new copper refinery, with a designed capacity of 420,000 tons of refined copper per year, in Amarillo, Texas. The estimated cost of the new facility is approximately $100 million. Construction began in mid-1973, and startup operations are planned for late 1975 or early 1976. The extent to which the addition of this new refinery will affect the operations at the Company's Perth Amboy, New Jersey copper refinery has not yet been determined.

The associated companies – principally those in Australia, Peru, and Mexico – also have major capital expansion programs under way. Capital expenditures by the three companies in 1972 aggregated $127 million and exploration expenditures exceeded $5 million.

ENVIRONMENTAL SAFETY AND HEALTH MATTERS

ASARCO has a somewhat unique postion in respect to environmental safety standards in the nonferrous metals industry because of its role as a custom smelter . . . and ASARCO has been particularly communicative about this. For example, in early 1973, the Company stated the following:

- ASARCO has made and will continue to make substantial expenditures for various pollution control facilities.

- ASARCO recently completed construction at its El Paso and Hayden smelters of facilities to reduce the sulfur dioxide content of smelter emissions by converting it into sulfuric acid. The aggregate cost of these sulfuric acid plants was approximately $33 million. In addition, ASARCO has begun construction at its Tacoma smelter of a liquid sulfur dioxide plant, estimated to cost approximately $16 million to supplement an existing sulfuric acid plant in reducing sulfur emissions at Tacoma. ASARCO is also constructing a new, tall smokestack at its Hayden smelter at an estimated cost of $6 million to improve the dispersion of emissions.

- Existing markets, freight rates, and competitive sulfur prices do not permit ASARCO to sell at compensatory prices the sulfuric acid and liquid sulfur dioxide produced and to be produced at its copper smelters. Operating at full design capacity, the Hayden, El Paso, and Tacoma sulfuric acid plants would produce approximately 498,000 tons of sulfuric acid per year and the Tacoma liquid sulfur dioxide plant would produce approximately 83,000 tons per year of that substance, a portion of which will be consumed in the Tacoma sulfuric acid plant. The copper oxide ore leaching operations at ASARCO's San Xavier unit and the leaching of copper from waste material at ASARCO's Silver Bell unit in Arizona will provide an internal use for approximately 61,000 tons of sulfuric acid per year and other mining operations which could utilize sulfuric acid are being investigated.

- Capital costs incurred in the construction of the new sulfur control facilities at the El Paso and Tacoma smelters have been and are being financed through a surcharge imposed on mines supplying copper-bearing materials to ASARCO's copper smelters, of 1¢ or 1.5¢/lb of copper (depending on refined copper prices) levied on the copper content of the materials received. As an alternative to the surcharge, two major shippers of copper concentrates have elected to participate with ASARCO in a partnership to own and operate the El Paso sulfuric acid plant and to contribute capital to the venture.

- ASARCO believes that the capital improvements to its El Paso and Hayden smelters will cause the operations of the smelters to comply with applicable Texas and Arizona air quality standards with only minimum curtailment of operations. However, the Arizona agency having jurisdiction has recently issued an order that would have the effect of increasing the level of air quality controls at Hayden beyond those which ASARCO believes are required by Arizona law. ASARCO plans to contest the order by appropriate proceedings. In addition, in July 1972, the EPA rejected Arizona's proposed sulfur dioxide emissions standards for smelters and proposed more stringent standards. ASARCO has participated in administrative proceedings in opposition to the EPA's proposed substitute standards and, together with others, has instituted an action contesting the validity of the EPA's rejection of the proposed Arizona standards. Depending on the outcome of these proceedings, ASARCO may be required to make further, extensive investment in control facilities and new process equipment at Hayden.

- ASARCO's Tacoma copper smelter is operating under a variance from the Puget Sound Air Pollution Control Agency, contingent on ASARCO's agreeing by December 31, 1974 to bring the operation into compliance with local emissions standards by December 31, 1976. The liquid sulfur dioxide plant now under construction at Tacoma will not alone be sufficient to bring the smelter's operations into compliance with existing standards and, unless the standards are modified, further substantial capital investment would be required. ASARCO intends to request modifications of the standards prior to December 31, 1974. In addition, regulations recently adopted by the local agency regarding arsenic particulate matter will require additional capital investment at the Tacoma smelter.

- At its East Helena, Montana lead smelter, ASARCO plans to install an improved particulate recovery system and taller smokestacks, at an aggregate cost of approximately $6 million. The plant has no sulfur recovery facilities, however, and emissions standards promulgated by the Montana Board of Health effective July 1, 1973 would impose strict limits on sulfur dioxide emissions. Standards recently proposed by the EPA would be slightly less stringent. ASARCO intends to apply for a variance from the state standards and has opposed the adoption of the EPA standards in administrative proceedings.

- ASARCO's Glover, Missouri lead smelter has no sulfur recovery facilities and has operated under a variance from the Missouri Air Conservation Commission. ASARCO has applied for renewal of the variance and, as a condition of renewal, the Commission could require ASARCO to construct sulfur control facilities for the smelter.

- ASARCO is also subject to federal and state legislation and regulations pertaining to plant and mine safety and health conditions, including the Occupational Safety and Health Act of 1970, the Metal and Nonmetallic Mine Safety Act and the Coal Mine Health and Safety Act of 1969. ASARCO has made and will continue to make expenditures to comply with such legislation and regulations. Future expenditures for these purposes may be substantial but cannot be estimated with accuracy at present.

- In November 1972, the Company completed financing arrangements for the construction of certain air pollution control facilities at its Tacoma, Washington plant whereby the Port of Tacoma issued \$16.5 million of industrial development bonds, bearing interest at 3.875% to 4.10% per annum, and maturing as follows: October 1, 1974 – \$5 million; April 1, 1975 – \$5 million; and October 1, 1975 – \$6.5 million.

Pursuant to the terms of a lease and leaseback arrangement with the Port, the Company will reimburse the Port for principal and interest payments made by the Port pursuant to the terms of the bonds. In addition, the Company entered into an indemnity agreement whereby the purchasers of the bonds are indemnified by the Company against any loss should the validity of the bonds be challenged or the bonds be declared invalid. Unexpended funds are committed to construction.

Long-Term Debt

	(In \$ Thousands)	
	1972	**1971**
3-7/8% – 4.10% Port of Tacoma, Washington Industrial revenue bonds, maturing serially 1974 and 1975	\$16,500	\$ ––
6% notes payable – relating to acquisitions of zinc properties in 1971 due in three equal annual installments commencing in 1974 (\$3,600,000 payable in 1973 included in Current Liabilities)	10,800	14,400
4-5/8% twenty-five year subordinated debentures (amount authorized \$50,000,000) due October 15, 1988 – sinking fund payments of \$1,637,000 required annually on October 14. Debentures have been purchased covering payments through 1975	23,684	23,684
	\$50,984	\$38,084

ASARCO owns 1,876,296 shares of common stock (33.4%) and \$22,763,000 principal amount of convertible debentures of Revere Copper & Brass Inc. No dividends were received during 1972 on the common stock, and no dividend was declared for the first quarter of 1973. In 1972, Revere reported a loss of 15¢ per common share before a write-off of $1.55 per share connected with startup costs at its Jamaican alumina plant. The results reflected "continuance of the unremunerative prices prevailing in the aluminum industry and in copper and brass fabricating."

The Company's 33.4% interest in Revere Copper & Brass Incorporated is carried at cost – $8,511,000. Under a consent decree with the U.S. Department of Justice entered into in March, 1967, among other things, the Company and Revere were prohibited from having a director or officer who was at the same time a director, officer or employee of the other, and the Company was, in effect, prohibited from voting its stock except in very limited circumstances, and from participating in the determination of the business policies or practices of Revere. In March, 1972, in accordance with the terms of the decree and on application of the Company, the decree was terminated and the action dismissed without prejudice.

Since the termination of the consent decree, the Company has not attempted to exercise any influence over Revere. ASARCO is presently studying its future course of action with respect to its investment in Revere, which action might include taking an active role in the policies of Revere and/or increasing, decreasing, or eliminating its present holdings. Until a course of action is decided, it cannot be determined whether the Company will have the ability to significantly influence Revere or whether such ability would continue other than on a temporary basis. Accordingly, the Company believes it is not appropriate at this time to adopt equity accounting for its investment in Revere and continues to carry this investment on the basis of cost.

At December 31, 1972, the Company's share of Revere's underlying equity amounted to approximately $50 million and the quoted market value for this common stock investment was approximately $16.9 million.

The Company's share of Revere's net loss for 1972 after providing for dividends on Revere's preferred stock was about $3.2 million, including the Company's equity of approximately $2.9 million in Revere's write-off of costs associated with a new Jamaican alumina plant.

ACCOUNTING NOTES

Except for its investment in Revere Copper & Brass Incorporated, ASARCO holds no significant investment of 20% or more in equity securities not accounted for by the equity method. No investment of less than 20% held in equity securities is accounted for by the equity method.

Tax accrual under APB Opinion No. 23 has not been made because the undistributed earnings of subsidiaries and of corporate joint ventures, accounted for by the equity method, have been reinvested, will continue to be reinvested indefinitely. No remittance of such earnings to ASARCO is foreseen.

4. ANACONDA

Anaconda is the third largest producer of primary copper and among the top ten domestic aluminum producers in the United States. In addition to primary copper and aluminum, Anaconda produces brass and wire mill products and fabricated aluminum products. In 1972, total corporate sales were $1.01 billion and net income before extraordinary items was $44 million. The company has over 25,000 employees. The estimated breakdown of sales and earnings, as reported by Anaconda, is shown in Table A-4.1.

Anaconda's North American copper mines, which provide the majority of present earnings, are relatively high in cost, creating wide cyclical swings, depending on price movements. Anaconda suffered from the expropriation of its Chilean properties in July, 1971. It is believed that the Chilean copper mines provided, over 40% of Anaconda's 1970 earnings and an even greater proportion in prior years.

In addition to copper, Anaconda produces and sells silver, gold, and uranium oxide concentrate. Production of lead ceased as of December 31, 1971, and zinc production ended in mid-1972. Cadmium production, which totalled 418,000 pounds in 1971, ceased with the closing down of zinc operations.

Over 40% of North American copper production comes from Montana, about 30% from Arizona, and the balance from Nevada and Canada. Major investments in Montana over the past few years have resulted in the ability to handle substantially larger tonnages there. Additionally, in 1972, Anaconda decided to proceed with the construction of a new plant in Montana to convert copper concentrates into electrolytic copper by a new hydrometallurgical process known as the "Arbiter" process, which was developed by Anaconda's research staff "as part of the effort to overcome the high costs and air pollution problems associated with conventional smelting."

In Arizona, Anaconda operates the Twin Buttes mine, which commenced production in 1969. This mine is located on properties leased from Banner Mining Company. Sulfide copper ores mined at Twin Buttes are concentrated at an adjacent plant and the resulting concentrates are, with minor exceptions from time to time, treated on a toll basis by nearby smelters owned by American Smelting and Refining Company (ASARCO) and Inspiration Consolidated Copper Company. Part of the blister copper produced is further treated by ASARCO and returned to Anaconda as refined copper, and part is returned as blister to Anaconda for refining at its own plants at Perth Amboy, New Jersey, and Great Falls, Montana.

TABLE A-4.1

THE ANACONDA COMPANY AND SUBSIDIARY COMPANIES
SALES AND PRE-TAX INCOME (LOSS)
CONTRIBUTED BY PRINCIPAL LINE OF BUSINESS

	Year Ended December 31, (Thousands of Dollars)			
	1971		1972	
	Sales	Pre-tax Income (Loss)	Sales	Pre-tax Income[b]
Minerals, Metals & Metal Products	920,595	(7,851)	988,616	43,069
All Other[a]	25,908	5,154	22,987	6,488
Total	946,503	(2,697)	1,011,603	49,557

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[a] For 1971, there are included herein sales of $19.069 million and pre-tax income of $2.891 million contributed by the forest products business The contribution from forest products in relation to total business was significantly higher in 1971 than it was in certain prior years due to labor strikes at the company's various mining operations during 1971. In 1972 the principal assets of the forest products division were sold.

During the years 1968 through 1970, forest products contributed less than 2% to consolidated sales and pre-tax income; in 1972, the contribution was less than eight percent.

[b] Pre-tax income has been restated. As more fully described on Page 18 of the 1972 Annual Report to Shareholders, the company in 1972 retroactively adopted the equity method of accounting for investments in certain affiliated companies. The accompanying "Summary of Operations" has been restated to reflect this accounting change which has the effect of increasing income before extraordinary items by (in thousands of dollars): $524 (3¢ per share) in 1968, $2,987 (13¢ per share) in 1969, $4,214 (19¢ per share) in 1970, $2,526 (12¢ per share) in 1971, and $4,953 (22¢ per share) in 1972.

Also in 1972, the Company changed its practice of translating foreign currency accounts into U.S. dollars so that such accounts are now translated on the basis of current rather than historical exchange rates. The effect of this change in 1972 was to reduce net income by $5.218 million (24¢ per share). Results reported for prior years would not have been materially affected by earlier adoption of this translation practice.

Source: Anaconda Annual Report 1972.

In 1972, Anaconda announced an agreement in principle with American Metal Climax, Inc. (AMAX), for its participation in the Twin Buttes mine. AMAX has agreed to purchase Banner's interest and will invest an estimated $93 million in mine development over a three-year period. AMAX will acquire a 50% interest in the mine and will be entitled to 50% of the mine production. Anaconda and AMAX will jointly expand production including the construction of a plant for treatment of oxide copper ore from the mine that was estimated to cost $59 million and will treat 10,000 tons of ore per day.

In 1972, production of copper from Anaconda's mines totalled 242,955 tons, and the company stated that all of the domestic primary copper producing facilities operated at or near capacity. Anaconda's sales by principal divisions are listed in Table A-4.2.

During 1972, approximately 12.5% of Anaconda's net income was attributable to equity in net income of affiliated companies in Mexico and Brazil.

As of December 31, 1972, Anaconda held 27.7% of the stock of Inspiration Consolidated Copper Company, which accounts for about 5% of U.S. mine output. The investment in the shares of Inspiration is included as an asset in Anaconda's consolidated balance sheet, and accounted for by the equity method.

Anaconda has approximately a one-third interest in an alumina production facility in Jamaica, West Indies. Anaconda is entitled to receive its share of the alumina produced and is committed to pay its share of the venture's costs. The new aluminum production plant at Sebree, Kentucky, which has a capacity of 120 million tons a year, will be supplied primarily from the Jamaican venture. With Sebree, and production from Anaconda's Columbia Falls, Montana, reduction plant, Anaconda will be able to produce approximately 300,000 tons per year of aluminum, enough for its manufacturing operations (not yet substantial contributors to profits), plus a sales position in the primary ingot and billet market.

With respect to the possible impact on Anaconda and its business from regulations relating to the protection of the environment, Anaconda has been involved in litigation with the Environmental Protection Agency and the State of Montana in connection with the proposed emission standards for the Anaconda copper smelter in Montana. Anaconda had estimated that, under the proposed standards, it could be forced to expend an additional $60 million in connection with the air pollution control program at the smelter. In addition, some investments made already in the program would be rendered purposeless. Anaconda was granted favorable preliminary relief in the federal case and has sought relief from enforcement of Montana standards that went into effect in 1973.

TABLE A-4.2

ANACONDA: SELECTED FINANCIAL DATA

Division Name	1972 ($ Million)
Anaconda Aluminum Company	198.4
Anaconda American Brass Company	346.5
Anaconda Wire & Cable Company	286.1
Anaconda Primary Metals Div.	360.0
Anaconda Forest Products*	24.6

Total of the above figures =	$1,215.6 million
Less Sales Between Divisions =	204.0 million.
Grand Total	$1,011.6 million

*Sale of assets to Champion International Corporation during 1972 for $117 million.

Source: Anaconda Annual Report 1972.

5. CITIES SERVICE COMPANY

Cities Service is engaged in finding, producing, manufacturing, and distributing oil, gas, and chemical products in the United States and in foreign countries. The principal areas of operations include petroleum and natural gas, natural gas transmission, petrochemicals, industrial chemicals, and metals. The Company had 1974 revenues of $2.85 billion. It employs 18,000 people.

Its North American Chemicals and Metals produced the following tonnages for sale in the last two years:

	1974	1973
	(thousands tons)	
Sulfuric Acid	850	910
Copper	31	40
Iron Products	124	217
Zinc Concentrates	6	18
Other Industrial Chemicals	161	206

Total sales from North American Chemicals and Metals operations were $137 million in 1974, $152 million in 1973.

INDUSTRIAL CHEMICALS

The Company conducts extensive operations in the "Copper Basin" region of Copperhill, Tennessee. Cities Service commenced its activity there with the purchase of Tennessee Copper Company in 1963. The ore is mined from five underground mines, and contains 35% iron, 24% sulfur, 1% copper and 1% zinc. Operations are integrated. (See Figure A-5.1.) The values of iron and sulfur recovered at Copperhill are considerably greater than the copper values per se. In 1970, a very large expansion and modernization program was begun, including a new copper smelter iron oxide pellet plant, and an additional sulfuric acid plant. Construction of yet another acid plant is under way, and construction of two water treatment plants to remove both chemicals and suspended solids from process water has begun.

Cities Service thinks of itself as one of the top ten copper producers in the United States. In addition to operations at Copperhill, a much more extensive copper mining operation is conducted in Arizona, as will be discussed below.

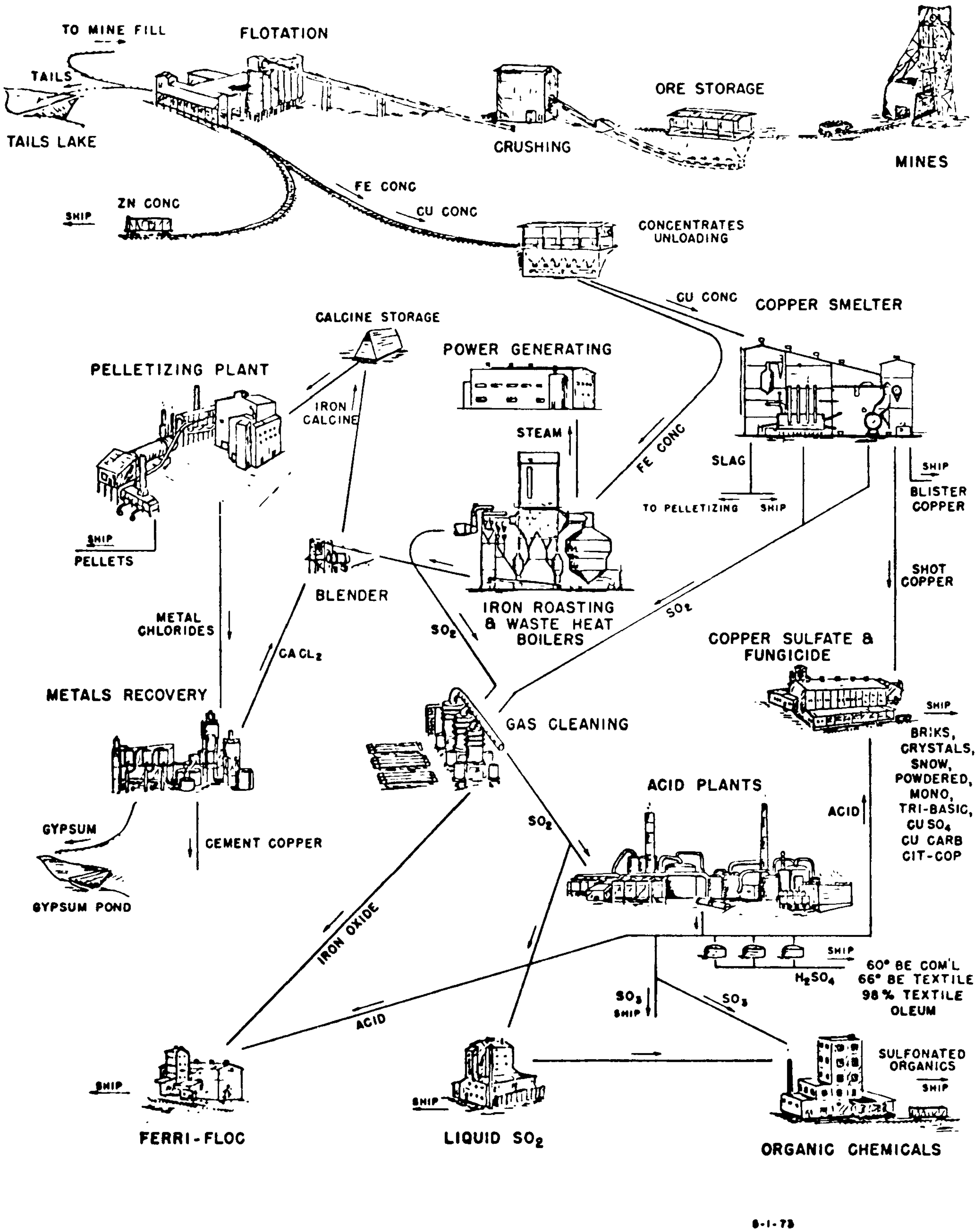

FIGURE A-5.1 CITIES SERVICE COMPANY (Copperhill Operations)
GENERALIZED FLOW SHEET

METALS

The mine and mill facilities of the Pinto Valley open pit mine near Miami, Arizona, were completed ahead of schedule and at capital costs slightly below estimates. This represents the largest construction project in the Company's history. The first division began production in June of 1974 and the second division in October of 1974. The design capacity of 40,000 tons of ore per day was reached early in 1975. This production rate will recover in excess of 60,000 tons of copper annually.

Copper produced in concentrate form will be controlled by the throughput of new smelter operations of another company (believed to be Inspiration Consolidated).

Development of the underground Miami East ore deposit is continuing and production is expected to begin in the early part of 1976, eventually increasing to 2,000 tons of high grade ore per day in 1978.

After many years of production, the in-place reserves of the Copper Cities and Diamond H open pit mines at Miami were exhausted early in 1975, but leaching operations will continue at declining rates for several years.

A solvent extraction-electrowinning plant to produce cathode copper at the Miami leaching operation is under construction and should be completed in mid-1976. This will eliminate the toll smelting-refining on the major part of the leach copper output.

An active mineral exploration program is being conducted in the Rocky Mountain area, in Alaska, and in Canada. The objective is to find deposits of copper and copper-associated minerals.

METAL FABRICATION AND SALES

Sales of fabricated copper products in the form of sheet, strip, and insulated wire were at record levels in 1974. Volumes have declined in the early months of 1975, reflecting the trend of economic conditions.

A 50% expansion in capacity was completed at the Chester, New York, plant which manufactures insulated wire and cable for the electric and electronic industries. Capability to manufacture flat wire was installed at the Seymour, Connecticut, plant.

FINANCIAL DATA

Table A-5-.1 presents a breakdown of Cities Service's sales, capital investments, and property by major business category. Also shown are statistics on capitalization and return on stockholders' equity.

TABLE A-5.1

CITIES SERVICE COMPANY
SUMMARY OF CONSOLIDATED FINANCIAL DATA

Stated in millions of dollars except per share data

INCOME

	1974	1973	1972
Gross income			
Sales and operating income			
North American petroleum*	2,102 5	1,382 3	1,177.1
Natural gas transmission	203 4	174 1	170 2
North American petrochemicals	272.6	215.2	200 2
North American chemicals & metals	136.6	151 5	223 6
International*	74 8	59 3	45 8
Other operations	16 4	52.2	45 2
Total	2,806 3	2,034.6	1,862 1
Investment and other non-operating income, net	40.3	31 6	8 3
	2,846.6	2,066.2	1,870 4
Costs and expenses			
Costs and operating expenses	1,993 2	1,421.1	1,309 1
Exploration expenses, including dry hole costs and lease amortization	149 2	89 5	64 5
Selling, general and administrative expenses	146 5	144.5	157 0
Taxes, other than Federal and foreign income taxes	80.1	59 1	60 1
Depreciation and depletion	128.4	114 2	114.8
Interest expense	56.9	46 3	43 2
Less Interest expense capitalized	(5 6)	(1 6)	(5)
Federal and foreign income taxes	89 1	55 2	21 6
Income applicable to minority interests	5.0	2.3	1.5
	2,642.8	1,930 6	1,771 3
Income before extraordinary credits	203 8	135.6	99 1
Extraordinary credits (net)	—	11 3	13.0
Net income	203.8	146 9	112.1
*Includes sales of purchased crude oil	731 5	469 1	379.5

EARNINGS PER SHARE OF COMMON STOCK**

	1974	1973	1972
Income before extraordinary credits	7 58	5.06	3 73
Extraordinary credits (net)	—	.42	.49
Net income	7.58	5.48	4 22
Average shares outstanding (millions)	26.9	26.8	26 6

**Adjusted for 3% stock dividend paid in 1974 and assuming conversion of all Preferred and Preference Stocks while outstanding

CASH DIVIDENDS

	1974	1973	1972
Preferred Stock requirements	—	—	—
Preference Stock requirements	—	—	—
Common Stock	61.0*	57 3	56.7
Total	61 0	57 3	56 7
Per share of Common Stock			
Adjusted for 3% stock dividend paid in 1974	2 268	2 136	2 136
Historical	2 30	2 20	2.20

*Plus 3% stock dividend

TABLE A-5.1 (Continued)

Stated in millions of dollars except per share data

CAPITAL EXPENDITURES	1974	1973	1972
North American petroleum			
Production	182.4	178.5	117 4
Natural gas liquids	6 9	4 1	7 0
Refined products	49.7	33 2	24 9
Alternate fuels	46.4	4 9	—
	285 4	220.7	149 3
Natural gas transmission	16 6	13.6	10.9
North American petrochemicals	19 0	12 5	12 6
North American chemicals & metals	90 5	75 1	72 4
International	28 0	19 6	6 2
Other operations	5.4	54 9	9 0
Total plant additions	444 9	396 4	260.4
Investments	2 0	5 8	1 3
Total	446 9	402 2	261 7

PROPERTY, PLANT AND EQUIPMENT	1974	1973	1972
North American petroleum			
Production	1,253.1	1,124 6	994 6
Natural gas liquids	220 7	215 2	216 6
Refined products	696 5	691 2	688 2
Alternate fuels	52 6	5 5	—
	2,222 9	2,036 5	1,899 4
Natural gas transmission	379 5	365 4	354 9
North American petrochemicals	309 2	313 3	304 3
North American chemicals & metals	365 2	281 7	255 1
International	50 8	39 0	27 0
Other operations	84 2	255 5	210 8
Total gross investment	3,411 8	3,291 4	3,051 5
Accumulated depreciation and depletion	1,481 0	1,437.6	1,356 4
Total net investment	1,930 8	1,853 8	1,695 1

CAPITALIZATION	1974	1973	1972
Long-term debt	581 2	613 8	577 0
Stockholders equity	1,673 7	1,530.1	1,433 8
Total capitalization	2 254 9	2,143 9	2 010 8
Ratio of long-term debt to capitalization	25 8%	28 6%	28 7%
Stockholders equity at year-end per share*	62 25	56 95	53 67
Return on stockholders' average equity — income before extraordinary credits	12 7%	9 2%	7 1%

*Adjusted for 3% stock dividend paid in 1974

Source: 1974 Annual Report

6. CLEVELAND-CLIFFS IRON COMPANY

INTRODUCTION

Cleveland-Cliffs was formed by consolidation under Ohio law in 1947 as the successor to business enterprises whose beginnings can be traced to earlier than 1850. Cleveland-Cliffs is engaged principally in the iron ore business. In particular, Cleveland-Cliffs holds and leases iron ore reserves, manages and has operating interests in mining ventures, and sells iron ore. Cleveland-Cliffs owns interests in electric power generating facilities and a railroad and owns and operates bulk carriers on the Great Lakes.

The Company also owns extensive timber properties and is engaged in the harvesting of logs (primarily hardwood) and the production and sale of veneer logs, specialty hardwoods, and other wood products. The Company owns investments in five steel companies, has interests in oil shale, and is engaged in exploration and research with respect to certain nonferrous minerals. A summary of major operations and projects is given in Table A-6.1.

Table A-6.2 sets forth the approximate contributions of Cleveland-Cliffs' mining operations, forest products, investment, and other activities to its consolidated revenues and consolidated income before income taxes and extraordinary items for the years 1970-74 as included in the Company's financial statements. Tables A-6.3 and A-6.4 give details of the royalty income, cost of goods sold and the value of securities and interest income. Table A-6.5 gives a comparative financial summary for 1972, 1973, and 1974.

IRON ORE PRODUCTION AND RELATED ACTIVITIES

Mining Operations

Cleveland-Cliffs' prodecessors commenced iron ore mining operations in the Lake Superior region in the mid-nineteenth century, and until the 1950's the Company's principal activities were the mining, transportation, and sale of iron ore and related activities. Progressively since the 1950's, its emphasis has shifted to the development and leasing of its iron ore reserves and the organization and management of joint ventures for the production of iron ore products, both in the Lake Superior region and elswhere.

United States and Canada

Cleveland-Cliffs owns, or holds long-term leasehold interests in, active properties in the United States and Canada containing approximately two billion tons of proven and probable crude iron ore reserves, principally "low-grade" deposits requiring beneficiation to produce salable iron ore products.

TABLE A-6.1

CLEVELAND CLIFFS: SUMMARY OF MAJOR OPERATIONS AND PROJECTS

MARQUETTE IRON MINING COMPANY
Operates Republic Mine & Pellet Plant
Humboldt Pellet Plant
Location Republic, Michigan
Humboldt, Michigan
Participants (1)
Jones & Laughlin Steel Corp
Wheeling-Pittsburgh Steel Corp
International Harvester Co
The Cleveland-Cliffs Iron Co , Manager

EMPIRE IRON MINING COMPANY
Operates Empire Mine & Pellet Plant
Location Palmer, Michigan
Participants
Inland Steel Co
McLouth Steel Corp
International Harvester Co
The Cleveland-Cliffs Iron Co , Manager

TILDEN MINING COMPANY (2)
Operates Tilden Mine & Pellet Plant
Location Tilden Township, Michigan
Participants (1)
Algoma Steel Corp Ltd
Jones & Laughlin Steel Corp
The Steel Company of Canada, Ltd
Wheeling-Pittsburgh Steel Corp
Sharon Steel Corp
The Cleveland-Cliffs Iron Co , Manager

THE NEGAUNEE MINE COMPANY
Operates Mather Mine
Location Negaunee, Michigan
Participants
Republic Steel Corp
Bethlehem Steel Corp
McLouth Steel Corp
Sharon Steel Corp
The Cleveland-Cliffs Iron Co , Manager

PIONEER PELLET PLANT (2)
Operates Pioneer Pellet Plant
Location Negaunee, Michigan
Participants
Republic Steel Corp
Bethlehem Steel Corp
McLouth Steel Corp
Sharon Steel Corp
The Cleveland-Cliffs Iron Co , Manager

UPPER PENINSULA GENERATING COMPANY
Location Marquette, Michigan
Participants
Cliffs Electric Service Company (3)
Upper Peninsula Power Company, Manager

CLIFFS ROBE RIVER IRON ASSOCIATES (2)
Operates Robe River Mine & Pellet Plant
Location Western Australia
Participants (1)
Robe River Ltd
Mt Enid Iron Co Ltd
Mitsui Iron Ore Development Pty Ltd
Texasgulf, Inc
Bank of America
First National Bank of Chicago
The Cleveland-Cliffs Iron Co
Manager Cliffs Western Australian Mining Co Pty. Ltd. (4)

THE ADAMS MINE
Location Kirkland Lake, Ontario
Participant
Dominion Foundries & Steel, Ltd
Manager Cliffs of Canada, Ltd (3)

SHERMAN MINE (2)
Location Temagami, Ontario
Participants
Dominion Foundaries & Steel, Ltd
Tetapaga Mining Co , Ltd (3)
Manager Cliffs of Canada, Ltd (3)

THE MESABA-CLIFFS MINING COMPANY
Operates Canisteo Mine
Location Coleraine, Minnesota
Participants (1)
Jones & Laughlin Steel Corp
Cyclops Corporation
Wheeling-Pittsburgh Steel Corp
National Steel Corp
The Cleveland-Cliffs Iron Co , Manager

CLEVELAND-CLIFFS STEAMSHIP COMPANY (3)
Owns or Charters (5)

E B Greene	C M White
W A Sterling	W P Snyder, Jr
Cliffs Victory	W B Boyer
Cadillac	R H Reiss
Champlain	W G Mather
T M Girdler	Pontiac
T F Patton	Frontenac

Operated by The Cleveland-Cliffs Iron Co

CLEVELAND-CLIFFS FOREST PRODUCTS DIVISION
Operates Forrest Center Sawmill
Location Munising, Michigan
Headquarters Iron Mountain, Michigan
Also coordinates selective harvesting and sales primarly from more than 330,000 acres of timberland owned by The Cleveland-Cliffs Iron Co in Michigan's Upper Peninsula

PARAHO PROJECT
Purpose Oil Shale Research
Location Anvil Points, Colorado
Participants (1)
Atlantic Richfield Company
The Cleveland-Cliffs Iron Company
Exxon Corporation
Gulf Oil Company
Kerr McGee Corporation
Arthur G McKee & Company
Marathon Oil Company
Mobil Oil Company
Phillips Petroleum Company
Shell Oil Company
Southern California Edison Co
Standard Oil Company of California
Standard Oil Company (Indiana)
The Standard Oil Company (Ohio)
Sun Oil Company
Texaco Inc
Webb Resources Inc Group
Operator
Development Engineering, Inc

THUNDERBIRD JOINT VENTURE
(Uranium Exploration)
Headquarters Casper, Wyoming
Participants
Pioneer Nuclear Inc
Getty Oil Company
Skelly Oil Company
Thunderbird Petroleums, Inc
The Cleveland-Cliffs Iron Co , Manager

CLIFFS-GETTY-SKELLY JOINT VENTURE
(Uranium Exploration)
Headquarters Casper, Wyoming
Participants
Getty Oil Company
Skelly Oil Company
The Cleveland-Cliffs Iron Co , Manager

PINTEC JOINT VENTURE
(Uranium Exploration)
Headquarters Casper, Wyoming
Participants
Pioneer Nuclear, Inc
Texas Eastern Nuclear, Inc
The Cleveland-Cliffs Iron Co , Manager

(1) Directly or through subsidiaries and/or affiliates. (2) Joint venture. (3) Wholly-owned subsidiary of The Cleveland-Cliffs Iron Company. (4) Subsidiary of The Cleveland-Cliffs Iron Company. (5) Bulk freighters.

Source: Cleveland Cliffs Annual Report 1974

TABLE A-6.2

CONTRIBUTIONS TO INCOME BY OPERATING GROUPS

(Dollars in Millions)

	1970		1971		1972		1973		1974	
Total Revenues										
Mining Operations (1)	$ 89.6	88%	$ 77.2	87%	$107.4	90%	$120.3	89%	$116.7	85%
Forest Products	5.6	6%	7.0	8%	7.8	6%	9.1	7%	11 1	8%
Corporate (2)	6.3	6%	4.3	5%	4.4	4%	5 9	4%	9.8	7%
	$101.5	100%	$ 88.5	100%	$119.6	100%	$135.3	100%	$137.6	100%
Income Before Income Taxes and Extraordinary Items (3)										
Mining Operations	$ 15.4	71%	$ 17.2	82%	$ 18 3	79%	$ 22 2	76%	$ 26 3	69%
Forest Products	1.0	5%	1.3	6%	1.9	8%	2.1	7%	2.4	7%
Corporate	5.3	24%	2.4	12%	3.0	13%	5.0	17%	9.2	24%
	$ 21.7	100%	$ 20.9	100%	$ 23.2	100%	$ 29.3	100%	$ 37.9	100%

1. Includes royalties, management fees, iron ore sales by Cleveland-Cliffs, lake shipping revenues, power revenues and equity in net income of unconsolidated railroad and mining operations. See also Table A-6.3.
2. Consists principally of dividends and interest from investments. See Table A-6.4.
3. After allocation of certain corporate expenses.

Source: Annual Reports 1971-1974.

TABLE A-6.3

CLEVELAND-CLIFFS IRON COMPANY "SALES, ROYALTIES AND OTHER OPERATING REVENUES" AND "COSTS OF GOODS SOLD AND OPERATING EXPENSES"

	Year Ended December 31				
	1974	1973	1972	1971	1970
Sales, royalties and other operating revenues:					
Sale of tangible products, lake shipping revenues and power revenues	$103,027,000	$107,308,000	$ 98,952,000	$69,657,000	$82,034,000
Royalties	15,897,000	13,133,000	9,921,000	9,146,000	8,222,000
Operating management fees	2,058,000	1,828,000	1,669,000	1,494,000	1,343,000
	$120,982,000	$122,269,000	$110,542,000	$80,297,000	$91,599,000
Cost of goods sold and operating expenses:					
Cost of tangible products sold, lake shipping costs and power costs	$ 89,377,000	$ 95,766,000	$ 86,931,000	$56,618,000	$69,935,000
Other costs and expenses	128,000	793,000	650,000	637,000	213,000
	$ 89,505,000	$ 96,559,000	$ 87,581,000	$57,255,000	$70,148,000

Source: Form 10-K Report to SEC, for the year 1974.

TABLE A-6.4

MARKET VALUE OF LISTED SECURITIES PORTFOLIO/ DIVIDEND AND INTEREST INCOME

The Cleveland-Cliffs Iron Company and Consolidated Subsidiaries

Market Value of Listed Securities Portfolio/Dividend and Interest Income

The Cleveland-Cliffs Iron Company and Consolidated Subsidiaries

	Shares Owned Dec 31, 1974	Market Value Dec 31, 1974	Dividend and Interest Income Year Ended December 31 1974	1973
Listed Securities				
Common Stocks				
Inland Steel Company . .	660,744	$21,147,000	$ 1,787,000	$ 1,434,000
Jones & Laughlin Steel Corporation (A)	—	—	157,000	139,000
Republic Steel Corporation	392,228	8,825,000	1,098,000	843,000
Wheeling-Pittsburgh Steel Corporation .	102,432	1,818,000	71,000	—0—
McLouth Steel Corporation .	95,100	1,272,000	127,000	16,000
		33,062,000	3,240,000	2,432,000
Preferred Stock				
Lykes-Youngstown Corporation . .	79,300	2,121,000	496,000	347,000
Subordinated Debentures				
Lykes-Youngstown Corporation	$10,000,000(B)	5,575,000	750,000	750,000
Total Listed Securities		$40,758,000	4,486,000	3,529,000
Other Interest Income (principally from investments in short-term securities)			4,477,000	2,908,000
Total Dividend and Interest Income .			$ 8,963,000	$ 6,437,000

(A) Disposed of in 1974, see Note I to the financial statements
(B) Principal amount

Source: Annual Report, 1974.

TABLE A-6.5

COMPARATIVE FINANCIAL SUMMARY

The Cleveland-Cliffs Iron Company and Consolidated Subsidiaries

Dollars in thousands except per share amounts	**1974**	1973	1972
Balance Sheet — December 31			
Cash and short-term securities	**$ 31,006**	$ 47,306	$ 39,621
Other current assets	**49,765**	30,341	37,445
Total Current Assets	**80,771**	77,647	77,066
Less current liabilities	**29,693**	17,703	24,297
Working Capital	**51,078**	59,944	52,769
Investments and other assets	**139,234**	107,446	103,088
Properties — net	**39,046**	33,369	33,708
	229,358	200,759	189,565
Long-term debt	**3,000**	4,000	10,000
Other long-term liabilities	**23,572**	11 749	8,599
Shareholders' Equity	**$202,786**	$185,010	$170,966
Represented by			
Preferred Shares	**$ 8,025**	$ 9,556	$ 10,602
Common Shares	**3,202**	3,202	3,202
Capital in excess of par value of shares	**15,287**	14 946	14,657
Retained income	**182,875**	165 302	151,281
Common Shares in treasury	**(6,603)**	(7 996)	(8,776)
	$202,786	$185,010	$170,966
Income Statement — Year Ended December 31			
Total revenues	**$137,631**	$135,265	$119,611
Total costs and expenses	**99,723**	105,969	96,389
Income before income taxes and extraordinary items	**37,908**	29,296	23,222
Income taxes	**12,112**	8,489	6 627
Income before extraordinary items	**25,796**	20,807	16,595
Extraordinary items	**—0—**	—0—	2,594
Net income	**25,796**	20,807	19,189
Dividend requirements for Preferred Shares — at $4 50 per share	**382**	454	562
Net income applicable to Common Shares	**$ 25,414**	$ 20,353	$ 18,627
Per Common Share*			
Income before extraordinary items	**$ 8.35**	$ 6 78	$ 5 35
Extraordinary items	**—0—**	—0—	86
Net income	**$ 8.35**	$ 6 78	$ 6 21
Income before extraordinary items			
As a percent of total revenues	**18.7%**	15 4%	13 9%
As a percent of average shareholders' equity	**13.3%**	11 7%	10 0%
Common Share Data			
Dividends paid — per share*	**$ 2.575**	$ 2 11	$ 1 82
— total amount	**$ 7,841**	$ 6 332	$ 5,462
Average number of shares outstanding*	**3,044,792**	3 002 342	3 000,598
Sales price range (high-low)*	**82½-50¼**	83⅜-56½	67½-53⅝

*Adjusted for 2-for-1 stock split in 1968.

Source: 1974 Annual Report.

Cleveland-Cliffs leases or subleases its reserves to unincorporated and incorporated joint ventures, which in each case include Cleveland-Cliffs and United States or Canadian steel producers (who are "participants" directly or through subsidiaries and/or affiliates) and which pay Cleveland-Cliffs royalties based on the number of tons of iron ore produced and the iron content. Cleveland-Cliffs receives royalties with respect to all iron ore produced in the facilities described except for The Adams Mine. Cleveland-Cliffs' North American iron ore royalty revenues for the indicated periods, not including underlying royalties payable to others,are shown in Table A-6.6.

TABLE A-6.6

CLEVELAND-CLIFFS IRON ORE ROYALTY REVENUES

(thousands of dollars)

	1970	1971	1972	1973	1974
Total Iron Ore Royalty Revenues Included in Consolidated Sales, Royalties and Other Operating Revenues. . . .	$8,222	$9,146	$9,663	$10,991	$13,347
Less Cleveland-Cliffs' Share as a Participant in Joint Ventures Included in Consolidated Cost of Goods Sold and Operating Expenses. . . .	2,678	2,951	3,398	3,926	3,274
Net Iron Ore Royalty Revenues.	$5,544	$6,195	$6,265	$ 7,065	$10,073

Source: Annual Report 1974

The major royalties are subject to periodic adjustment based on changes in the Bureau of Labor Statistics index of wholesale commodity prices or in the published iron ore pellet prices.

Cleveland-Cliffs' principal North American properties are located on the Marquette Range of the Upper Peninsula of Michigan where there are four mines (three open-pit and one underground) and five pellet plants in operation. Two railroads link the range with Lake Michigan at Escanaba and Lake Superior at Marquette. There is also an open-pit mine and pellet plant in Ontario, Canada and an open-pit mine on the Mesabi Range in Minnesota. The reserves available to the respective properties are presently estimated to be sufficient, after reflecting reductions in crude ore tonnage resulting from anticipated mining, concentrating and pelletizing conditions, to maintain current rates of production at operating mines for periods varying from 8 to 50 years.

In addition, Cleveland-Cliffs owns or leases mining rights in substantial tonnages of undeveloped natural and low-grade iron-bearing material. Certain of these properties are currently under study for possible future development, but there are presently no definitive plans for commercial use. Commercial development would involve large expenditures.

Cleveland-Cliffs, pursuant to management agreements with the participants having operating interests in the mining venture projects, manages the development, construction, and operation of iron ore mines and concentrating and pelletizing plants to produce natural ore and iron ore pellets. Cleveland-Cliffs is reimbursed by the mining ventures for substantially all expenses directly or indirectly incurred by it in the operation of the particular properties and is paid a management fee with respect to North American operating properties, which is usually subject to escalation as in the case of royalties, based on the number of tons* of iron ore produced from the properties. The annual production of each of the mines is determined each year by the participants and, accordingly, the amount of management fees, like the royalties, during any particular year will depend upon their ore requirements. Ordinarily the management contracts run for the economic life of the property but may be terminated earlier. The crude ore reserves for all these operations are leased from Cleveland-Cliffs except The Adams Mine, an open-pit mine and pellet plant in Ontario, Canada.

Cleveland-Cliffs' management fees with respect to operating properties are shown in Table A-6.7.

Cleveland-Cliffs has direct or indirect operating interests ranging from 10% to 31% in the joint ventures which mine and concentrate iron ore and produce iron ore pellets from iron ore properties leased or subleased from Cleveland-Cliffs. Under the operating agreements each participant contributes its proportionate share of capital, operating costs, and working capital and takes its share of production (as its sole means of recouping investments and advances) either for its own consumption or for sale to others.

The low grade iron ore is crushed, ground, and concentrated by various methods (e.g., magnetic separation, elutriation, selective flocculation, and flotation) depending on the ore's characteristics. The concentrated ores are then pelletized. There have been no recent changes in the deposits being mined or mining conditions at the above-mentioned facilities which have significantly affected the product or the production cost thereof.

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*Unless otherwise specifically indicated, all references to tonnages of iron ore (including "gross tonnages") are to long tons of 2,240 pounds.

TABLE A-6.7

CLEVELAND-CLIFFS MANAGEMENT FEES

(thousands of dollars)

	1970	1971	1972	1973	1974
Total Management Fee Revenues Included in Consolidated Sales, Royalties and Other Operating Revenues.	$1,343	$1,494	$1,669	$1,828	$2,058
Less Cleveland-Cliffs' Share as a Participant in Joint Ventures Included in Consolidated Costs of Goods Sold and Operating Expenses.	384	348	390	454	379
Net Management Fee Revenues	$ 959	$1,146	$1,279	$1,374	$1,679

Source: Annual Report 1974

Table A-6.8 sets forth information as to iron ore production and shipments in the United States and Canada by Cleveland-Cliffs and mining ventures managed by Cleveland-Cliffs.

TABLE A-6.8

CLEVELAND-CLIFFS IRON ORE PRODUCTION & SHIPMENT

(thousands of gross tons)

	1970	1971	1972	1973	1974
Iron Ore Production:					
Cleveland-Cliffs' Share	3,493	3,264	3,160	3,223	2,446
Other Participants' Share	8,796	9,030	9,408	9,296	10,106
Total Production	12,289	12,294	12,568	12,519	12,552
Pellets Included in Total Production	10,072	9,963	10,854	10,935	10,883
Iron Ore Shipments:					
Cleveland-Cliffs' Share	3,410	2,937	3,808	3,905	2,574
Other Participants' Share	8,455	8,234	9,441	9,420	9,933
	11,865	11,171	13,249	13,325	12,507
Production from others' mines	96	0	161	252	0
Total Shipments	11,961	11,171	13,410	13,577	12,507
Pellets Included in Total Shipments	9,901	9,486	11,620	11,435	10,976

Source: Annual Report 1974

Of the approximately 10.1 million gross tons of iron ore produced in the United States and Canada as "Other Participants' Share" in 1974, the shares of participants having the four largest amounts, Dominion Foundries & Steel, Limited, Inland Steel Company, Jones & Laughlin Steel Corporation, and McLouth Steel Corporation, aggregated 6.8 million gross tons or 67%. None of these participants accounted for more than 20% of such production. Other participants in Cleveland-Cliffs' mining ventures in the United States and Canada include Algoma Steel Corporation Limited, Bethlehem Steel Corporation, Detroit Steel Corporation, International Harvester Company, National Steel Corporation, Republic Steel Corporation, Sharon Steel Corporation, The Steel Company of Canada, Limited, and Wheeling-Pittsburgh Steel Corporation.

During 1974, Cleveland-Cliffs sold 95% of the natural iron ore and pellets produced in the United States and Canada for its account and iron ore it purchased from others to 10 U.S. and Canadian iron and steel manufacturing companies. Approximately 83% of total 1974 sales were made pursuant to agreements with purchasers for remaining terms ranging from 3 to 25 years or life of mine, some with renewal options. All such agreements provide for sales at prevailing published market prices at the date of shipment. The Company's present sales agreements call for the sale of large quantities of natural iron ore and pellets over the next several years which, depending upon market conditions, may require all the iron ore expected to be available to Cleveland-Cliffs from its present interests in the mining ventures.

Empire Iron Mining Company, managed by Cleveland-Cliffs and in which Cleveland-Cliffs has a 20% operating interest, has expanded its Empire Mine to increase its rated annual pellet production capacity from 3.5 million tons to 5.3 million tons. Initial operations of the expanded facilities commenced in the latter part of 1974. To finance the expansion, $67 million has been borrowed from banks under arrangements whereby the participants are responsible to the banks for their separate shares of the borrowing. Cleveland-Cliffs is responsible for $13.4 million of such borrowing.

Tilden Mining Company, a joint venture of J&L-Cliffs Ore Partnership (a partnership composed of subsidiaries of Jones & Laughlin Steel Corporation and Cleveland-Cliffs) and Tilden Iron Ore Company (in which four other steel companies and Cleveland-Cliffs are the participants), has developed an open-pit iron ore mine located on the Marquette Range on deposits owned by Cleveland-Cliffs and has constructed primary crushing facilities, grinding mills, classification and concentrating facilities, and a pellet plant. Completion of the facilities occurred early in 1975, although some pellet production commenced in December, 1974. The crude ore, which is principally a fine-grained hematitic ore, is crushed, ground autogenously, concentrated by selective flocculation, elutriation and flotation, and pelletized. The facilities, which are designed to produce approximately 4 million tons of pellets per annum, were fully completed during the first part of 1975 at a total expenditure of approximately $228 million (including preproduction development expenditures, interest during construction, and other expenses) of which Cleveland-Cliffs' share is $45.6 million. Cleveland-Cliffs is managing the project and is receiving an operating management fee. Its aggregate operating interest in the project is 20%.

A significant portion of the total cost of the project has been financed through $160 million in long-term borrowings from groups of banks and insurance companies. Cleveland-Cliffs is indirectly responsible for $32 million aggregate principal amount of such borrowings. In addition to the above borrowings, Cleveland-Cliffs has made $17.9 million in subordinated loans to the associates of Tilden, of which Cleveland-Cliffs is indirectly responsible as a participant in the associates for $3,561,000. Cleveland-Cliffs has agreed to loan an additional $9.1 million, under certain conditions, of which it would be responsible for $1,564,000. These loans have substantially the same interest rate and maturities as the insurance company loans. It appears that the project may be able to borrow approximately $4.8 million under pollution control financing by means of industrial development revenue bonds which may partially reduce Cleveland-Cliffs' obligation to loan the additional $9.1 million. If such financing is obtained, Cleveland-Cliffs will be responsible for 20% of such obligation.

Power generating facilities of the Upper Peninsula Generating Company have been expanded and are nearly completed in connection with the Empire Mine expansion and Tilden Mine construction programs.

Australia

Cleveland-Cliffs' 53%-owned subsidiary, Cliffs Western Australian Mining Co. Pty. Ltd. ("Cliffs Western Australian"), has a 30% interest in Cliffs Robe River Iron Associates ("Robe River Associates"), a joint venture formed in 1970 to mine iron ore deposits acquired by Cleveland-Cliffs in 1964 in the Robe River region of Western Australia and to develop and construct an open-pit mine, a processing and pelletizing plant, a 104-mile railroad, a power plant, a port, townsites, and other facilities. Production and delivery of pellets and sintering fines commenced in 1972. Pellet shipments reached approximately 4.0 million tons in 1974. Pelletizing capacity is expected to be further increased by approximately 500,000 tons per annum when current plant extensions are completed late in 1975. Shipments of sintering fines reached 6.9 million tons in 1974.

Most of the production of the Robe River Mine is presently being sold under long-term agreements with six Japanese steel companies. Under the agreements, the Japanese steel companies have contracted to purchase from the participants in the joint venture a total of 86.7 million tons of pellets over 21 years commencing in 1973 and a total of 71.8 million tons of prepared sintering fines over 15 years commencing in 1972 at fixed unit prices in U.S. dollars for initial periods up to 1980, with renegotiations thereafter based on market price.

Devaluations of the U.S. dollar and upward revaluations of the Australian dollar subsequent to entry into the agreements adversely affected the profitability of these agreements to the participants. (In August 1973, the Japanese steel companies agreed to modify, effective April 1, 1973, the prices under the agreements generally in recognition of such devaluations and revaluations.)

Further devaluations of the U.S. dollar relative to the Australian dollar, or revaluations of the Australian dollar relative to the U.S. dollar, would adversely affect the profitability of the agreements to the participants in the joint venture.

Costs for petroleum products from the Mideast, the primary fuel for firing the pellet plant and power generation at Robe River, increased drastically in 1974. Additional price negotiations were concluded in 1974 in an effort to reduce the effect of the abnormal fuel oil price increases.

During 1974, trial shipments of fines were made to European steel firms, with ongoing shipments planned for 1975. Negotiations for term sale agreements with European steel companies are presently under way.

The Robe River reserves are held by Cliffs International, Inc., a wholly owned subsidiary of the Company, under an agreement for a mineral lease from the State of Western Australia, covering proven and probable reserves initially aggregating approximately 160 million tons of crude iron ore. In addition, Cliffs International, Inc. has an agreement for a sublease, subject to royalties, covering 150 million tons of iron ore in extensive deposits located near the Robe River reserves and held by Dampier Mining Company Limited. Cliffs International, Inc. has agreed to sublease all these reserves to Robe River Associates for a royalty, in addition to the underlying royalties, payable to it based on tonnage produced. Under the agreements pursuant to which the Dampier reserves were acquired, Dampier has options expiring December 31, 1975 to acquire from the Robe River Associates, on the basis of depreciated costs at the time of purchase, interests of up to 50% in the railroad and up to 100% in the port, as well as certain rights to purchase ore produced by Robe River Associates and to share in the profits of the joint venture by way of royalties if its option is exercised. Negotiations between the Government of Western Australia and the joint venture participants are under way for the addition to the leased properties of other areas containing iron ore deposits which preliminary drilling work indicates contain substantial further reserves.

Cleveland-Cliffs receives royalties on ore mined by Robe River Associates. In 1972 royalties amounting to U.S. $258,000 were received subsequent to the commencement of operations in the fourth quarter. For the years ending December 31, 1973 and 1974, royalties from Robe River Associates were U.S. $2,142,000 and $2,550,000 in 1974, of which Cleveland-Cliffs indirectly bears the cost as to 15.9%.

Under a management agreement with an initial term of 10 years, Cliffs Western Australian is the manager of the Robe River project and is entitled to operating management fees based on the f.o.b. port value of ores shipped.

In connection with the financing of the Robe River project, long-term loan agreements have been executed by Cliffs Western Australian. Debt of U.S. \$68,481,000 was outstanding at December 31, 1974 and an additional \$2,519,000 was borrowed in January, 1975. Cleveland-Cliffs is indirectly responsible for repayment of U.S. \$36,295,000 of the debt outstanding December 31, 1974 (\$1,335,000 of the January, 1975 borrowings) through a future date to be determined in accordance with agreements, at which time Cleveland-Cliffs will be committed to maintain 53% of working capital of \$2.5 million in Cliffs Western Australian until the loans are repaid.

Marine Transportation

Cleveland-Cliffs operates on the Great Lakes 14 oil-fired bulk carriers, of which 11 are owned and three are chartered. The vessels range in age from 23 to 64 years and in capacity from 13,350 to 26,150 gross tons and have an aggregate trip capacity of 230,925 tons.

The Cleveland-Cliffs fleet is utilized to carry iron ore produced for participants in its various mining operations and iron ore produced by others. Of the 9,307,413 tons of iron ore carried from January 1, 1974, through December 31, 1974, 33% was iron ore produced by Cleveland-Cliffs for itself and for participants in its mining operations and 67% was iron ore produced by others.

Pursuant to a long-term agreement with Republic Steel Corporation, Cleveland-Cliffs transports by vessel all of Republic's domestic iron ore requirements shipped through Upper Lakes ports and in 1974 transported in its own fleet and other vessels 6,824,829 tons under this contract.

Iron ore is transported from loading ports on Lake Superior and Lake Michigan to unloading ports in the Detroit area, to ports on Lake Erie, such as Toledo, Huron, Cleveland, Ashtabula, Conneaut, and Buffalo, and to the Chicago area on Lake Michigan. The fleet also occasionally carries coal cargoes from Lake Erie ports to Upper Lake ports on Lake Superior and to ports on Lake Michigan and grain from Duluth-Superior to Buffalo. The primary business of the Cleveland-Cliffs fleet is the transportation of iron ore; the carrying of other products is largely incidental to such primary purpose.

Pursuant to the bulk cargo exemptions of the Interstate Commerce Act, the marine transportation charges of Cleveland-Cliffs are not subject to regulation.

In February, 1972, Cleveland-Cliffs entered into an Interim Capital Construction Fund Agreement with the Secretary of Commerce providing for deposits by Cleveland-Cliffs into a Capital Construction Fund for the purpose of constructing, reconstructing, and acquiring vessels for operation on the Great Lakes. Under that Agreement the Company has deposited approximately $9.3 million of which approximately $5.5 million had been expended as of December 31, 1974. The Company has no definite plans for constructing new vessels; however, a commitment has been made to lengthen one of its existing vessels at a cost of approximately $2,735,000, which will be funded from the Capital Construction Fund.

Other Activities Related to Mining Operations

Power Generation

As an adjunct to its domestic iron ore production activities, Cleveland-Cliffs owns an 80.96% stock interest in Upper Peninsula Generating Company (the "Generating Company"), which operates electric generating facilities having a 1974 capacity of approximately 179 megawatts, at its Presque Isle Station in Marquette, Michigan. Cleveland-Cliffs is currently entitled to approximately one-half of the Generating Company's output from these facilities, the balance being available to the other shareholder, Upper Peninsula Power Company, for sale to residential and industrial customers. Approximately 85% of total power requirements of Cleveland-Cliff's mining and pelletizing operations on the Marquette Range are supplied by the output of the electric power generating facilities. The balance is purchased from Upper Peninsula Power Company.

In connection with the expansion of the Empire Mine and the development of the Tilden Mine, the Generating Company completed construction of an 80-megawatt generating unit in December, 1974, and substantially completed construction of another 80-megawatt generating unit in February of 1975 (Cleveland-Cliffs being entitled to 100% of the output of both units).

As of December 31, 1974, the Generating Company had outstanding debt of $63,007,000. Cleveland-Cliffs is obligated to pay its share of annual fixed charges to the Generating Company, including amounts sufficient to amortize $54,754,000 of the debt outstanding on December 31, 1974. Cleveland-Cliffs is entitled to pro-rata reimbursement for such costs by mining ventures managed by Cleveland-Cliffs as they require electric power.

Rail Transportation

Cleveland-Cliffs owns a 77.58% stock interest in Lake Superior and Ishpeming Railroad Company which operates approximately 105 miles of track in the

Upper Peninsula, principally to haul iron ore from mines to Lake Superior at Marquette, Michigan, where the railroad has a dock, or to interchange points with another railroad for delivery to Lake Michigan at Escanaba, Michigan. During 1974, approximately 85% of the railroad's revenues were derived from hauling iron ore and pellets and other services in connection with mining operations managed by Cleveland-Cliffs. The railroad is subject to regulation as to its rates by the Interstate Commerce Commission.

Mineral Diversification

In General

In 1962, Cleveland-Cliffs commenced a program of investigating mining activities other than iron ore, in an effort eventually to diversify into industries not directly dependent upon the cyclical nature of the American steel industry. While present activities primarily are concentrated on exploration for uranium and investigation of the possibility of economically successful recovery of oil from oil shale, explorations for non-ferrous metals, and a limited program of oil and gas exploration have been and are being conducted. In 1974 Cleveland-Cliffs' research, exploration, and development expenditures for mineral diversification totaled $915,000. Except possibly for three uranium deposits, none of these exploration activities has resulted in the discovery of significant commercially minable ore bodies.

Uranium

Cleveland-Cliffs began in 1966 to investigate the possibility of entering the domestic energy market through uranium and by mid-1967 an exploration campaign was under way in several western states. To date, the Company has expended approximately $5 million on this project.

In addition to exploring for its own account, Cleveland-Cliffs manages and participates in uranium exploration joint ventures, including three primary exploration drilling programs in the Powder River Basin of Wyoming. To date, the Company and the other venturers have expended $9.7 million on uranium exploration, including the $5 million indicated above. In one of the ventures, three uranium ore bodies have been discovered, and land patent applications have been filed. Proposals to examine and develop portions of these uranium properties have been made to a utility and their evaluation is currently under way. Under these proposals, further development would entail specific delineation of the mineralized zone and a pilot mining project before committing to a commercial mine-mill complex.

Oil Shale

Since 1964, Cleveland-Cliffs in association with others has been involved in a research program for the extraction of oil from shale using a process developed by The Oil Shale Corporation of Los Angeles. An experimental mine and pilot plant on lands owned by the venture operated intermittently until 1972. In 1974, Cleveland-Cliffs terminated its interest in this research program. Under the termination arrangement, Cleveland-Cliffs retained its pro-rata share of the venture's oil shale reserves by exchanging its interest in certain properties for an increased interest in other of the joint properties, and sold its interest in three smaller noncontiguous properties. As of December 31, 1974, Cleveland-Cliffs had spent a total of approximately \$16.8 million on the research and land acquisition of this project of which \$6.6 million representing essentially land, is currently capitalized.

In September, 1973, Cleveland-Cliffs joined with other companies in a joint venture aimed at evaluating the technical and economic feasibility of an oil shale extraction process developed by Paraho Development Corporation of Denver, Colorado. If proved successful, members of the group will receive a license to use the process. Cleveland-Cliffs is responsible for staffing most of the project and conducting mining operations during the thirty-month \$7.5 million research program. As of December 31, 1974, Cleveland-Cliffs' share of total program expenditures was approximately \$300,000. To date there has been no commercial production of shale oil in the United States known to Cleveland-Cliffs.

Copper

Cleveland-Cliffs was engaged in a modest copper leaching joint venture research program near Mountain City, Nevada. The development work consisted of preparation of an old underground copper mine for eventual hydrometallurgical copper extraction involving considerable new extraction and minerals processing technology. Some minor amounts of copper were produced in 1973 and 1974. Operating and development expenditures by Cleveland-Cliffs and a venturer for the program totaled \$1.5 million for 1973 and \$2.7 million for 1974. In December, 1974 a decision was reached to suspend operations, and proceed towards an eventual shutdown of the operation.

Activities also continue in a search for additional economically feasible copper and other non-ferrous deposits in which Cleveland-Cliffs might become involved. Such activities do not comprise a significant portion of Cleveland-Cliffs' present business.

Employees

As of December 31, 1974, Cleveland-Cliffs had 5,541 U.S. and Canadian employees, including employees of iron ore mining ventures managed by Cleveland-Cliffs. Of the foregoing, 4,297 were hourly employees, of whom almost all were represented by one of the several unions with which Cleveland-Cliffs or its affiliated companies have collective bargaining agreements. The United Steelworkers of America represents the largest number of such union employees. A fifteen-day strike at the domestic iron ore operations occurred in August, 1974. Cleveland-Cliffs considers its labor relations to be good.

As of December 31, 1974, the Robe River Mine, managed by Cliffs Western Australia, had 1,183 employees, 888 of whom are represented by nine different unions. In common with most industry in Australia, where employment is currently high, the Western Australia mining industry has had substantial labor unrest and numerous work stoppages. At the Robe River Mine, during 1974, labor stoppages have lost approximately 2.5% of total man-hours available.

Competition

Cleveland-Cliffs experiences intensive competition in each of its lines of business.

There are numerous other mining companies and mining divisions of iron and steel manufacturing companies which, directly and through affiliates, produce and distribute iron ore in the markets served by Cleveland-Cliffs.

Cleveland-Cliffs believes that most of the iron ore produced in the Great Lakes region of the United States and Canada is produced for consumption by steel companies which, directly or indirectly, are the owners or lessees of the reserves. Of the portion of the Great Lakes production which is currently not consumed by the producers, Cleveland-Cliffs is one of the two principal sellers, although there are several other merchant sellers and several steel companies which sell significant quantities of Great Lakes iron ore from time to time. The Company believes that in recent years substantially all sales of iron ore produced in the Great Lakes region have been made at prices based on the published Lower Lake Ports quoted prices, and that nonetheless competition among the several sellers is predicated upon normal competitive factors, such as availability of supply, product performance, service, and cost to the consumer.

The Robe River Mine in Western Australia, in which Cliffs Western Australia has a 30% interest, currently sells most of its production to six Japanese steel companies and the balance to European steel mills. The Robe River Mine is one of five large mining operations developed in Australia within the last eleven years principally for the purpose of producing iron ore for shipment to Japan. Australian iron ore now constitutes a major portion of the supply of iron ore consumed in Japan, although shipments are made into Japan from many other mines throughout the world. Most of the sales of Australian iron ore are made under long-term contracts at negotiated fixed prices, generally with provision for renegotiation of prices at specified future intervals. Agreements have been announced providing for increases in the prices under these contracts in recognition of the effect of changes in the relationship of the Australian and United States dollars since the period 1964-1969 when the contracts were negotiated as well as increases in fuel and other costs. Cliffs International, Inc., as sales representative for the owners of the Robe River Mine, is currently negotiating with the Japanese steel companies with respect to possible additional long-term sales contracts. Cleveland-Cliffs understands that certain other of the Australian mining companies, as well as other producers of iron ore in Canada, South America and elsewhere, are conducting similar negotiations. In Europe, Cliffs International has also been negotiating for sales against similar competition, and commercial deliveries have just begun. Among the factors involved in these negotiations are the nature and quality of the iron ore products, available and proposed loading and shipping facilities, capital requirements for necessary mining, processing and transportation facilities, financing arrangements, costs to the consumer and realization to the producer and other factors.

There are numerous operators of vessels on the Great Lakes available for transportation of iron ore. Cleveland-Cliffs' fleet is one of five principal United States fleets which together with numerous Canadian vessels are actively engaged in carrying iron ore for other than the vessel owners. In addition, several steel companies own their own vessels, which sometimes are available for transporting iron ore for others. Iron ore is transported on the Great Lakes at published lake freight rates or under long-term contracts or time charters or other arrangements at negotiated rates. Most of these vessels are also capable of transportation of grain, coal and other bulk commodities, and there are a considerable number of other lake vessels primarily carrying other commodities but usable for iron ore.

Cleveland-Cliffs' forest products division is one of the major producers of northern hardwood lumber in the Midwest. Its sales of hardwood lumber and other forest products are made largely in the Midwest and West in competition with numerous other producers and distributors of hardwood lumber and other materials, but it also sells for delivery in Canada and other foreign countries.

Environment and Energy

Cleveland-Cliffs has historically sought to preserve the environment in which the mining operations are located. Operations have been conducted with a view to minimum disturbance of the natural land conditions in the generally remote areas where the iron ore deposits are located, with revegetation of inactive tailings basins and rock piles and other efforts toward the restoration of natural conditions after mining operations are completed. Because iron ore mining is located in areas with sparse population, the Company recognizes the benefits of providing clean air and water, good housing, and open lands around its properties to attract and retain employees. Due to increased public interest in and demands for a quality environment, Cleveland-Cliffs has had for a number of years a full-time Director of Environmental Affairs, a Corporate Public Affairs Committee, and a Public Interest Committee of the Board of Directors.

These concerns have increased during the past twenty years as the processing of the low-grade iron ores for the production of high iron content blast furnace feed has required increasing quantities of natural gas or fuel oil for pelletizing. The production of the electrical energy required for the crushing, grinding, and concentrating processes uses water for cooling purposes and requires the consumption of major supplies of coal. In the construction of the Company's facilities and in its operating arrangements, substantial costs have been incurred, and will be incurred in the future to avoid undue effect on the natural water and air environments. Prior to 1971 expenditures for facilities designed to protect the environment were not separately accounted for by the Company. Cleveland-Cliffs' commitment to environmental conservation in 1974 required capital expenditures of $19.4 million by itself and venturers. In the years 1971-1974 the Company and its joint venturers spent approximately $48.4 million for pollution control facilities, including electrostatic precipitators, tailings dams, in-plant dust collecting systems, and marine sewage disposal systems.

There have been public hearings held in connection with the necessary governmental authorizations for the Tilden Mine, open conferences with governmental authorities, public notices and discussions in connection with the Presque Isle generating station expansion and the Marquette coal unloading facilities, and public meetings with local residents. These have involved interchanges of ideas and planning as to operating requirements and environmental concerns, and public recognition of the importance of the Company's iron ore mining operations to the economy, employment, and general well-being in the Upper Peninsula. Additional hearings and securing of permits continue to be required from time to time.

Some disruption of existing property interests is necessarily involved in the development and operation of the Company's mining projects. In connection with the water arrangements for the Empire and Tilden Mines, for example, many parcels of property have been or are being acquired by the Company. In some cases property owners adjacent to the plants have sold their properties to the Company or other plant operators after complaints. Certain legal actions by such property owners are now pending.

Cleveland-Cliffs and other Great Lakes bulk cargo vessel operators are engaged in litigation with agencies of the State of Michigan as to enforcement of the Michigan Watercraft Pollution Control Act of 1970, which may ultimately subject Cleveland-Cliffs to additional capital expenditures and possible increased operating costs to bring its vessels into compliance with environmental requirements.

In 1974 the Great Lakes fleet felt the effects of the embargo which resulted in the increased price of fuel oil. Compared to 1973, fuel prices more than doubled in 1974.

Although there has not yet been any material interruption of the supply of natural gas for the Company's operations and the Company has a contract providing on a firm basis (subject to some curtailment) for the natural gas requirements of its present operations through October of 1977, the present and prospective shortage of gas supplies has required the making of arrangements for the substitution of possible fuel oil to cover part or all of the requirements of the Company's current operations and expansions. In 1974, the Company finalized a contract with Exxon Corporation for the supply from the Interprovincial pipeline of a special blend of heavy fuel oil from Alberta, Canada, at a negotiated price, including transportation. The imported fuel oil is presently subject to Canadian export control regulations of the Canadian Energy Board. A wholly owned subsidiary of the Company has constructed at Rapid River, Michigan, at the Interprovincial pipeline, a fuel oil storage facility from which the oil is trucked to the mining properties. The cost of the facility, estimated at approximately $3.8 million, is expected to be financed by industrial development revenue bonds, subject to necessary local and other governmental action authorizing the financing arrangements and providing the necessary permits to the facility.

In past years the Company has burned coal on an experimental basis as the kiln firing source at one of its pellet plants. This was terminated when quantities of natural gas and fuel oil became available at more attractive costs. In an effort to further assure future energy fuel supply at reasonable cost, the Company in 1974 again tested such possible usage of coal and is continuing such tests in 1975. In view of the Canadian National export policy, the Company is endeavoring to cover all its pellet plant fuel requirements with back-up domestic fuel supply sources. At present it is believed that sufficient back-up sources can be obtained.

Currently anticipated capital expenditures to meet the above environmental and energy problems have been included in the costs incurred and estimated to be incurred as referred to herein. However, it is impossible to estimate the costs which may be required to satisfy future requirements and standards. For example, while the Company believes that the air quality requirements recently established in Michigan which are applicable to the Presque Isle generating station in 1975, as well as the more stringent requirements established to become effective in 1978, can be satisfied by the continued use of low sulfur coal, the availability and cost of such coal in the future is not predictable. Furthermore, the capital costs of any method which may be developed which would permit the usage of other more economical coal or fuels, or substitute coal or oil for natural gas, are not known. Negotiations are under way with respect to long-term coal supply agreements.

While the Company does not believe that additional operating costs which may be required to satisfy changed energy requirements or appropriate environmental standards will be material, any substantial interruption of operations resulting from governmental regulations or injunctive order would be materially adverse.

7. COPPER RANGE COMPANY

Copper Range Company, a Michigan corporation, and its subsidiaries, have since its organization in 1899 been engaged in the business of mining and refining primary copper in northern Michigan and, since 1931, in fabricating and distributing copper and brass products. The Company is the seventh largest producer of domestic primary refined copper in the United States. Sales in 1972 were $97.6 million. Refined copper accounted for 59%, fabricated copper products were 39%, and other revenues were 2% of sales. The Company has approximately 3,800 employees.

The Company's mine, mill, and smelter for producing refined copper are located in White Pine, Michigan. Its principal fabricating plant is located in Leetsdale, Pennsylvania, with two smaller plants in Eminence, Kentucky, and Anderson, Indiana, and its principal executive offices are in White Pine, Michigan. The mine and mill have a capacity of 25,000 tons of ore per day. The Company is a relatively high-cost producer. The smelter has a capacity of 85,000 tons of copper per year.

The copper produced at White Pine is Lake Copper whose principal distinctive characteristic is a natural silver content. It is fire-refined and cast at White Pine into standard commercial shapes for sale. Copper Range has fabricating facilities with an annual capacity of 51.5 million pounds of copper-brass products.

Sales and marketing activities with respect to refined copper are conducted from the Company's offices in New York City. White Pine copper is marketed principally to domestic copper and brass mills, wire and cable mills, foundries, and other specialized fabricators. Approximately 17.6% of the White Pine copper in 1972 was used by the Company in its own metal fabricating activities.

The principal metal products fabricated by Copper Range are copper bar and copper strip sold through the Hussey Metals Division principally to the electrical industry and other industrial accounts, standard copper sheet sold principally to the electrical, graphic arts, and casket manufacturing industries as well as for general industrial use. The Company also acts as a distributor of products which are not manufactured by it, mainly copper, brass, bronze, aluminum and stainless steel sheets, rods and wire which are sold chiefly for industrial use.

About 73% of the total sales of Copper Range's fabricated metal products in 1972 were made directly to end-users with the balance made to distributors.

Approximately 24.86% of Copper Range's production of refined copper during 1972 was sold to Revere Copper and Brass Incorporated (Revere), and approximately 9.8% to Anaconda American Brass Company (Anaconda). During the past seven years, Revere purchased each year between approximately 20% and 27% of the company's refined copper. The Company states that there are no material aspects to the relationship between it and Revere or Anaconda outside the vendor-vendee relationship.

Copper Range does not engage in material operations in foreign countries, nor is a material portion of its sales or revenues derived from customers in foreign countries.

Compared to western ores, the White Pine ore has a low sulfur content and Copper Range has stated that it has met both the primary and secondary Federal Air Quality Standards under the Clean Air Act of 1970. The Company has stated that "but given presently available technology, we do not believe that it would be economically feasible for us to meet a 90% emission standard. A research and development effort is in progress to identify and develop a process which will reduce sulfur dioxide emissions from our White Pine smelter on a reasonable economic basis."

8. CYPRUS MINES CORPORATION

Cyprus Mines Corporation was incorporated in 1916 in New York. It operated the Old Dick Mine near Bagdad, Arizona. At present, Cyprus is engaged directly and through its subsidiaries and affiliated companies in the production and marketing of a diverse group of metallic minerals including copper, lead, zinc, iron ore, silver, and molybdenum; ocean transportation of iron ore and other basic commodities; the production, processing and marketing of nonmetallic minerals, including premium grade talc, kaolin, clays, and cement; and in the manufacture and marketing of wire cable, tubing and related products for the electrical industry.

Cyprus, through Pima Mining and Bagdad Copper, is a source of over 200 million pounds per year of domestically mined copper.

The Company operates principally through wholly owned divisions and corporations in which it has a majority interest and management control. There are three exceptions: (1) Marcona Corporation, which is engaged in iron ore mining, principally in Peru, and shipping, is owned 50% by Cyprus and 50% by Utah International as to voting stock (and 46% each as to equity); (2) Mount Goldsworthy Mining Associates, in which the Company owns an undivided one-third interest in the iron ore reserves in Western Australia and participates equally with Consolidated Gold Fields Australia and Utah Development Company in the ownership and management of Goldsworthy Mining Limited, the contract mining Company; and (3) Hawaiian Cement Corporation, in which the company owns a 45.4% interest. The products of Cyprus Mines Corporation and the 1972 revenues derived therefrom are listed in Table A-8.1.

NONFERROUS MINERALS GROUP

The nonferrous minerals group of Cyprus Mines Corporation includes the Pima and Bruce mines in Arizona, the Anvil mine in Yukon Territory of Canada, and the Cyprus Island operation.

PIMA MINING COMPANY

Pima Mining Company, which has been managed by Cyprus Mines Corporation since its initial development in the mid-1950's, is a California corporation, 50.01% owned by Cyprus. The balance is owned by Union Oil and Utah International, Inc. While essentially a producer of copper in the form of copper concentrates, Pima also recovers minor amounts of molybdenite (a molybdenum sulfide) concentrates and silver. In 1972, the open pit copper mine and concentrator near Tucson, Arizona, produced in concentrates 159 million marketable pounds of copper, 908,301 marketable ounces of silver, and 1,021,000 pounds of molybdenum contained in the molybdenite concentrates.

TABLE A-8.1

1972 REVENUES BY PRODUCTS AND INCOME
CYPRUS MINES CORPORATION

	1972 ($ Millions)
Total revenues, including share of revenues of affiliated corporations:	
Nonferrous minerals	72.3
Iron ore mining	89.6
Ocean transportation	15.3
Industrial minerals and pigments	20.0
Electrical products	68.2
Timber and other divested properties	----
Other	3.0
	268.4
Add minority share of consolidated subsidiaries eliminated from above	50.5
Total	318.8
Gross profit and other income:	
Nonferrous minerals	22.7
Iron ore mining	10.6
Ocean transportation	6.1
Industrial minerals and pigments	3.6
Electrical products	4.3
Timber and other divested properties	----
Other	(.2)
	47.1
Less tax provisions by affiliated corporations	(1.4)
Add minority share of consolidated subsidiaries eliminated from above	16.7
Total	62.4
Less general and administrative expenses, mineral exploration and interest:	11.7
Less provision for foreign and domestic income taxes:	10.3
Less Minority Interests	11.5
Net Income for the Year:	28.8

Source: Annual Report – Cyprus Mines – 1972.

Ore reserves which could be mined and processed commercially at current copper prices and operating costs on December 31, 1972, were 241 million short tons averaging approximately .50% copper content.

Under long-term contracts, copper concentrates are shipped to two Arizona smelters for smelting and refining. About half of the refined copper and the silver are returned to Pima for sale through normal channels while the balance of the copper is sold to one of the smelters and the balance of the silver to the other smelter. Molybdenite concentrates are sold in the open market.

Cyprus has stated that:

> "Pima has not incurred any direct cost for compliance with environmental regulations. It is difficult to estimate the cost to comply in future years, although there is the possibility of a contribution of from two cents to six cents per pound of copper to a smelter depending on the requirements of the Pollution Control Board; in this event, the cost per year would range from $3 million to $9 million."

A 35% expansion of facilities at Pima was completed during the first quarter of 1972. For the year as a whole, the mill processed an average of 51,200 tons of the ore per day, a 28% increase over 1971.

ANVIL MINING CORPORATION

Anvil Mining Corporation Limited (Anvil) is a British Columbia corporation 60%-owned by Cyprus. Anvil operates an open pit lead and zinc mine and concentrator in the Yukon Territory of Canada. It completed its third full year of production in 1972.

In 1972, Anvil produced lead concentrates containing 194,536,000 pounds of lead and 2,168,046 ounces of silver, zinc concentrates containing 216,203,000 pounds of zinc, and bulk concentrates containing 32,862,000 pounds of lead, 49,583,000 pounds of zinc, and 428,286 ounces of silver. Concentrates are sold on the basis of London Metal Exchange quotations for lead and the European Producer Price for zinc.

CYPRUS ISLAND DIVISION

The Cyprus Island Division is not considered a material asset of Cyprus Mines Corporation or a foreseeable material contributor to the total revenues of the Company.

BRUCE MINE DIVISION

The Company's Bruce mine is a small, relatively high-grade, underground mine with a mill and supporting facilities, located near Bagdad, Arizona. The property is secured by patented mining claims on United States Government land.

Like the Cyprus Island Division, the Bruce Mine Division is not considered a material asset of the Company or a foreseeable material contributor to the total revenues of the Company.

NEW DEVELOPMENTS

Cyprus Mines Corporation acquired Bagdad Copper Corporation in June, 1973, in an exchange of stock. Bagdad had sales revenues of about $33 million and earnings of $3.7 million in 1972. Cyprus' financial results are now being restated to account for Bagdad on a pooling-of-interests basis.

9. DUVAL CORPORATION (Subsidiary of Pennzoil)

Pennzoil Company (formerly Pennzoil United, Inc.) was formed in 1968 by the consolidation of Pennzoil Company and United Gas Corporation. Total sales and operating revenues were $810 million in 1972, operating income $196 million, and net income after taxes was $58.7 million.

Through the United Gas Division,* a large natural gas transmission business has been operated, based primarily in the Gulf Coast area, with a pipeline system serving parts of Texas, Louisiana, Mississippi, with the line extending also to Mobile, Alabama and Pensacola, Florida. Through Duval Corporation, a wholly owned subsidiary, extensive interests are held in copper, molybdenum, sulfur, and potash properties. Through Duval Sierrita, a major copper ore body is being mined. It is financed by the General Services Administration, the debt being repaid by delivery of copper to the Government.

Production, refining, and marketing of oil, gas and petroleum products have accounted for about 31% of revenues and 49% of operating income; natural gas transmission approximates 51% and 36%; and Duval mining, 18% and 15%,* respectively.

Duval has been operating two open-pit copper-molybdenum mines in Arizona known as the Esperanza and Mineral Park Properties. Duval estimated its proven ore reserves as of December 31, 1970 at Esperanza to be 26 million tons, with an average copper content of 0.037% and an average molybdenum content of 0.034%; and at Mineral Park to be 34 million tons with an average copper content of 0.47% and an average molybdenum content of 0.048%.

Duval operates two copper-gold-silver open-pit mines located in Nevada, known as the Copper Canyon and Copper Basin mines, which were placed on a full production basis in July, 1967. Duval estimated its proven ore reserves as of December 31, 1970, at Copper Canyon to be 14 million tons with an average copper content of 0.78% and an average silver and gold content of 0.51 and 0.024 ounces per ton of ore, respectively; and at Copper Basin to be 1.3 million tons with an average copper content of 1.55% and an average silver and gold content of 0.27 and 0.022 ounces per ton of ore, respectively.

Duval, including Duval Sierrita, accounts for about 6% of domestic copper production and 9% of domestic molybdenum production.

The prospectus dated March 23, 1971, in connection with a Pennzoil United debenture offering presented the following financial and accounting information,

*In March, 1974, Pennzoil was making arrangements to spin off its United Gas business.

which is useful to an understanding not only in the case of Duval, but perhaps more generally with respect to many other major, publicly held, mining-based companies.

Mine development costs of Duval are capitalized for financial reporting purposes and are depreciated or depleted over the operating lives of the related properties. For federal income tax purposes, such costs are deducted as incurred. To the extent such capitalized costs are utilized in reducing current income tax, such reduction in current tax is charged to income and credited to deferred income tax. In 1969, Duval sold mineral production payments in the amount of $100 million and taxes payable resulting from this sale have been charged to deferred income tax. Proceeds applied to the liquidation of the production payments are included in income as produced and the related income tax charged against income.

DUVAL SIERRITA – GSA CONTRACT*

In November, 1967, the U.S. General Services Administration (GSA) and Duval Sierrita Corporation, an operating subsidiary of Duval, entered into a domestic copper production expansion contract pursuant to the provisions of the Defense Production Act of 1950 for the development of a low-grade copper-molybdenum ore body (Sierrita Property) adjacent to Duval's Esperanza Property.

Construction of a mill and related facilities designed to process an annual average rate of ore throughput equal to not less than 66,000 tons per day and the pre-mining stripping of 126 million tons of waste overburden were substantially completed in March 1970. Approximately $181 million was required to develop the original project (not including the cost of the expansion project referred to below) of which $83 million was obtained from the GSA in the form of advances against future deliveries of copper produced from the property; $48.75 million from commercial bank loans guaranteed in part by the GSA; $10 million from the Company; and the remainder from Duval in equity or loans. Duval provides management and technical guidance to Duval Sierrita at cost.

The contract with the GSA provides that repayment of advances will be made by delivery of about 218.4 million pounds of copper to the GSA prior to June 30, 1975. The advances will be credited at the rate of 38¢ for each pound of refined copper delivered. While the contract provides that certain minimum deliveries must be made at stated intervals during the period from commencement of production to the final repayment date, Duval Sierrita is entitled to sell in the

*This information was taken from Pennzoil-United's March 23, 1971 prospectus.

open market its molybdenum and by-product silver production and such amount of its copper production as may be necessary to cover all cash operating expenses and maintain working capital. The commercial bank loans are payable in installments from December 1975 through June 1978.

In May 1970 these contracts were amended to provide for an increase in the mine and mill capacity at the Sierrita Property. Duval Sierrita agreed to spend not less than $8 million on additional facilities and guaranteed the GSA an average rate of ore throughput on an annual basis of not less than 72,000 tons per day. In turn, the GSA and the commercial banks have agreed to permit Duval Sierrita to sell on the open market for its own account 90% of production attributable to any ore throughput exceeding 72,000 tons per day. The remaining 10% of such production (net of sales required to meet cash operating expenses attributable thereto) will be delivered to the GSA at a fixed price of 38¢ per pound. Cash flow generated by such sales for the account of Duval Sierrita will be available for general corporate purposes, including the payment of dividends and the repayment of advances from Duval or loans from others required to finance the expansion. It is anticipated that the expansion of the mill and mine capacity will cost about $13 million of which $6 million had been expended through December 31, 1970.

The facilities for integrated copper-molybdenum milling operations were completed in the latter part of 1970 and normal production commenced subsequently.

Duval estimates the proven ore reserves of the Sierrita Property to be 524 million tons with an average copper content of 0.33% and an average molybdenum content of 0.033%. The stripping ratio during the operational life of the mine, excluding pre-mining stripping of waste overburden, is estimated to be 1.28 to 1. The stripping ratio during the first five years of operations is estimated to be 2.25 to 1.

AGREEMENT WITH ASARCO

American Smelting and Refining Company has agreed to purchase at least 50% of Duval and Duval Sierrita's aggregate production of copper concentrates and precipitates other than that to be delivered to the GSA (as previously described). The remaining concentrates and precipitates are smelted and refined on a toll basis by American Smelting and Refining Company with the resultant refined copper being marketed by Duval and Duval Sierrita to various copper consumers. The marketing of molybdenum production is the responsibility of the respective companies. Although both companies have a number of short-term sales contracts and to date have not encountered any difficulty in marketing copper production, there are no existing long-term contractual commitments for the sale of a substantial portion of their copper production.

10. EAGLE-PICHER INDUSTRIES, INC.

Eagle-Picher is a diversified manufacturer of products sold in industrial markets. The principal lines of business, products, and markets are:

- Basic Materials and Chemicals
- Machinery and Allied Products
- Transportation Products

Eagle-Picher manufactures a wide variety of products, primarily for other manufacturers, at 67 locations. Types of manufacturing include: chemical processing, mining, metal fabrication, aluminum, bronze and brass foundries, precision machining, electronic and electrical assembly, molded and extruded rubber and plastic, printing and publishing, among others.

Products manufactured by the company generally are sold to customers through company sales organizations which have offices, for the most part, in the United States and Canada and in certain cases through independent dealers and sales representatives.

Due to its diversification, Eagle-Picher is not dependent upon any single source for its raw materials, nor upon any few customers for a substantial part of its business.

The Basic Materials and Chemicals Group is composed of operations which produce a basic material or chemical or use one as a raw material. The Machinery and Allied Products Group consists of capital goods manufactured by the Company, or products which are sold to other manufacturers of capital goods and incorporated into their products. Transportation Products includes all operations which manufacture original equipment and replacement parts for passenger cars, trucks, buses, aircraft, and railroads.

In the Basic Materials and Chemicals Group, some specific products of interest are agricultural micronutrients such as compounds of zinc, copper, and manganese, which replace trace elements depleted from soil; animal feed supplements; diatomaceous earth; porcelain frit; concrete pipe; high-purity germanium and gallium. Also, Eagle-Picher is the only producer of the boron-10 isotope, used in nuclear applications.

The Mining Department of the Basic Materials and Chemicals Group is headquartered in Oklahoma, with operations at a plant in Oklahoma and one in Illinois. The Oklahoma operation produced about 3000 tons/year of copper contained in concentrates until recently when it was closed. In the past, this concentrate was sold to ASARCO. Some 70-80 employees are involved. This represent less than $10 million per year in revenues, and is believed to have represented a negligible earnings contribution to Eagle-Picher.

The Company's Machinery Group manufactures a complete line of special purpose batteries, including nickel-cadmium, lithium, magnesium perchlorate, water-activated, and zinc-air. These are used principally in power systems for military hardware, submarine, and aerospace applications.

In the Transportation Group, rubber and polyurethane products and elastomeric compounds are important.

Table A-10.1 presents a summary of total company sales and income for the years 1970-1974. Sales in 1974 were $367 million, and net income was $18 million, both representing record high figures for the company. Capital expenditures increased in 1973 and 1974 from the level of the previous several years, reaching nearly $14 million in 1974. Depreciation and amortization changes were $9.2 million in 1974 ($7.7 million for 1973), with the result that Eagle-Picher's cash flow was well in excess of capital spending.

Long-term debt at the end of fiscal 1974 was $43 million, and shareholders' equity was $118 million, giving the Company a debt-to-equity ratio of 36.5%.

The Company has about 9,350 employees.

11. GULF & WESTERN INDUSTRIES (New Jersey Zinc)

INTRODUCTION

Gulf & Western Industries, Inc. ("G&W"), known as an acquisition-minded conglomerate, is a large diversified company whose activities are presently organized into eight operating groups – Food and Agricultural Products, Manufacturing, Natural Resources, Paper and Building Products, Financial Services, Leisure Time, Automotive Replacement Parts, and Consumer Products.

The Natural Resources Group, consisting primarily of The New Jersey Zinc Company, a division of G&W, operates zinc mines and produces zinc products, pigments, metal powders, and certain industrial chemicals.

Table A-11.1 summarizes recent financial information for G&W and consolidated subsidiaries.

TABLE A-11.1

GULF AND WESTERN FINANCIAL DATA

	Years Ended July 31	
	1973	1974
	$ Millions	
Income Statement		
Net sales and other operating revenues	1,927.2	2,295.5
Operating income*	177.2	224.7
Dividends and other income	3.0	3.0
Interest expense	60.1	87.0
Minority interest	7.1	12.6
Net earnings after taxes	89.2	100.6
Depreciation and depletion charges	44.0	48.1
Balance Sheet		
Working capital	545.6	585.8
Current ratio, assets to liabilities	2.2x	1.9x
Total assets	2,364.1	2,683.0
Total assets less intangibles	2,312.7	2,628.6
Long-term debt (less current maturities)	653.3	758.3
Convertible subordinated debt (less current maturities)	419.8	416.7
Shareholders' equity	653.9	706.3

*Includes equity in earnings, before income taxes, of unconsolidated affiliates in the amount of $44.8 million for 1973 and $28.7 million for 1974.

Source: G&W's Form 10K Report to S.E.C., Nov. 15, 1974.

Table A-11.2 shows the approximate percentage contributions by each of G&W's operating groups to G&W's total revenues and operating income for the past five fiscal years. For the purpose of these calculations, revenues of the Financial Services Group, not consolidated in G&W's financial statements, have been included in all periods.

TABLE A-11.2

CONTRIBUTION OF OPERATING GROUPS TO G&W REVENUES

	1970		1971		1972		1973		1974	
	Revenues	Operating Income(a)	Revenues	Operating Income(a)	Revenues	Operating Income(a)	Revenues	Operating Income(a)	Revenues	Operating Income(a)
Food and Agricultural Products	4%	15%	4%	18%	5%	19%	6%	20%	6%	26%
Manufacturing	36	39	32	16	29	11	30	14	29	24
Natural Resources	5	2	4	3	5	5	5	7	6	18
Paper and Building Products	10	4	11	7	11	6	12	9	14	15
Financial Services	18	30	19	38	19	37	19	27	18	9
Leisure Time	12	---	14	15	14	21	12	22	11	8
Automotive Replacement Parts	7	6	7	6	8	7	8	7	8	7
Consumer Products	8	8	9	9	9	8	8	8	8	6
	100	104	100	112	100	114	100	114	100%	113%
Corporate Expenses and Intercompany Items		(4)		(12)		(14)		(14)		(13)
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

( ) Denotes deduction.

Note (a)—Operating income represents earnings from operations before dividends and other income, and before deduction of interest expense, minority interest and income taxes, except that for Financial Services it is operating earnings before income taxes.

Source: G&W Form 10-K Report to the SEC, November 15, 1974.

NATURAL RESOURCES GROUP

It may be seen from above that G&W's Natural Resources business represents a very small part of its total business, in terms of revenues; and, until the atypical economic conditions of 1974, has represented a small contribution to total earnings.

As indicated above, G&W's natural resources operations are primarily conducted by The New Jersey Zinc Company which is now operated as a division of G&W ("NJZ"). NJZ is principally an integrated producer of a full line of zinc products and a manufacturer of titanium dioxide pigments, metal powders, anhydrous ammonia, liquid carbon dioxide, lead concentrates, limestone, spiegeleisen (a ferro-manganese product), cadmium and sulfuric acid. The information on the following pages is taken directly from G&W's Form 10-K Report to the SEC for Fiscal 1974.

Mining and Milling Operations

Mining operations are carried on at five properties owned by NJZ in Colorado, Pennsylvania, Tennessee, Virginia and New Jersey. Ores produced are concentrated at mills at NJZ's mines and all the concentrates are shipped to NJZ's smelter in Palmerton, Pennsylvania. NJZ's aggregate mine production in fiscal 1974 was 1,789,319 tons, compared to 1,927,672 tons in fiscal 1973; the decline was attributable to the shutdown in September 1972 of the Flat Gap, Tennessee mine and reduced production from the Jefferson City, Tennessee property due to diminishing reserves. At the Friedensville, Pennsylvania mine, a shaft-deepening project, which will make accessible for mining the deeper level ore reserves, is scheduled to be completed during the first half of calendar 1975. No other changes have been experienced recently in either mining conditions or deposits being mined that have materially affected production or costs, and no such changes are now anticipated by NJZ. In June 1972, NJZ began construction of a new mine in Elmwood, Tennessee, which is expected to commence initial production in November 1974. In August 1973 (as an extension of its Jefferson City operations), NJZ began construction of a new mine on its Lost Creek, Tennessee property, which is expected to commence operation in 1975. In October 1974, work was begun on the further development and construction of the Idol, Tennessee mine, which is expected to commence operations in 1976. NJZ also owns or controls undeveloped or nonoperating properties in Tennessee, Virginia and Canada. At August 1, 1974, reserves at NJZ's operating mines and mines under development were estimated in the aggregate at 29,553,800 tons of proven and probable ore with an average content of 6.7% zinc, and reserves at undeveloped and nonoperating properties were estimated in the aggregate at 26,995,500 tons of probable ore with a 3.8% average zinc content.

Table A-11.3 summarizes at August 1, 1974 the proven and probable ore reserves and certain production data of NJZ's developed mines, the proven and probable reserves of its mines under development and nonoperating properties, the probable reserves of its undeveloped properties, and additional mineralized deposits at certain properties.

Manufacturing Operations

During fiscal 1974, NJZ produced 91,608 net tons of zinc metal (including zinc alloys and rolled zinc but excluding metal used for pigments), 104,117 net tons of zinc pigments and 74,033 net tons of titanium pigments, compared to

TABLE A-11.3

NEW JERSEY ZINC ORE RESERVES

Mines(1)	Ore Reserves Tons	Ore Reserves % Zinc	Ore Reserves % Lead	Net Tons and Grade of Ore Mined and Milled in the 12 Months ended July 31, 1974(2)	Operating Direct Cost per Ton of Ore Mined and Milled in the 12 Months ended July 31, 1974(3)
Gilman, Colorado	2[illegible]200	10.6	1.2	205,626, 11.7% Zn 1.7% Pb, .13 Cu and 2.42 oz Ag	$19.72
Friedensville, Pennsylvania	11,1[illegible]00	6.5		399,973 5.9% Zn	9.28
Jefferson City, Tennessee	1,1[illegible]00	3.1		389,781 2.9% Zn	5.38
Austinville, Ivanhoe, Virginia	4,[illegible]000	3.5	.4	597,907 3.3% Zn	5.90
Sterling, New Jersey	3,31[illegible]00	19.9		195,032 18.5% Zn	14.06
Total Mines	20,578,000	7.9		1,789,319	
Mines Under Development(1)					
Elmwood, Tennessee(4)	1,355,000	4.4			
Idol, Tennessee	5,655,200	4.0			
Lost Creek, Tennessee(5)	1,965,000	4.0			
Total	8,975,200	4.1			
Nonoperating Properties					
Flat Gap, Tennessee(6)	11,397,300	3.1			

Undeveloped Properties(8) (9)	Ore Reserves Tons	Ore Reserves % Zinc	Ore Reserves % Lead
Tennessee:			
Straight Creek	65,000	13.9	
Shiloh	100,000	7.2	
Beaver Creek(7)	5,500,000	3.0	
Big War Creek	2,355,000	4.4	
Chucky Pike	290,000	4.4	
Total Tennessee	8,310,000	3.6	
Virginia:			
Arminius(11)	3,803,000	4.0	.6
Julia Mine(11) (12)	1,955,000	4.8	1.3
Cofer(11)	600,000	6.9	1.5
Chaffin	930,200	4.0	.8
Total Virginia	7,283,200	4.5	.9
Grand Total Undeveloped Properties	15,598,200	4.0	
GRAND TOTAL	56,549,300	5.3	

Additional Mineralized Deposits (9) (10)	Tons	% Zinc	% Lead
Tennessee:			
Sugar Creek	130,000	4.8	1.2
Independence	900,000	4.6	
Eidson (Davis)	2,300,000	3.7	
Eidson (Price)	1,350,000	2.2	
Little War Creek	830,000	4.2	
Total	5,510,000	3.6	

(1) After allowance for pillars or dilution. The term "pillars" refers to those parts of an orebody that are left, temporarily or permanently, to support the mine openings. The term "dilution" means the waste rock or weakly mineralized rock which will be unavoidably mined with the ore

(2) Zn-Zinc; Pb-Lead; Cu-Copper; Ag-Silver.

(3) Excludes depreciation and depletion estimated in the aggregate to be $.51 per ton of ore mined and milled, and taxes and administrative expenses

(4) Based upon its experience in developing and mining its Jefferson City mine and in developing its Elmwood mine, NJZ anticipates that continued expansion of underground workings at the Elmwood mine will establish additional ore reserves (the possibilities of which have been indicated by widespread diamond drillings) in quantities sufficient to justify the further development of the mine and the construction of the mill

(5) Based upon its experience in developing and mining its Jefferson City mine, NJZ anticipates that additional ore reserves will be established, when and as underground work is done, in quantities sufficient to justify further development of the mine; ore from the mine will be processed at the Jefferson City mill

(6) The Flat Gap mine was closed in September 1972 Reopening of this mine will be dependent on metal prices and future concentrate requirements The mine, however, is not planned for production in the near future

(7) It is planned to begin development work on this mine in late 1974

(8) The tonnages shown for these properties are probable reserves only.

(9) No allowance for pillars or dilution

(10) These properties are not currently listed as ore reserves because they are not required in NJZ's present plans for supplying its smelter operations

(11) NJZ has entered into an agreement with another mining company for the further exploration of these properties and possible development of mines on them. If certain conditions are met, that company may acquire a 49% interest in these properties.

(12) Under lease to NJZ

Source: G&W — 10K Form 1974

production of 102,792, 106,737 and 70,327 net tons, respectively, for the 1973 fiscal year. Production was carried on at plants owned by NJZ in Palmerton, Pennsylvania, Gloucester City, New Jersey, Depue, Illinois, and at a leased plant in Ashtabula, Ohio.

At its Palmerton plant, NJZ processes zinc concentrates to produce zinc metal of various grades sold primarily for galvanizing steel products, production of brass or for use in the die-casting industry. Some of the metal is further processed to produce rolled zinc and zinc dust. Zinc oxide pigments are produced at Palmerton for sale primarily to the paint, rubber and reprographic paper industries. The plant also produces spiegeleisen for sale to steel plants and iron foundries and anhydrous ammonia for sale to industrial users and fertilizer manufacturers. Cadmium metal, sulfuric acid and liquid carbon dioxide are all produced as by-products at Palmerton and sold for industrial use. The Palmerton plant, which comprises approximately 270 acres, has an annual capacity of 118,000 tons of primary zinc metal, 72,000 tons of refined metal and 92,000 tons of zinc oxide. Production of these products at Palmerton during fiscal 1974 was at approximately 88%, 86% and 96% of capacity, respectively. Current production at Palmerton is at 86% of capacity for primary zinc metal, 88% for refined metal and at full capacity for zinc oxide.

At its Gloucester City, New Jersey plant, NJZ produces a full line of titanium dioxide pigments for sale primarily to the paint, rubber and paper industries. The plant, comprising approximately 34 acres, has an annual capacity of approximately 43,000 net tons of anatase and rutile grade titanium dioxide pigments. During fiscal 1974, operations were at capacity, and current production is at the same rate.

In 1972, NJZ took over operation of a titanium tetrachloride and titanium dioxide plant in Ashtabula, Ohio, pursuant to a lease which gives NJZ an option to purchase the facilities. Titanium tetrachloride is produced for sale to third parties and is used as a raw material for production of titanium dioxide pigment. Most of the titanium tetrachloride produced for sale is sold to one producer of titanium sponge (from which titanium metal is produced). The Ashtabula plant has an annual capacity of approximately 29,000 tons of titanium dioxide pigment and approximately 98,000 tons of titanium tetrachloride. During fiscal 1974 the pigment plant and the titanium tetrachloride unit both operated at full capacity. Current production is at the same rate.

At its Depue, Illinois plant, NJZ produces zinc dust from purchased scrap zinc. NJZ had produced zinc, diammonium phosphate fertilizer, sulfuric acid and other products at the Depue plant, but all of these operations were terminated in 1971 because of substantial operating losses. NJZ has leased (and given an option to purchase) to another company the diammonium phosphate and sulfuric acid facilities at Depue, as well as certain other facilities there; pursuant to such agreement, NJZ received notice from the lessee during the fall of 1974 that it intends to exercise its option to purchase in September 1975.

NJZ has under way a capital expenditure program at its Palmerton plant to improve pollution control facilities, operating efficiencies and zinc oxide production. Total expenditures for the program (which was initiated in 1971) are presently estimated at $35 million, of which $12 million has been authorized and $5.5 million had been spent through July 31, 1974. It is anticipated that a major portion of this program will be completed by mid-1977.

NJZ is studying the feasibility of constructing a new electrolytic zinc refinery complex to be located on a 675-acre tract near Clarksville, Tennessee. Planned annual capacity for this complex would be 160,000 tons of zinc metal and 260,000 tons of sulfuric acid. If undertaken, this project will require capital expenditures presently estimated to be approximately $130 million.

OTHER MINERAL INTERESTS

Quebec Iron and Titanium Corporation

G&W has a one-third interest in Quebec Iron and Titanium Corporation ("QIT"), which owns deposits of ilmenite ore, an iron-titanium oxide, near Havre St. Pierre, Quebec. Reserves are estimated at 100 million tons of proven ore, averaging approximately 34% titanium dioxide and 38% iron. NJZ purchases the titanium slag requirement of its Gloucester City plant from QIT under a long-term arrangement.

EXPLORATION

NJZ conducts an active exploration program in various parts of North and South America and the Middle and Far East in search of zinc and titanium raw material reserves and other minerals. Exploration expenditures aggregated $1,585,600 in fiscal 1974 and are expected to approximate $2,530,000 in fiscal 1975. Since 1964 NJZ has been exploring (primarily by diamond core drilling) for zinc deposits in middle Tennessee where it leased, as of August 1, 1974, properties aggregating about 160 square miles. NJZ is continuing its exploration activity in middle Tennessee alone and through joint venture programs with other companies.

RESEARCH AND DEVELOPMENT

NJZ's Research Department is involved in metallurgical, chemical and minerals research, new products research and product application studies. Research expenditures aggregated $1,663,000 in fiscal 1973 and $1,525,000 in fiscal 1974 and are expected to approximate $1,990,000 in fiscal 1975.

COMPETITION

NJZ is one of six primary producers of zinc metal and five primary producers of zinc pigments in the United States. Competition is intense among these American producers as well as a number of foreign producers. The domestic price of zinc metal is normally subject to worldwide marketing conditions. Until December 1973 NJZ's base price for zinc metal was limited under the Federal government's price controls to 20¼¢ per pound while foreign producers were able to sell zinc metal in the United States at prices up to 35¢ per pound. In December 1973, Federal price controls on zinc metal and a number of zinc products were removed. Since then NJZ has increased its base price for zinc metal to 40¢ per pound and has increased its price for other zinc products correspondingly. In 1972, 1973 and 1974 the United States government released substantial tonnages of zinc metal from its stockpile, due to the recent strong demand for zinc, and additional stockpile releases are anticipated in 1975.

NJZ's principal products experience increasing competition in most of their end uses with a variety of other products including corrosion-resistant materials such as stainless steel, copper, aluminum and plastics used either as the basic material in fabrication or as a protective coating for other materials. The principal competitive factors in the sale of zinc are price, product quality and customer service.

EMPLOYEES

NJZ employs approximately 3,600 persons, of whom about 75% are members of a collective bargaining unit. The principal bargaining agreement is subject to renegotiation during 1975.

RAW MATERIALS

Over the past three fiscal years approximately 68% of NJZ's annual zinc requirements were supplied by its mines and the balance was purchased. It is expected that during fiscal 1975 approximately 75% of NJZ's zinc requirements at its Palmerton plant will be supplied from mines operated by NJZ. Assuming production of zinc products at the level expected for fiscal 1975 and use of NJZ concentrates at a 70-75% level, NJZ estimates that its present proven and probable reserves would be sufficient for about 22% years of operation. Approximately two-thirds of the zinc content of these reserves are on properties currently in operation or under development.

The proportion of purchased concentrates depends on the supply available from both NJZ mines and other suppliers, the demands of other users, the relation between the price of purchased concentrates and NJZ's mining costs and other factors. Other materials used in NJZ's manufacturing operations are either purchased under long-term contract or are usually readily obtainable in the open market. NJZ is experiencing some difficulty in purchasing fuel and other supplies and materials for its operations, although thus far it has been able to supply its plants with sufficient fuel and materials at significantly increased cost. If it were to be unable to continue to obtain adequate fuel and material supplies, some production cutbacks would be necessary.

ENVIRONMENTAL PROTECTION

NJZ is engaged in various projects to improve air and water pollution control at its mines and manufacturing plants. Approximately 20% of NJZ's research expenditures in fiscal 1974 was allocated to investigation of systems to help resolve effluent problems. Expenditures at all operations for environmental protection approximated $2.5 million in fiscal 1974 and are expected to average $8 million to $10 million in each of the next three or four fiscal years. A major portion of these future expenditures will be made at the Palmerton, Pennsylvania plant to meet air emission requirements and at the Gloucester City, New Jersey plant to meet water effluent requirements.

At several operations, emissions exceed standards presently applicable or to become applicable under existing Federal and state environmental regulations, and JNZ has applied for variances or filed compliance programs under the applicable laws in order to develop and implement means to bring its emissions within permitted limits. While some of these variances or programs have not yet been approved, NJZ expects to be able to reach mutually satisfactory agreements with the appropriate authorities concerning the terms of these programs, although of course there can be no assurances as to any such agreements. NJZ expects to be in compliance with existing environmental standards at all operations by the end of fiscal 1977, provided that certain emissions can be controlled at reasonable expense either by use of existing technology with appropriate modifications or by development of new technology. NJZ does not anticipate that significant production curtailments will result from the operation of the pollution control systems to be installed pursuant to approved programs.

CAPITAL EXPENDITURES AND LONG-TERM DEBT

G&W's total consolidated capital expenditures for property plant and equipment averaged nearly $100 million per year over the period 1972-1974. In addition, the Company has invested in affiliates and other corporate securities, in an amount averaging on the order of $50 million per year.

In has financed its expansion, investments (and debt repayment) with cash flow from operations plus disposition of various properties and securities, and issuance of new long-term debt (aggregating over $500 million over the three fiscal years 1972-1974).

The capital expenditure program at NJZ is believed to account for on the order of 10% of G&W's combined total, including investments. However, this percentage could rise significantly over the next several years – say to on the order of 20%, depending on pollution control requirements and on the decision to proceed with the new zinc refinery complex in Tennessee.

G&W has been earning a reasonable rate of return on its shareholders' equity, although it is leveraged with nearly 50% of capitalization represented by long-term notes and debentures.

Because of the scale and complexity of G&W's operations and finances, not much can be deduced about the desire or ability of G&W to make substantial additional investments in NJZ's operations. There is apparently nothing yet to indicate any significant change in its posture, however.

Maturities of long-term and convertible subordinated debt during the five years ending July 31, 1979, are:

1975	$38,891,000
1976	40,733,000
1977	47,367,000
1978	70,834,000
1979	31,909,000

The Company has complied with restrictions and limitations required under terms of variôus loan agreements.

12. GULF RESOURCES AND CHEMICAL CORPORATION

Gulf Resources and Chemical Corporation is engaged in the mining, smelting, and refining of certain nonferrous metals, including lead, zinc, silver, cadmium, and gold; the strip mining of bituminous coal; the mining of lithium ores and the production and sale of lithium metal, lithium salts, and lithium compounds; and, in addition, production of potassium sulfate and sodium sulfate in facilities located adjacent to the Great Salt Lake at Ogden, Utah.

Gulf's operations are principally carried on by The Bunker Hill Company (Bunker Hill), C&K Coal Company (C&K), Lithium Corporation of America (LCA), and by Great Salt Lake Minerals and Chemicals Corporation (GSL). Gulf has approximately 3,000 employees.

In 1961, Gulf acquired by merger the name, assets and business of Gulf Sulphur Corporation. In 1967, Gulf's name was changed to Gulf Resources and Chemical Corporation as the survivor of a merger with Lithium Corporation of America, Inc. In May, 1968, Gulf acquired by merger the assets and business of The Bunker Hill Company. In January, 1970, Gulf acquired all of the outstanding capital stock of C&K Coal Company. Consolidated sales were $125.6 million in 1972, and net income was $3.5 million.*

The breakdown of sales and pre-tax operating income was as follows:

	1972	
	Sales	Income
Coal	14%	32%
Lead, Zinc, Silver	73%	56%
Lithium Products	13%	12%
GSL	–	–
	100%	100%

Bunker Hill is a leading factor in the lead-zinc-silver industry, operating in the Coeur d'Alene district of Idaho; Bunker Hill accounts for approximately 7-8% of domestic zinc production, and 14% of U.S. primary refined lead. The major part of its refined metal output is sold to NL Industries, Inc., under contract

*Great Salt Lake Minerals and Chemicals Corporation (GSL), a 51%-owned subsidiary in 1972, is in a preoperating and start-up stage, and was not included in consolidated statements of income. GSL is capitalizing its costs and expenses as preoperating costs rather than expensing them until it begins operations. On May 8, 1973, Gulf became owner of 10% of the outstanding stock of GSL. Consequently, in future reports, GSL will be a consolidated subsidiary.

extending through 1975. Various interests are held in other operating and non-operating mining firms. Bunker Hill's net sales in 1972 were $92 million, about 75% from lead and zinc; the rest mainly refined silver, cadmium, and gold.

SMELTING AND REFINING

Bunker Hill's mines produce a portion of the lead and zinc concentrates required for the operation of its smelters. Other concentrates for the smelters are obtained under supply contracts from other mines in the United States, Canada, South America, Australia, and elsewhere. During the five-year period ended December 31, 1972, the proportion of Bunker Hill's annual lead requirements and zinc requirements supplied by mines owned or controlled by Bunker Hill averaged 32% and 46%, respectively. In 1971 and 1972, such mines furnished 34% and 29% of lead and 56% and 47% of zinc requirements, respectively, for its smelters.

Other products which are recovered from lead ores and concentrates through the lead smelting operation include silver and zinc and minor qualities of gold, cadmium, copper, and antimony. The silver, zinc, and cadmium are further processed in separate facilities to produce fine silver, zinc oxide and cadmium metal, respectively. The gold and copper recovered are sold to others for further refining. The antimony is further processed by Bunker Hill into an antimonial lead alloy which is sold chiefly to manufacturers of electric storage batteries.

Zinc concentrates are smelted at Bunker Hill's electrolytic zinc plant at Kellogg. Related products obtained in the zinc refining operation include cadmium and sulfur. Bunker Hill manufactures sulfuric acid from sulfur removed from the stack gases of the plants located at Kellogg.

Bunker Hill, in a joint venture with Stauffer Chemical Company, produces phosphoric acid and ammonium phosphate fertilizers at a fertilizer plant in Kellogg. In the past, a major portion of Bunker Hill's sulfuric acid was sold to this joint operation. Bunker Hill has installed a third sulfuric acid plant in order to comply with Idaho clean air standards. Acid produced by such plants will be marketed in the Pacific Northwest.

Listed below are the major products at Bunker Hill's Kellogg smelters, including production from concentrates purchased from other sources, for 1972:

Lead Metals (Tons)	131,804
Zinc Metal (Tons)	101,743
Zinc Oxide (Tons of Zinc Content)	25,307
Cadmium Metal (Tons)	540
Refined Silver (Tons)	250
Fertilizer (Tons P_2O_5 Content) (100%)	26,734

BUNKER HILL PLANT FACILITIES

Lead Smelter: The principal facilities are chiefly of steel, brick or concrete construction, and are in good repair and adequate for present and foreseeable needs. Annual capacity of the plant was recently increased to approximately 130,000 tons of primary refined lead. Production in 1972 was 126,300 tons and is expected to reach full capacity in 1973.

Zinc Plant: The zinc plant had been expanded in 1968 to a calculated capacity of 109,000 tons and production gradually rose toward that level (103,000 tons in 1968 and 105,700 in 1969). Purposeful curtailment of production beginning in mid-1970 as a result of unfavorable market conditions was the reason for the 1970 decline to 96,000 tons. This factor together with severe metallurgical (process control) problems encountered in attempting to return to normal operating rates in mid-1971, caused 1971 production to decline to 94,000 tons. A series of plant modifications were made in the fall of 1971 and a turnaround was made in 1972 with a production of 102,000 tons. Recalculation and tests of plant capacity in 1972 indicate that with expected feed materials the actual average capacity of the plant is about 104,000 annual tons rather than the 109,000 originally projected.

13. HANNA MINING COMPANY AND CONSOLIDATED SUBSIDIARIES

GENERAL

The Hanna Mining Company is one of the world's largest independent producers of iron ore. It operates four iron pellet projects in the United States – one wholly owned, one jointly owned – and two in which it has minority interests. It operates one natural ore mine in Minnesota. It is the largest stockholder of Iron Ore Company of Canada and serves as manager of that company. Through St. John d'el Rey Mining Company, Hanna has an indirect one-third interest in a Brazilian iron ore company which in 1973 began operating a major new project.

Hanna produces primary nickel, ferrosilicon, and silicon metal at wholly owned facilities in the United States. It has interest in oil and gas production and in an integrated aluminum producer in Brazil.

It operates bulk cargo vessels on the Great Lakes and in the St. Lawrence Seaway, an ocean shipping chartering agency, and coal and ore docks owned by others.

Hanna conducts geological exploration and metallurgical research, most of which in recent years has been focused on non-ferrous minerals.

Its investments include minority holdings in National Steel Corporation, two Canadian concession companies, and a Brazilian petrochemicals holding company.

Table A-13.1,which includes Hanna's equity portion of earnings and losses of Iron Ore Company of Canada, St. John d'el Rey Mining Company, and other associated companies, indicates the approximate percentage contribution to Hanna's total net sales and operating revenues, and to its income before income taxes, by each of its lines of business for each of the past five years.

The company in 1974 had 3,338 employees.

A summary of Hanna's operating results for the last five years is presented in Table A-13.2.

Sales to customers outside the United States and Canada accounted for approximately 24% of the total iron ore tonnage sold in 1974. There is no significant difference in profitability between domestic and foreign sales of iron ore originating from the same operation. Foreign sales by Hanna and its subsidiaries are made in U.S. dollars and on terms and conditions similar to domestic sales.

TABLE A-13.1

HANNA MINING SALES AND REVENUE

	1974	1973	1972	1971	1970
Net Sales and Operating Revenues ($ millions)	272	205	176	197	203
Revenue Breakdown:					
Iron Ore	67%	67%	70%	76%	74%
Ferronickel	15	19	20	15	16
Transportation	13	12	9	8	9
Other	5	2	1	1	1
Total	100%	100%	100%	100%	100%

	1974	1973	1972	1971	1970
Income before Income Taxes:					
Iron Ore	26%	54%	58%	68%	54%
Ferronickel	47	49	61	43	40
Transportation	17	7	3	2	5
Silicon Products	13				
Other Products	8	4	2		
Investments	16	16	14	12	12
Unallocated Exploration, Administrative and Other	(27)	(30)	(38)	(27)	(11)
Total	100%	100%	100%	100%	100%

Source: Hanna Mining Co., 1974 Annual Report.

Approximately 17% of the tons sold in 1974 by Iron Ore Company of Canada, located in Canada, were to Hanna.

PROPERTIES

Hanna Mining Company has ownership interests and manages six iron ore concentrate and pellet plant operations in the United States and Canada (Table A-13.3).

Each of the concentrate and pellet plants referred to above receives its ore from nearby mines. (The amount of crude ore which must be processed to yield one ton of concentrates or pellets ranges from two to slightly more than three tons for the mines from which Hanna makes purchases.)

Production by Hanna-operated iron ore properties in North America in 1974 totaled some 32 million tons, including 9.9 million tons for the Company's own account.

TABLE A-13.2

SUMMARY OF OPERATIONS

THE HANNA MINING COMPANY AND CONSOLIDATED SUBSIDIARIES

	YEAR ENDED DECEMBER 31				
	1974	1973	1972	1971	1970
	(Amounts in thousands, except per share data)				
Net sales and operating revenues	$272,227	$204,790	$176,399	$197,089	$203,442
Cost of goods sold and operating expenses	210,686	168,637	144,759	165,969	167,410
Depreciation and depletion	9,456	9,815	7,740	7,149	7,165
Interest on long-term debt	4,142	2,805	2,742	2,828	2,979
Income taxes	16,262	7,285	5,166	4,897	9,296
Income of consolidated companies	30,259	15,085	14,225	14,993	17,460
Income(loss) of companies carried at equity	(9,756)	7,736	3,794	11,380	13,696
Net income	20,503	22,821	18,019	26,373	31,156

Source: Hanna Mining Co., 1974 Annual Report

In 1974, Iron Ore Company of Canada shipped 23.1 million tons of ore. Capacity at IOC has been expanded to about 32 million tons of ore per year. Most production has already been sold under long-term contracts extending through 1996.

Hanna produces ferronickel from a mine and smelter located near Riddle, Oregon. The smelter, the only one in the United States, has an annual capacity of approximately 26 million pounds of contained nickel and produced 26,154,000 pounds in 1974.

Hanna produces silicon metal and ferrosilicon at a smelter near Wenatchee, Washington. The smelter, which has an annual capacity of approximately 30,000,000 pounds of contained silicon, produced 16,645,000 pounds in 1974, after acquisition by Hanna.

Hanna-operated vessels on the Great Lakes and in the St. Lawrence Seaway transported 6.4 million tons of iron ore in 1974 (down from 1973 as a result of strikes).

TABLE A-13.3

HANNA MINING PLANT OPERATIONS
(1974)

Name and Location	Annual Capacity in Thousands of Long Tons	Production in Long Tons	Hanna's Interest
Groveland Mine, Michigan - pellets	2,000	2,015	100%
Butler Taconite Project			
Mesabi Range, Minnesota - pellets	2,500	2,524	37.5%
National Steel Pellet Plant			
Mesabi Range, Minnesota - pellets	2,600	2,477	15%
Pilot Knob Pellet Company			
Missouri - pellets	[illegible],000	686	50%
Iron Ore Company of Canada: (IOC)			
Carol Lake, Labrador			
Pellets	1[illegible],000	7,969	26.37%
Concentrates (to be shipped)	1[illegible],[illegible]00*	4,761	26.37%
Sept Iles, Quebec - pellets	[illegible],000*	1,999	26.37%

* Capacity when full operating rates are achieved.

Source: Hanna Mining Co. Annual Report 1974

Additional information is presented in Table A-13.4.

CAPITALIZATION AND FINANCES

The Company had $48 million in long-term debt at December 31, 1974. This represented 15% of total capitalization.

Net working capital was $47.5 million, the second-lowest level in several years, and the current ratio was only 2.0, the lowest in over a decade.

A seven-year financial comparison is presented in Table A-13.5.

The Company's 27.1% interest in Iron Ore Company of Canada is carried at cost adjusted for equity in earnings and losses since date of acquisition, less dividends.

TABLE A-13.4

HANNA MINING PROPERTIES, AFFILIATES AND OPERATIONS

Iron Ore/United States

Wholly Owned

Groveland Mine
Open pit mine, concentrator and pellet plant, Michigan

Partially Owned

Butler Taconite Project (37.5%)
Open pit mine, concentrator and pellet plant; Minnesota

Hanna Ore Mining Company (15%)
Whitney Mine; Minnesota

National Steel Pellet Company (15%)
Open pit mine, concentrator and pellet plant, Minnesota

Pilot Knob Pellet Company (50%)
Underground mine, concentrator and pellet plant, Missouri

Ore Sales Division
Cleveland, Ohio

Iron Ore/Canada

Partially Owned

Iron Ore Company of Canada (27.14%)
Open pit mines at Schefferville, open pit mines, concentrator and pellet plant at Labrador City, Quebec North Shore & Labrador railroad, concentrator and pellet plant and loading terminal at Sept-Iles, Quebec and Labrador

Hollinger North Shore Exploration Co., Limited (40%)
Quebec concessions

Labrador Mining and Exploration Co., Limited (22.3%)
Labrador concessions

Managing Agents

National Steel Corporation of Canada, Limited
Open pit mine, concentrator and pellet plant, Ontario

Ore Sales Agent
London, England

Non-Ferrous Operations

Wholly Owned

Ferronickel
Open pit mine and smelter, Oregon

Silicon and Ferrosilicon
Smelter, Washington

Overseas Operations

Partially Owned Iron Ore

St John d'el Rey Mining Company, Limited (66.3%)
49% ownership of Mineracoes Brasileiras Reunidas S.A.--MBR, open pit mines and properties, crushing and screening facilities and vessel loading terminal; Brazil

Partially Owned Aluminum

Companhia Mineira de Aluminio (Alcominas) (30%)
Open pit bauxite mine, alumina refining plant and aluminum smelter, Brazil

Partially Owned Nickel

Exploraciones y Explotaciones Mineras Izabel, S.A. (Exmibal) (20%)
Open pit mine and smelter under construction; Guatemala

Partially Owned Petrochemicals

Uniao de Industrias Petroquimicas S.A. (Unipar) (15%)
Holding company with varying interests in seven petrochemical plants, Brazil

Marine Operations

Domestic

Operators of Ore Unloading and Coal Loading Docks
Cleveland, Ashtabula and Sandusky, Ohio, and Philadelphia, Pennsylvania

One Partially Owned (33-1/3%) Lake Vessel

Operators of Lake Vessels Owned by National Steel Corporation

Seaway

Partial Ownership in Four Vessels Operating in St. Lawrence Seaway

Ocean

Two Wholly Owned Bulk Cargo Vessels

Chartering and Shipping Agency
Greenwich, Connecticut

TABLE A-13.5

SEVEN YEAR FINANCIAL COMPARISON

SUMMARY OF OPERATIONS	1974	1973	1972	1971	1970	1969	1968
	(Amounts In Thousands, Except Per Share Data)						
Net Sales and Operating Revenues	$272,227	204,790	176,399	197,089	203,442	175,988	153,104
Cost of Goods Sold and Operating Expenses	$210,686	168,637	144,759	165,969	167,410	141,314	130,262
Depreciation and Depletion	$ 9,456	9,815	7,740	7,149	7,165	7,113	5,943
Interest on Long-Term Debt	$ 4,142	2,805	2,742	2,828	2,979	3,317	3,637
Income Taxes	$ 16,262	7,285	5,166	4,897	9,296	7,592	146
Income of Consolidated Companies	$ 30,259	15,085	14,225	14,993	17,460	16,028	12,548
Income (Loss) of Companies Carried at Equity	$ (9,756)	7,736	3,794	11,380	13,696	5,472	9,945
Net Income	$ 20,503	22,821	18,019	26,373	31,156	21,500	22,493
Net Income Per Share	$ 2.32	2.58	2.04	2.99	3.55	2.47	2.59
Cash Dividends	$ 11,927	11,927	11,927	11,485	11,403	10,658	8,684
Dividends Per Share	$ 1.35	1.35	1.35	1.30	1.30	1.225	1.00
BALANCE SHEET							
Working Capital	$ 47,483	49,392	46,680	74,102	74,141	63,663	56,370
Property, Plant, and Equipment	53,424	52,274	45,783	38,775	36,942	39,982	42,669
Other Assets	246,375	227,221	217,606	192,972	179,189	167,494	165,317
Long-Term Debt	(48,503)	(39,044)	(31,840)	(30,813)	(30,860)	(34,591)	(41,583)
Total	$298,779	289,843	278,229	275,036	259,412	236,548	222,773
Less Reserves	15,616	15,256	14,537	17,437	16,701	15,671	14,086
Total Stockholders' Equity	$283,163	274,587	263,692	257,599	242,711	220,877	208,687
Shares Outstanding	8,835	8,835	8,835	8,835	8,835	8,747	8,688
Book Value Per Share	$ 32.05	31.08	29.85	29.16	27.47	25.25	24.02

The above summary has been restated to reflect various accounting changes.

Source: Hanna Mining Co. – Annual Report 1974

Following is a summary of financial information of Iron Ore Company of Canada:

	1974	1973
Net current assets	$ 58,583,000	$ 21,257,000
Investments and other assets	16,410,000	17,646,000
Property, plant and equipment–net	690,918,000	708,462,000
	765,911,000	747,365,000
Long-term debt and reserves	(498,501,000)	(481,638,000)
Net assets	$267,410,000	$265,727,000
Sales and operating revenues	$364,121,000	$281,085,000
Net (loss) income	$ (48,317,000)	$ 11,324,000

14. HECLA MINING COMPANY

Hecla and its subsidiaries are engaged in three lines of business: mining and concentration of nonferrous ores, production and sale of sand and gravel products, and fabrication of prestressed concrete structures. Over 50% of Hecla's revenues come from silver mining, with the balance split about equally between lead and all other products. The Company has substantial interests in the Coeur d'Alene silver mining district of Idaho.

Hecla owns the Lucky Friday Mine (acquired in 1964) and a one-third interest in the Sunshine Unit Area (operated by Sunshine Mining Company – see separate profile), and has a 30% interest (with Bunker Hill owning the balance) in the Star-Morning Unit Area production of silver, lead, and zinc. The Company also owns Ace Concrete Company, a producer of ready-mix concrete and sand and gravel; and owns 10.3% of the stock of Day Mines.

Hecla holds a 50% interest in the large Lakeshore Copper property near Casa Grande, Arizona, and is the operator of the Lakeshore Mine project (El Paso National Gas owns the remaining 50%). Production of electrowon cathodes and copper precipitates began in 1975, and should build up gradually to a total of 65,000 tons of copper per year by the end of the year. An agreement was made covering 35,000 tons/year of copper, contained in precipitates, which will be sent to ASARCO for smelting at its Hayden, El Paso, and Tacoma smelters. The total cost of the project is estimated to be nearly $200 million. Hecla's share (exclusive of interest) of the cost to complete the project is expected to be $30 million.

This project thus looms large in Hecla's outlook, since the Company's total revenues in 1974 were only $29 million (an all-time high). Capital expenditures in 1974 were $29 million. The Company has a credit agreement with major commercial banks to assist in financing its share of costs to complete the Lakeshore project. The Company's total capitalization at year-end 1974 was represented by $20 million in debt and $63 million in stockholders' equity (the latter around $100 million with common stock at market value).

Hecla also owns 35.4% of Granduc Mines, Ltd. (British Columbia), whose Granduc Mine is leased to ASARCO and a Newmont Mining subsidiary for development. Granduc Mines, Ltd. has been in financial difficulties. Hecla recorded a small loss on its equity in 1974, and was "uncertain as to what extent and when further income might be realized."

15. HOMESTAKE MINING COMPANY

Homestake Mining Company and its subsidiaries are principally engaged in mining and related activities. The Company has a total of about 2000 employees. Its products are gold, lead, zinc, copper, silver, uranium, and forest products. Total revenues in 1974 were $125 million, with net income of $34 million.

Gold bullion, which is produced at the Homestake gold mine in Lead, South Dakota, is sold mainly to commercial consumers within the U.S. Gold sales ($59.8 million in 1974) also include unrefined bullion purchased for further processing. Homestake is the largest U.S. gold producer (343,650 ounces in 1974). The Company claims total reserves of over 15 million tons of ore averaging 0.262 ounces of gold per ton.

Lead-zinc operations ($51 million in 1974 sales) are believed to provide the largest share of profits. Lead and zinc concentrates and refined lead are produced at a mine, mill, and lead smelter near Boss, Missouri, which are owned jointly with AMAX. Refined lead (33,586 tons in 1974) is sold to U.S. commercial consumers. Lead concentrates are sold to domestic and foreign smelters. Zinc concentrates (55,181 tons in 1974) are sold to a domestic smelter. (Additional details are provided below under Homestake Lead Company of Missouri.)

Silver-lead concentrates are produced at the Company's Bulldog mine and mill near Creede, Colorado and sold under a contract with a domestic smelter. Silver sales in 1974 exceeded 1 million ounces.

Uranium ore is mined and processed at the United Nuclear-Homestake Partners' facilities (30%-owned, with a carrying value of $2.3 million) near Grants, New Mexico. Uranium concentrates produced from the partnership mines are distributed in kind to the partners. In addition, Homestake operates a uranium mine in the Grants area and these ores are processed through the partnership mill on a toll basis. Uranium concentrates are sold primarily in the domestic market. The Company also purchases uranium concentrates for resale. In 1974, Homestake's share of production amounted to 200 tons of U_3O_8; revenues were $1.7 million.

Copper, lead, and zinc concentrates are produced at the Madrigal Partnerships' mine in Peru and sold to smelters in Japan. The Homestake-Keweenaw Venture, in which Homestake Copper Company, a wholly owned subsidiary, has a 60% interest, is exploring copper properties on the Keweenaw Peninsula in Michigan; a pilot mill is under construction and expected to produce 3100 tons of copper per year. The subsidiary's investment in the venture aggregated $1,256,000 as of December 31, 1974.

Lumber and by-products are produced at Spearfish, South Dakota from timber harvested from company-owned and U.S. Forest Service lands in South Dakota and Wyoming. Lumber products are sold in the midwest commercial market and are also used in the gold mining operation.

Homestake's consolidated income statement for the years 1973 and 1974 is presented in Table A-15.1.

Homestake had operating revenues in 1974 of $122 million, with operating income of $53 million, and net income of $34 million – all were all time high figures, reflecting the recent historically high gold prices and strong lead-zinc markets.

The Company had total assets as of December 31, 1974, of $155 million, of which mining properties and plant and equipment accounted for less than $40 million, at book value. The Company has built up substantial investments in marketable securities, and a strong working capital position.

Stated capitalization at the end of 1974 was $128 million of which 4% was debt, and the balance, shareholders' equity.

Homestake Lead Company of Missouri, a wholly owned subsidiary, has a 50% undivided interest in lead-zinc mining properties and a concentrating mill near Boss, Missouri; Homestake Lead's interests are included in property, plant, and equipment. Mining and milling operations of the jointly owned facilities are conducted at cost for the tenants in common. Amax-Homestake Lead Tollers, a partnership in which Homestake Smelting Company, a wholly owned subsidiary of Homestake Lead, has a 50% interest, operates a nearby smelter which provides services for the partners and others on a toll basis. Homestake Smelting's investment as of December 31, 1974 and 1973 aggregated $11,698,000 and $11,543,000 respectively, represented by its equity in the partnership, $11,386,000 and $11,201,000, and unamortized interest cost of $312,000 and $342,000. Financial statements of the partnership are included in annual reports filed with the Securities and Exchange Commission; summarized financial position as of December 31, 1974 and 1973 and operating results for the two years then ended are listed in Table A-15.2.

Uranium

The partnership mill operated at near capacity in 1974. Approximately 33% of the available capacity was used to process ores on a toll basis for a non-partner (Anaconda) in accordance with an agreement entered into in late 1973. The partnership encountered significant amenability problems in processing the non-partner's ores. As a result, the processing of these ores was suspended in late 1974 and possible remedial steps are being studied.

TABLE A-15.1

HOMESTAKE MINING COMPANY AND SUBSIDIARIES
STATEMENT OF CONSOLIDATED INCOME
FOR THE YEARS ENDED DECEMBER 31, 1974 and 1973

	1974	1973
	$ Millions	
Revenues:		
Sales:		
Gold	$ 59.8	$ 40.10
Lead and zinc	51.1	36.44
Silver	6.3	5.47
Uranium	1.68	9.30
Forest products	2.84	3.80
Interest and dividends	4.59	2.84
Losses – marketable and other securities	(2.67)	
Share of profits – mining ventures	.48	.47
Royalties	.71	.58
Sales of exploration venture interests		.60
Other income	.78	.86
Total	125.72	100.49
Costs and Expenses:		
Product and shipping costs – excluding items listed below	57.60	54.65
Administrative and selling expenses	5.58	4.50
Taxes – other than income taxes	3.57	3.15
Exploration costs	2.79	1.38
Amortization, depreciation, and depletion	3.56	3.40
Interest – principally long-term bank loans	.52	.68
Provision for loss on stock previously acquired in disposition of Port Costa Products Company		1.00
Income taxes	18.00	9.20
Total	91.62	77.98
Income Before Extraordinary Item	34.10	22.51
Extraordinary Item – Income tax reductions resulting from utilization of loss carryforwards		.70
Net Income	$ 34.10	$ 23.21
Earnings Per Share: (11,300,000 shares outstanding at 12/31/74)		
Income before extraordinary item	$3.01	$2.00
Extraordinary item		.06
Net income	$3.01	$2.06
Dividends Per Share	$1.25	$ .45

Source: Homestake Annual Report 1974.

Exploration and development expenditures were substantially increased in 1974, to nearly $3 million. Homestake acquired the 50% interest, previously held by a partner, in several promising properties and completed the acquisition of an 85% interest in lands known as the Pitch properties which are located in Colorado. Exploration and development expenditures in 1974 were mainly directed toward the development of properties held by the Company rather than seeking new properties.

TABLE A-15.2

AMAX-HOMESTAKE LEAD TOLLERS
(Homestake's 50% portion)

	1974	1973
Financial position:		
Current assets	$ 4,392,000	$ 3,597,000
Property and deferred charges—net	7,874,000	8,105,000
Total	$12,266,000	$11,702,000
Current liabilities and deferred income	$ 880,000	$ 501,000
Partner equity	11,386,000	11,201,000
Total	$12,266,000	$11,702,000
Operating results:		
Revenue	$ 7,601,000	$ 6,314,000
Costs and expenses	5,943,000	4,747,000
Depreciation and amortization	928,000	904,000
Total	6,871,000	5,651,000
Net income	$ 730,000	$ 663,000

16. INSPIRATION CONSOLIDATED COPPER COMPANY

Inspiration is almost entirely a domestic copper producer and accounts for about 4% of U.S. refined output. A continuous cast and rolled copper rod-making facility converts about 65% of Inspiration's copper production into a fabricated form sold to wire and cable manufacturers.*

The bulk of its mine production comes from relatively low-cost open-pit operations in Arizona. Sales were \$85 million in 1972, and included \$73.9 million in deliveries of copper and \$11.2 million in smelting and refining tolls and other operating revenues.

Total mine production in 1972 was 132 million pounds of copper, of which some 75% was obtained from open-pit mining. The Inspiration area mines including heap and dump leaching operations, contributed 77%, Christmas Mine 16%, and the Ox Hide Mine's open-pit and heap-leaching operations, 7%.

The average price received for the 145.5 million pounds of refined copper delivered in 1972 was 50.8¢/pound versus 52.0¢ in 1971. Costs before depreciation, depletion, and taxes were about 4.4¢/pound compared with 38¢/pound in 1971.

Reserves at the Inspiration area are estimated to contain nearly 1 million tons of recoverable copper. Reserves are relatively small compared with other domestic producers, but have been expanded periodically by inclusion of lower-grade ores as the company becomes able to treat such ores economically. (While the amount of ore treated is expanded, the lower grades of ore are a partially offsetting factor.)

Ore reserves at the Christmas mine are estimated at 280,000 tons mineable underground and 130,000 tons mineable in open-pits. Underground mining has been plagued by water inflow and unstable rock conditions. Underground operations were suspended in 1966; the open-pit operations have been expanded. The underground operations are being maintained on a standby basis. Approximately 15,000 tons of reserves are at the Sanchez (Arizona) mine, presently being developed.

The oxide-sulfide ores are concentrated at the Company's dual-process plant and shipped to a nearby smelter (acquired in 1969 from an Anaconda subsidiary) for smelting. Anode copper produced in the smelter is refined in the electrolytic refinery at Inspiration.

*Inspiration lists two major customers, Western Electric and Anaconda Wire and Cable Co., each of whom accounted for more than 24% of total 1972 revenues.

The smelter at Inspiration treated 356,000 tons of new copper-bearing material during 1972. Toll and custom material from other producers' mines accounted for 59% (56% in 1971).

Inspiration has faced one of the heaviest burdens for pollution abatement expenditures and costs, relative to the size of the Company and its financial resources. In 1972, Inspiration's plan for meeting Arizona smelter emission control standards by 1974 called for a new installation costing about $45 million. Some $13.2 million was to be advanced by a toll customer, to be repaid over the term of a ten-year contract for treating the customer's concentrates. The balance was being borrowed on bank revolving credit, to be replaced by long-term debt financing.

Expenditures for Inspiration's smelter pollution control project reportedly reached $54 million by year-end 1973. Some $16.8 million has been advanced by toll customers with repayment to be made over the term of ten-year contracts for treatment of concentrates. Following receipt of a favorable ruling from the Internal Revenue Service in October, 1973, an additional $38 million in bank loans was converted into tax exempt Pollution Control Revenue Bonds. These bonds, held by the same banks, will be repaid quarterly over a six-year period beginning May 15, 1974.

The new smelter, using an electric furnace design by Elkem of Norway, converters designed by Metallurgie Hoboken-Overpelt of Belgium, and including a Lurgi (German) sulfuric acid plant adjacent to the existing Arizona smelter, was scheduled to come on-stream in early 1974. The new complex is designed to meet Arizona's air pollution standards.

A key ingredient in Inspiration's opting for an electric furnace was the availability of a "large block of interruptible reserve power at a tolerable price" from the Salt River Power Project in the area.

Another factor was Inspiration's large tonnage of submarginal mineral amenable to copper recovery by sulfuric acid leaching and Inspiration's prior work on acid leaching. Thus, unlike most other companies, it could utilize most of the acid produced from the new smelter complex.

When sulfuric acid from the new plant is available, a heap-leaching operation will be started at Willow Springs, using ore from the new Red Hill and Barney mines, which will produce about 10 million pounds of copper annually.

17. KENNECOTT COPPER CORPORATION

Kennecott Copper Corporation is the largest domestic producer of copper, the second largest domestic producer of molybdenum, and an important source of gold, silver, lead, zinc, high quality iron, and titanium slag. Kennecott is an integrated producer of minerals, metals, and metal products. Kennecott has also been engaged in the coal mining business through its wholly owned subsidiary Peabody Coal Company. Total annual revenues exceed $1 billion. Peabody is one of the two largest producers of coal in the domestic market and the largest supplier of coal to the electric utility industry in the United States.

As of December 31, 1972, the Company employed approximately 29,800 persons in all its divisions and subsidiaries, both domestic and foreign.

Table A-17.1 sets forth, for the year ended December 31, 1972, the approximate amounts of the Company's consolidated sales and income (before income taxes, minority interests, and extraordinary items) attributable to each of its principal lines of business or other sources.

Copper and copper products comprised approximately 80% of Kennecott's Minerals, Metals, and Metals Products sales in recent years. Lead and zinc concentrates have accounted for 2.5-3% of such sales, and amounted to $25 million in 1972.

Kennecott's 49% interest in Sociedad Minera El Teniente S.A., a Chilean corporation which owns and operates the El Teniente copper mine in Chile, was expropriated by the Chilean Constitutional Reform Bill, which became effective in July, 1971. In prior years, Kennecott received over $20 million per year in dividends from El Teniente. Kennecott's investment in Chile was carried at $143.3 million as of December 31, 1971. Some $84.6 million of El Teniente Mining Company notes was the subject of a Contract of Guaranty with the U.S. Overseas Private Investment Corporation. In 1972, Kennecott received a $64.9 million settlement of its expropriation insurance claim, and wrote off its $50 million ($26 million after tax effects) equity in El Teniente stock. Wholly owned subsidiaries include Chase Brass and Copper Co., and Ozark Lead Company. Chase is a leading fabricator of copper and brass mill products. Chase buys a large portion of its copper from Kennecott, accounting for about 10% of Kennecott's copper sales. Profit margins are typically low in this part of the industry; in fact, Chase showed a loss in 1971 and 1972. (In 1972, operations at Chase were profitable in the latter part of the year, but offsetting this was an extended strike in the first quarter.)

TABLE A-17.1

KENNECOTT: SELECTED FINANCIAL DATA

	1972 (In $ Millions) Sales	Income
Minerals, metals and metal products[1]	$800.9	$117.7
Nonoperating income[2]		9.6
Nonoperating deductions		(1.6)
Coal[3]		10.2
Nonoperating income	344.4	8.3
Nonoperating deductions		(2.8)
Shutdown expenses during strikes		(3.9)
Other nonoperating income		2.3
Other nonoperating deductions[4]		(32.6)
Totals	$1,145.3	$107.1

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(1) As a result of an adverse court decision, income for the years 1968 through 1971 has been restated to reflect additional Utah state franchise taxes plus interest.

(2) In each of the years 1968 through 1970, a substantial portion of non-operating income resulted from dividends and interest received from Sociedad Minera El Teniente S.A. in which the company held a 49% equity interest. The company's interest in El Teniente was expropriated by the Government of Chile during 1971 (see "El Teniente" infra).

(3) Peobody Coal Company was acquired on March 29, 1968. Sales and income exclude revenues applied against the Peabody production payment.

(4) Consists of interest, research and miscellaneous expenses.

Source: Kennecott Annual Report 1972

Kennecott also holds two-thirds of Quebec Iron and Titanium Corporation. (Gulf & Western/New Jersey Zinc have minority interests.)

Kennecott operates four copper properties in the United States. In both 1971 and 1972, these divisions produced about 450,000 tons of copper, and 13,000,000 pounds of molybdenum. Kennecott's Utah Copper Division mine in Bingham, Utah, is the second largest copper producer in the world, ranking next to Chile's Chuquicamata mine. (The El Teniente mine in Chile is the world's largest underground copper mine.) Blister copper from the Utah smelter is refined at the company's electrolytic refinery at Garfield, with an annual capacity of 260,000 tons.

The Chino Mines Division comprises the Chino mine at Santa Rita, New Mexico and a concentrator and smelter at Hurley, New Mexico, nine miles away. The Chino mine is an open-pit operation and produced 80,000 tons in 1970 and 71,500 tons in 1971. The Ray Mines Division operates an open-pit mine at Ray, Arizona. The ore is concentrated and smelted in Company facilities at Hayden, Arizona.

At the Nevada Mines Division, mining is by the open-pit method in Ruth, Nevada. The ore is concentrated, then smelted in company plants at McGill, Nevada. Blister copper produced from the Ray Mines and Nevada Mines is refined at the refineries of Kennecott Refining Corporation and American Smelting and Refining Company in Baltimore, Maryland.

During 1972, the Federal Environmental Protection Agency (EPA) disapproved portions of the "implementation plans" submitted under the requirements of the Clean Air Amendments of 1970 by the four western states in which Kennecott operates copper smelters. In each case, the portion so disapproved included the state's control strategy for meeting federal air quality standards for sulfur dioxide, emitted by the Company's copper smelters. The plans rejected by the EPA were evolved by the states after lengthy hearings and, in each case, contained stringent requirements with respect to emissions from the Company's smelters. Believing that the states' implementation plans are adequate to ensure compliance with federal air quality standards, Kennecott petitioned the federal courts to review the action of the EPA in rejecting these plans. The requirements of the rejected state plans would necessitate the expenditure by Kennecott of substantial amounts (estimated to total more than $160,000,000) for pollution control equipment and would result in increased operating costs. To the extent that the EPA substitutes more stringent requirements for those included in the state plans, it can be expected that the cost of compliance will increase substantially over the amount indicated above. In the case of Kennecott's Nevada smelter the imposition by the EPA of more stringent requirements than those contained in the Nevada plan may result in the closing of the smelter. In addition, the EPA has recently announced its intention to revise certain of the federal air quality standards. While the effect of this action upon the Company's operations cannot be predicted, Kennecott stated it is reasonable to assume that any increase in the level of air quality standards from those presently in effect will require both additional capital investment and increased operating costs.

In addition to federal regulation, each of the four states has adopted local air quality requirements which, in some cases, are more restrictive than the federal requirements. In Utah, Kennecott is operating its largest copper smelter under a variance which expired on July 1, 1975, while in Arizona operations are being conducted under a conditional operating permit that expired in January, 1974. The Arizona permit, however, cannot be renewed, and the Company's Arizona smelter was to have been in compliance with the state's requirements by January, 1974.

18. MOLYCORP, INC.

GENERAL

Molycorp is engaged in the mining, refining, and distribution of molybdenum, tungsten, boron, rare earths, and columbium.

Molycorp is a leading producer of molybdenum concentrate and the world's leading miner and processor of rare earth products. The Company's principal mines are in New Mexico and California; its principal processing plants are in Pennsylvania (ferroalloys) and Colorado and California (chemicals).

Sales for 1974 were $75 million, with net income of $14 million. Molybdenum products accounted for 56% of sales and 37% of operating profits; rare earth products 31% and 52%; and (other) ferroalloys 13% and 11%, respectively. Approximately 27% of sales were for export.

Molybdenum concentrate production totaled 11.2 million pounds of contained Mo in 1974. Proven ore reserves at January 1, 1975, were 98,152,000 tons grading 0.17% molybdenum disulfide (about 60% molybdenum by weight).

Rare-earth operations are conducted at the Mountain Pass, California open pit mine. Production of rare-earth concentrate in 1974 was 43.9 million pounds. Mill capacity is being expanded to 60 million pounds per year. Proven minable ore reserves at 1974 year-end were 6,118,000 tons containing 7.29% rare-earth oxides. (Major uses for rare-earth products are in color television phosphors, catalysts, glass, iron and steel.)

Molycorp is also a principal domestic supplier of ferrocolumbium and columbium concentrates, which are imported. A 33%-owned Brazilian affiliate, Comp. Brasileira de Metalurgia e Mineracao, is the world's largest producer of columbium concentrates. Production of columbium oxide in concentrates totaled 22.7 million pounds in 1974. (Molycorp and Kennecott Copper each own a substantial interest in Quebec Columbium Ltd., which has mining rights in Quebec.)

Since processing of molybdenum concentrates has been one of the principal activities of Molycorp, further details are important. These concentrates, containing approximately 75% to 90% molybdenum disulfide, are converted to molybdenum oxide by roasting in two furnaces at its Washington, Pennsylvania plant. Roasted product (molybdenum oxide), which contains approximately 60% molybdenum, is the principal product sold. A portion of molybdenum oxide is further processed to ferromolybdenum and molybdenum chemical products. A portion of Molycorp's molybdenum oxide produced must be chemically treated to reduce its lead content to acceptable levels.

Since February, 1966, Molycorp has used concentrates from its Questa mine for approximately 77% of raw material required at its processing operations. In addition, MoS_2 concentrates and other molybdenum products have been purchased from domestic producers and from government stockpiles.

In 1974, Molycorp sold 17.9 million pounds of molybdenum contained in products. Molycorp has a purchase contract with a domestic copper company (believed to be Kennecott) for the purchase of molybdenum concentrate produced as a by-product of copper mining. Such purchases were 1.5 million pounds of contained Mo in 1974. Stockpile purchases were 4.6 million pounds, and the sources accounted for 0.6 million pounds. The balance of 11.2 million pounds, or 62.5%, represented the production from Questa.

Table A-18.1 summarizes details of the Questa and Mountain Pass operations.

The following information and caveats are taken from the May 9, 1975 prospectus issued by Molycorp, Inc.:

UNCERTAIN FUTURE OF QUESTA MINE

Molycorp has been engaged in large-scale open-pit molybdenum mining operations at its Questa, New Mexico facility since 1966. In mid-1971, it became apparent that Molycorp, as a result of, among other factors, higher production costs and lower sales prices than anticipated, would be unable to generate sufficient funds to meet its then current debt repayment requirements and continue its planned rate of development of the Questa mine. As a result, in July 1971, Molycorp instituted a plan restricting the amount of waste removal at its Questa mine to a point which would permit continuation of mining until 1977, and arranged to reschedule the maturities of its bank debt. Recent improvements in market conditions for molybdenum together with Molycorp's improved financial condition, permitted adoption of a modified mining plan which will allow continuance of operations in the present open-pit, with a limited amount of additional waste removal, through 1979 and possibly 1980. Operations at Questa beyond then will require removal of substantial amounts of waste overburden in the present pit or development and preparation for mining of a mineralized zone located about 5,000 feet southwest of the present pit, which is being evaluated by diamond drilling but has not been established as proven or probable ore reserves. Either alternative would require favorable market conditions for molybdenum and substantial additional funds, neither of which is assured. If operations at the Questa facility are not continued so as to ultimately enable mining of substantially all proven and

TABLE A-18.1

MINING OPERATIONS: PRODUCTION COSTS

A. Molybdenum (Questa Operation)

	1970	1971	1972	1973	1974
Ore to primary crusher, tons	6,277 208	6,495,109	5,575,036	5,351,008	5,840,277
Grade, % MoS_2	185	182	218	220	.218
Screen reject, tons	980,982	890,277	237,209	—	—
Grade, % MoS_2	082	094	084	—	—
Ore milled, tons	5,296,226	5,604,832	5,337,827	5,309,236	5,818,276
Grade, % MoS_2	204	196	224	.220	.218
Mill recovery, %	78 00	76 83	76 80	78.35	74 98
Production, molybdenum concentrate, lbs Mo	10,112 370	10,062,186	10,974,761	10,866,261	11,199,993
Sales value of production, per lb Mo, in concentrates (1)	$1 69	$1 68	$1.52	$1.47	$1.96
Cash cost of production, per lb Mo (2)	$1 00	$1 04	$.85	$.96	$1.03
Total cost of production, per lb Mo (3)	$1 39	$1.49	$1 27	$1 40	$1.53

B. Rare Earths (Mt. Pass Operation)

Ore milled, tons	204,397	181,175	228,488	305,073	499,597
Flotation plant feed, % oxides ("REO")	7 2	7 9	7 3	8.6	8.2
Flotation plant recovery, %	68 2	75 2	72 3	74 3	53.4
Production, rare earth concentrate, lbs REO (in thousands)	20 054	21,655	23,602	38,682	43,883
Sales value of production, per lb. REO in concentrates(1)	$ 397	$ 373	$.377	$ 393	$.497
Cash cost of production, per lb REO(2)	$ 154	$ 121	$ 118	$.121	$.186
Total cost of production, per lb. REO(3)	$ 192	$ 152	$ 146	$ 139	$.205

(1) Sales value of production is based on actual sales to customers plus fair market value of intracompany shipments, plus or minus fair market value of increase or decrease in inventories.

(2) Cash cost of production includes all expenditures at mine and mill and chemical plant except capitalized expenditures for land, plant, equipment and mine development

(3) Total costs are cash costs plus depreciation amortization and cost depletion Home office, selling,

Source: Molycorp Prospectus – May 1975 probable open-pit ore reserves, it may be necessary at some indeterminate future date to write off significant amounts of the net book investment in the Questa mine and mill. Molycorp's net book investment in the Questa mine and mill was approximately $66 million at December 31, 1974.

CHANGING CONDITIONS IN MARKET FOR MOLYBDENUM

Molybdenum operations, after allocation of interest expense, were not profitable for the years 1971, 1972 and 1973. For more than two years prior to mid-1973, molybdenum was in over-supply and during much of such period price discounting was prevalent. However, in 1973 demand firmed due to the higher rate of steel operations and by year-end, prices had returned to levels prevailing prior to the price discounting. In 1974, prices were further increased on several occasions to a level which in January and February 1975 remained approximately 60% above the lowest levels of 1973. Molybdenum operations during 1974 were profitable.

Competitively, Molycorp believes that other major producers of molybdenum, particularly those whose production is as a by-product of copper mining operations, have a cost advantage over Molycorp. Also, a significant new source of molybdenum is under development by Amax at Henderson, Colorado. Molycorp has no contractual assurance of a market for its molybdenum products.

Molycorp's mining, milling and processing operations require significant amounts of energy. Molycorp's power generation facilities at its Questa mine are powered by natural gas, with diesel fuel as a standby source of energy. Molycorp's gas purchase contracts are terminable by the sellers and there can be no assurance that adequate supplies will continue to be available.

If operation of the Questa mine is discontinued, it will be necessary to purchase all molybdenum concentrates from others. Molycorp has no commitments for such supplies of molybdenum concentrates.

Molycorp obtains water for use in Questa operations from the Red River and from wells owned by Molycorp. Current milling rates require approximately 3,900 gallons per minute. Molycorp believes present supplies are adequate for continuous operations at these levels.

As of March 1, 1975, the Questa operation employed approximately 550 persons.

ENVIRONMENTAL MATTERS

Molycorp has been granted a permit under the Federal Water Pollution Control Act to decant water from its Questa tailings pond into the Red River. However, the restriction on the molybdenum content in the effluent is, in the opinion of Molycorp, excessively restrictive and would require the installation of a reclaim water line at a cost estimated to be $4 million. Molycorp has appealed for a lower standard than that set by the Permit, and such appeal is pending.

Molybdenum roasting operations at the Washington plant result in the discharge of pollutant sulfur dioxide. Molycorp has been granted a variance by the State of Pennsylvania to permit operation until January 1, 1976 without meeting established pollution control regulations. Molycorp does not expect to be able to comply with the air pollution standards by that date, and, if the variance cannot be extended or modified, it may be necessary to discontinue molybdenum roasting operations at the Washington plant. Molycorp has not decided whether to install air pollution control equipment at the Washington roasters, to construct new roasters (with pollution control equipment) at another location, or to construct new facilities using a hydrometallurgical process (presently being tested). In part, the decision as to whether Molycorp will continue roasting operations depends upon the determination of the future of the Questa mine with respect to periods after 1979. If Molycorp cannot process molybdenum disulfide concentrates, Molycorp's molybdenum operation (including the Questa mine) would be adversely affected.

In 1972, 1973 and 1974 Molycorp made capital expenditures of approximately $39,000, $315,000 and $174,000, respectively, which were directly related to pollution control. By reason of changing legislation and enforcement policies, Molycorp believes that it is not possible to accurately predict future expenditures for pollution control. However, based upon present conditions, Molycorp believes that necessary capital expenditures directly related to pollution control at its mines and plants may aggregate as much as $5 million over the next several years, assuming that roasting operations at the Washington, Pennsylvania plant are discontinued. Molycorp estimates that it may be required to spend as much as an additional $10 million if new molybdenum processing facilities are constructed. Since the mining and chemical industries are particularly affected by environmental problems, expenditures in excess of those currently anticipated may be required. It is likely that such pollution control expenditures will increase production costs, which may not be matched by increased sales prices of products.

FINANCIAL

Molycorp's capitalization at year end 1974 consisted of $13.7 million in long-term debt and $87 million in stockholders' equity. Table A-18.2 presents a five-year summary of changes in financial position.

Molycorp is affiliated with International Mining Corporation, which owns 18% of Molycorp common stock, plus warrants and preferred stock. International Mining and Molycorp also have some common officers and/or directors; as of March 3, 1975, International Mining was deemed the "parent" of Molycorp within the meaning of the Securities Act of 1933 and SEC regulations thereunder.

Under a 1974 agreement, on January 1, 1975, Mitsubishi International Corporation began to serve as exclusive sales agent for Molycorp in Japan. As part of the agreement it purchased from Molycorp a 6.5%, 15-year subordinated note for $5 million due 1989, and convertible into Molycorp common stock at $40 a share.

TABLE A-18.2

MOLYCORP, INC. AND SUBSIDIARIES

CONSOLIDATED STATEMENT OF CHANGES IN FINANCIAL POSITION

For the five years ended December 31, 1974

	Years ended December 31,				
	1970	1971	1972	1973	1974
FUNDS PROVIDED BY:					
Income after current tax provision	$ 4,494,751	$ 1,080,942	$ 5,053,683*	$12,091,331	$18,410,128
Charges (credits) not requiring expenditure of funds:					
Amortization, depletion and depreciation	5,272,061	5,894,427	6,055,329	6,451,548	7,434,491
Amortization of bond discount and expense	307,800	307,801	198,354	112,807	
Deferred bond discount and expense allocable to purchased debentures			689,729	281,390	181,559
Equity in earnings of affiliate, net of cash distribution received	(1,637,128)	548,108	(1,617,645)	(4,482,319)	(5,543,720)
Adjustments of prior year tax provisions charged to deferred taxes	(77,312)	75,755	(24,979)*	75,809	42,364
Total from operations	$ 8,360,172	$ 7,907,033	$10,354,471	$14,530,566	$20,524,822
Notes payable to banks	$10,150,000	$ 5,734,960			
Notes payable to others	200,845		$ 317,129		$ 5,000,000
Increases in accounts payable and accrued expense	726,730	(386,528)	2,077,376	$ 1,847,975	4,112,023
Sales of common stock, net of expenses		2,624	9,506,317	750	(33,865)
Total from other sources	$11,077,575	$ 5,351,056	$11,900,822	$ 1,848,725	$ 9,078,158
TOTAL FUNDS PROVIDED	$19,437,747	$13,258,089	$22,255,293	$16,379,291	$29,602,980
FUNDS USED FOR:					
Additions to property, plant and equipment	$11,449,667	$ 8,664,687	$ 7,029,911	$ 6,215,200	$12,189,796
Repayment of notes to banks	5,900,000	500,000	6,000,000	2,750,000	12,000,000
Repayment of other debt	389,405	202,701	61,044	93,268	79,448
Purchase of debentures			6,013,300	3,264,100	1,329,900
Increase in other deferred items	305,189	1,126,529	(402,809)	273,031	241,787
Increases in other current assets and cost of investments	1,794,769	2,746,949	2,262,321	1,494,343	3,329,562
Common dividends paid					733,646
Preferred dividends paid	502,586	502,578		1,005,046	502,518
Purchase of treasury shares					634,751
TOTAL FUNDS USED	$20,341,616	$13,743,444	$20,963,767	$15,094,988	$31,041,408
NET INCREASE—(DECREASE) IN CASH	$ (903,869)	$ (485,355)	$ 1,291,526	$ 1,284,303	$(1,438,428)

* Restated for comparative purposes

Source: Molycorp Prospectus May 1975

19. MOORE MCCORMACK RESOURCES, INC. (PICKANDS MATHER & CO.)

INTRODUCTION

Moore McCormack Resources, Inc. (formerly Moore & McCormack Co., Inc.) is a water transportation and natural resource company engaged in cargo liner services, the management of iron-ore and coal-mining properties and related transportation services, and the sale of mine-related products.

Regularly scheduled cargo liner services are provided by Moore-McCormack Lines, a federally-subsidized ocean carrier, which operates two steamship lines between the Atlantic Coast and foreign ports.

The Company significantly increased the scope of its operations in April 1973, with the purchase of substantially all of the assets of Pickands Mather & Co. (PM) from Diamond Shamrock Corporation (for $6.1 million cash, a $30 million short-term note, and $30 million in the preferred stock of a subsidiary). PM is a leading supplier of iron-ore pellets and services to the steel industry. PM also owns and operates dry bulk cargo ships that carry iron-ore, pellets, coal and other minerals between the Great Lakes ports.

Moore McCormack groups its sales and revenues by lines of business as shown in Table A-19.1.

Financial position for the same three years is shown in Table A-19.2.

A description of each line of business is presented below:

1. Cargo Liner Services

Moore-McCormack Lines, Incorporated (Lines), a wholly owned subsidiary, operates fourteen general cargo vessels in foreign trade between East Coast United States ports and the East Coast of South America (American Republic Line) and to the South and East Coasts of Africa (Robin Line).

In July and September of 1974, two C-3 class vessels came offhire from charters to the Military Sealift Command and entered the usual trading routes serviced by Lines.

In its overall operation, Lines employs 340 domestic, 281 foreign, and 588 seagoing employees.

TABLE A-19.1

MOORE MCCORMACK RESOURCES: SALES AND REVENUE

	1974		1973 (1)		1972	
	Revenue	Operating Profit	Revenue	Operating Profit	Revenue	Operat Profit
	Millions of Dollars					
Cargo Liner Services	108.0	23.0	69.7	6.1	56.9	4.4
Bulk Transportation	29.4	2.9	23.1	4.3	----	---
Management of Properties	5.4	2.4	4.1	1.9	----	---
Sales of Products						
Coal	91.2	6.8	18.0	3.1	----	---
Other	48.2		26.7		----	---
Totals	282.1	35.2	141.5	15.5	56.9	4.4

NOTES:

(1) Includes results of Pickands Mather & Co., acquired April 3, 1973.

(2) Operating profit is before federal income tax, extraordinary items, and net interest.

Source: Moore McCormack Resources, Inc. Form 10-K report for year ending December 31, 1974.

TABLE A-19.2

MOORE MCCORMACK FINANCIAL POSITION

	1974	1973	1972
		$Millions	
Net Working Capital	40.8	31.4	25.4
Ratio of Current Assets to Current Liabilities	1.6	1.7	3.1
Total Assets	278.2	235.7	138.9
Funds provided from operations	32.4	18.3	9.7
Ratio of average long-term[(a)] debt to average capitalization	37%	33%	24%
Average long-term debt[(a)]	63.9	47.1	28.3
Average stockholders' equity	107.3	97.6	89.0
Average capitalization	171.2	144.7	117.3
Return on average stockholders' equity[(b)]	23%	10%	4%

NOTES:

(a) Long-term debt includes the present value of financing leases and the preferred stock of subsidiary, but excludes borrowings being used to finance the construction of capital assets, until such assets are placed in service.

(b) Return is based on income before extraordinary items.

Source: Moore McCormack Resources Form 10-K Report 1974.

In August 1974, Lines entered into a new Operating Differential Subsidy Agreement with the Maritime Administration. The new agreement became effective, for the purposes of payment of subsidy, on January 1, 1975, and will run for a period of 20 years. Lines has an obligation under the agreement to replace its existing fleet with deliveries beginning in 1985. The agreement terminates on December 31, 1994, and is subject to earlier termination by the United States in the event of various defaults thereunder.

Lines' existing labor agreements with the National Maritime Union, the Masters, Mates and Pilots Union, the Marine Engineers Beneficial Association, American Radio Association and Staff Officers' Association, were scheduled to expire in June 1975, and Lines was negotiating for their renewal as this was written.

2. Bulk Transportation

Pickands Mather & Co. (PM), a wholly owned subsidiary, operates the Great Lakes fleet of The Interlake Steamship Company, a wholly owned subsidiary of Lines, consisting of eleven bulk freighters with an aggregate capacity of 223,000 gross tons, used primarily to transport iron ore at competitive rates for four iron and steel companies pursuant to contracts which expire between 1976 and 1987.

PM also has an ownership interest in, or manages on a fee basis, the operations of several dock facilities for the transshipment of iron ore and coal from bulk vessels.

PM employs approximately 500 employees in its related bulk transportation activities.

Moore-McCormack Bulk Transport, Inc. (Bulk), a wholly owned subsidiary of Lines, executed a Contract of Purchase with National Steel and Shipbuilding Company in July of 1973, for the purchase of three 39,700 ton Coronado class tankers at a cost of $49 million including capitalized interest and net of Construction Differential Subsidy. The vessels are scheduled for delivery in 1975, 1976, and 1977. Bulk has obtained preliminary commitments from the Maritime Administration for the issuance of U.S. Government guaranteed Title XI Merchant Marine Bonds for 75% of the actual cost of the three tankers, and has obtained a commitment for the sale and leaseback of each of the tankers effective at their respective delivery dates. Bulk has executed Charter Agreements with Shell International Petroleum Co., Ltd. to charter each of the vessels for a period of seven years. Bulk has entered into an Operating Differential Subsidy Agreement with the Maritime Administration for the operation of each of these vessels.

3. Management of Properties

PM is the manager of five operating iron ore properties located in Minnesota, Ontario, Newfoundland, Quebec, and Tasmania and has an interest of approximately 5%, 25% and 24%, respectively, in the mines at the latter three locations. As manager, PM supervises the mining of the iron ore and the construction and operation of concentration and pelletizing plants to produce primarily high-grade iron ore pellets. It also plans, manages the construction of, and in some instances, operates the town sites located near the mines and the railroads, docks, and loading facilities required for the transportation of mine products. These properties are operated by PM pursuant to agreements with the owners who are primarily major steel companies, and as compensation PM is reimbursed for substantially all expenses and receives a commission based on the number of tons shipped. The agreements generally continue for the economic life of the property, but may be terminated by either party at the end of any year upon one year's notice. However, in the case of some of the properties, the agreements extend to the end of fixed periods ranging between 1976 and 1988. During 1974, production from these properties amounted to 21,300,000 tons (which amount is substantially the annual capacity), and of this amount, approximately 1,060,000 tons were for PM's account. The three properties in which PM has an interest are held under leases expiring between 1996 and 2055, and at the current rate of production, the economic life for one is one to two years, and the lives of the other two properties are 11 and 65 years. PM also receives payments measured by tonnages shipped from certain properties previously transferred to others.

PM, with Bethlehem and another steel company, is proceeding with the construction of a new pelletizing complex in Hibbing, Minnesota, the initial production of which will be approximately 5,400,000 tons of pellets a year. PM will manage the property and will have a 15% interest therein. Production is expected to be on-stream in 1976. The management arrangement, economic life of the property and the terms of the leases fall within the ranges set forth above. Plans have recently been announced to enlarge the plant's productive capacity 50%, increasing its projected output to 8,100,000 tons annually beginning in 1978. The extent of PM's participation in the expansion tonnage is as yet undetermined.

PM, with a syndicate of European and Japanese companies and an Ivorian Government company, is currently investigating the feasibility of an iron ore development in the Ivory Coast, Africa, where a large scale low grade ore deposit is located at Mount Klahoyo near the City of Man. Preliminary test results indicate that ore at the initial mine site could be beneficiated to produce an estimated 350 million metric tons of high grade magnetic concentrate. Annual production could be in the range of 9-12 million metric tons of pellets.

PM has a one-half interest in a property in Quebec, Canada, estimated to be capable of yielding approximately 200,000,000 tons of iron ore concentrates for pelletizing or for use in a direct reduction process.

PM manages three coal mines, one in Kentucky and two in West Virginia. PM has no ownership interest in two of the mines, but holds a 12.5% interest in the other West Virginia mine which has a production capacity of 1,500,000 tons annually and its reserves are sufficient for 27 years at this production rate. Various steel companies own the first two mines and the balance of the ownership in the third mine. PM has organized and is developing two new underground coal mines in Pike County, Kentucky. The start-up of production is scheduled for late 1976 and 1977, and the financial arrangements for these operations are in the final stages of negotiation. A third mine is in the organizational stage. PM will have a 20% interest in each of these mines, with the balance being held by major utility, steel and manufacturing companies. The projected total annual capacity of these three mines is planned at 3,250,000 net tons. Based on total estimated reserves of 80,000,000 tons, the average life of these three mines will be approximately 25 years.

PM employs approximately 330 persons in its management of properties and supervises approximately 7,000 employees (including 5,300 hourly and 1,700 salaried) who are employed at the various managed operations.

Table A-19.3 summarizes PM's property management business.

4. Sales of Products

PM manufactures and sells foundry coke and related by-products produced at its Solvay Coke Co. Division plant, Milwaukee, Wisconsin (annually approximately 248,000 net tons of coke from its 100 coke ovens). PM also sells commodities both as broker for its own account and as sales agent. These include: the resale of iron ore from its ownership interests and/or iron ore purchased from others; the resale of coal from its ownership interest and coal sold as sales agent; coal purchased and resold as broker; and the sale, as sales agent, of pig iron, ferroalloys, and coke. PM holds the exclusive United States and Canadian rights to issue licenses for the INMOLD and FLOTRET processes (both registered trademarks of Materials and Methods, Ltd.) relating to the production of nodular iron castings. Several licensing arrangements have been consummated and others are pending.

PM has limestone quarrying and processing operations located in adjoining areas of eastern Ohio and western Pennsylvania, near Youngstown, Ohio, on properties owned or held under leases which expire between 1977 and 1997. During 1974, the operations produced 1,870,000 net tons of limestone and 128,000 net tons of by-product.

TABLE A-19.3

PICKANDS MATHER MANAGED PROPERTIES

Managed Iron Ore Properties

	Owners	PM ownership Interest	Annual Production Capacity in Tons(1) (000 omitted)
Erie Mining Company, Minnesota	Bethlehem Steel Corporation, Lykes-Youngstown Corporation; Interlake, Inc ; The Steel Company of Canada, Limited	—	10,300
Wabush Mines, Newfoundland and Quebec, Canada	The Steel Company of Canada, Limited; Dominion Foundries and Steel, Limited; Lykes-Youngstown Corporation, Inland Steel Company; Interlake, Inc ; Wheeling-Pittsburgh Steel Corporation; Finsider (Italy); Pickands Mather & Co	5.2%	6,000
Savage River Mines, Tasmania, Australia	Mitsubishi Corporation; Pickands Mather & Co International; Sumitomo Shoji Kaisha, Ltd; Cerro Corporation; Chemical International France, Ltd ; seven Australian firms	24%	2,500
The Griffith Mine, Ontario, Canada	The Steel Company of Canada, Limited	—	1,500
The Hilton Mines, Quebec, Canada	The Steel Company of Canada Limited, Jones & Laughlin Steel Corporation; Pickands Mather & Co	25%	900
Hibbing Taconite Company, Minnesota(2)	Bethlehem Steel Corporation; Pickands Mather & Co.; The Steel Company of Canada, Limited	15%(3)	5,400(3)

(1) Dry long tons (2,240 pounds). (2) Under construction (3) Original construction

Managed Coal Properties

	Owners	PM ownership Interest	Annual Production Capacity in Net Tons (000 omitted)
Beckley Mine, West Virginia	Jones & Laughlin Steel Corporation; Hoogovens IJmuiden B V., The Steel Company of Canada, Limited, Pickands Mather & Co.	12½%	1,500
Chisholm Mine, Kentucky	The Steel Company of Canada, Limited	—	1,000
Madison Mine, West Virginia	The Steel Company of Canada, Limited	—	750
Leslie Mine, Kentucky(2)	Carolina Power and Light Company; Pickands Mather & Co	20%	1,000
Scotts Branch Mine, Kentucky(2)	Ford Motor Company, Wheeling-Pittsburgh Steel Corporation; Interlake, Inc. , Pickands Mather & Co.	20%	1,250

(2) Under construction.

Source: Pickands Mather Annual Report 1974.

PM employs approximately 530 persons in these operations, including 235 in its coke actıvitites and 240 in the limestone activities.

5. Moore-McCormack Energy, Inc.

(Energy), a wholly owned subsidiary of Moore-McCormack, is a development company which promotes projects utilizing foreign and domestic crude oil sources which involve the utilization of water transportation and related logistical skills. It is anticipated that if such development projects come to fruition, Energy will retain the right to some equity participation and will obtain long-term contracts for water transportation which will be supplied by other related subsidiaries. In addition, Energy has purchased and resold liquid petroleum gases and natural gas liquids.

FINANCIAL STRATEGY AND COMMENTS

Moore-McCormack has given considerable attention to its investment and financing philosophy in its 1974 annual report, embracing many of the questions which EPA has been concerned about in specific cases. It may therefore be useful to present here the approach Moore-McCormack appears to be taking toward investment opportunities, expected returns and risks, and the mix of debt and equity financing in respect to its announced $200 million "Resources Expansion Program."

In view of the strong long-term demand foreseen for such resources as coal and iron ore and for various types of vessel services, the Company has reevaluated and increased its expected after-tax return on the aggregate $200 million in new investment from 10% to approximately 13%. Allowing for an overall six percent cost of new debt capital, Moore-McCormack Resources has in turn raised expected after-tax net return on total capital employed in the projects from 4% to 7%, with the return considerably higher on stockholders' equity alone.

The nature and extent of the company's participation in these new projects is indicated in Table A-19.4. At present, adequate construction financing required in connection with these projects has been arranged and commitments for $171 million of long-term financing have been made, including $136 million in Title XI vessel financing, under the Merchant Marine Act, which is backed by government guarantees. The Company's success in financing such substantial sums in a relatively stringent credit market "confirms management's confidence in the soundness of the expansion program."

The effect of the large proportion of the financing that will be committed in debt form will be to increase, over time, Moore-McCormack Resources' debt-to-capitalization ratio which averaged 37% during 1974. Although "the company has

TABLE A-19.4

FINANCIAL STRUCTURE OF MOORE MCCORMACK
RESOURCES EXPANSION PROGRAM

Financial Structure of Moore McCormack Resources Expansion Program

(In Thousands of Dollars)

Project	Moore McCormack Participation	Equity	Debt
Hibbing Taconite	36,000 15%	10,000	26,000
Moore-McCormack Bulk Transport Three Coronado Class 39,700 DWT Tankers	49,000	0	49,000 leveraged lease
Scott's Branch Coal	10,000 20%	0	10,000
Moore-McCormack Lines Midbody Conversion of Two Constellation Class Vessels	15,000	4,000	11,000
The Interlake Steamship Company Two 59,000 Ton Bulk Carriers	88,000	12,000	76,000
Leslie Coal Mining	9,000 20%	0	9,000
The Interlake Steamship Company Conversion of the H C Jackson	6,000	1,000	5,000

not yet defined an ideal target mix of debt and equity in its capital structure, management feels that continued involvement in projects of the quality under current development, requiring heavy capital investment, warrants a prospective debt capitalization of 50% or more."

Moore-McCormack Resources believes that a high degree of security obtains in its new projects, illustrated by some of their major characteristics: Most of the projects are based on medium- to long-term contractual obligations of others to Moore-McCormack. Such arrangements help to input stable, predictable revenue flows.

The size and relative financial strength of companies with which Moore-McCormack has such contracts also gives additional assurance of stability which, in turn, will assist in financing the projects. Examples are tanker charters to a member of the Royal Dutch/Shell Group, the presence of major U.S., Canadian, and international iron and steel companies as project partners in iron ore development and property interests, and the association of large steel, iron, automotive, and utility companies as partners in coal projects.

"Even though the activities of Pickands Mather & Co. are clearly tied to historically cyclical industries such as steel, the downside risk is not great in a recessionary period. One reason is that most of the mining properties which are managed by PM are designed to be run at capacity. Further, taconite pellets enjoy greater relative demand than natural iron ore, even when a general industry decline occurs in iron ore requirements."

The company stated in its Form 10-K report to the SEC early in 1975 that "Compliance with Federal, state and local provisions regulating the discharge of materials into the environment and relating to the protection of the environment, has not had a material effect upon (its) capital expenditures, earnings or competitive position."

20. NATIONAL ZINC COMPANY

The National Zinc Company operates a horizontal retort smelter in Bartlesville, Oklahoma, which has a capacity of about 55,000 short tons per year of slab zinc and zinc dust. National Zinc accounted for about 7% of domestic primary zinc production in 1972. The Company has an affiliate – Cherry Vale Zinc Company – which is a small feed preparation plant near National Zinc. The horizontal retort smelter is operating under a variance from the Oklahoma particulate emission standards which are reportedly similar to the federal standards.

National Zinc is a custom smelter for domestic mines and sells approximately 45% of its output to hot dip galvanizers and the balance to steel companies directly. Several years ago, the Company spent $2 million for an acid plant which will enable it to meet federal ambient sulfur dioxide emission standards. National Zinc is the only horizontal retort smelter in the U.S. with acid production facilities. Acid sales are now made to large industrial customers such as chemical companies and soap and detergent manufacturers. National Zinc was contemplating an expenditure of about $300,000 to recover sulfur, lead, and cadmium values presently escaping from the sintering plant. With respect to particulate control, National Zinc estimated in 1972 that a bag filter collection system would cost in excess of $5 million and require on the order of $0.8-1 million in annual operating costs.

National Zinc was owned until late 1972 by a New York-based holding company, Metminco, Inc. We understand that the Company was sold in its entirety to a group of private investors from Bartlesville.

In early 1974, Engelhard Minerals & Chemicals Corporation announced plans to acquire, through its Philipp Brothers division, the assets of National Zinc Company, and to construct a 56,000-ton smelter on the Company's plant site. The total cost of the acquisition and construction program combined is expected to be $30 million to $35 million. (Philipp Brothers is a major merchant of more than one hundred minerals, metals, ores, and ferroalloys, and counts lead and zinc among its more profitable items.)

Engelhard expects that permission will be granted by Oklahoma authorities to continue the plant's operation until the new facilities are completed in about two years. The new plant will include some of the existing facilities. The present smelter operation employs about 450 workers.

According to Engelhard, the National Zinc facility's present infrastructure would be retained, and the horizontal retort smelter would be replaced with a "nonpollution" electrolytic zinc smelter.

Early last year, National Zinc stated that it would make capital investments to convert its operation during the 1973-1975 period to an electrolytic plant having approximately a 50,000-ton capacity.

21. NEWMONT MINING

Newmont is a diversified holding company, whose subsidiaries explore, develop, finance, manage, and operate mineral properties. Newmont also has interests in petroleum and cement companies and maintains a securities portfolio. Total revenues in 1972 were $302 million, and net income $44.8 million.

Magma Copper Company is the single largest source of Newmont's income: $166 million in sales and $26 million in net income for 1972 (compared to $113 million and $24 million, respectively, in 1971). Magma, wholly owned is the fourth largest U.S. copper producer. Its principal copper properties, smelter, and refinery are located at San Manuel, Arizona. Another mine-mill complex is at Superior, Arizona.

In Canada, the Granduc copper mine in Northern British Columbia is jointly leased with American Smelting & Refining Company (see ASARCO). The wholly owned Similkameen project near Princeton, B.C., began producing copper concentrates in mid-1972. Design capacity is 15,000 tons of ore daily. Newmont has sold its share of concentrates production at both Canadian properties for several years to Japanese interests.

O'okiep Copper Company, 57.5% owned, operates several South African copper mines; AMAX has a 17% interest. Other mining subsidiaries include Carlin Gold Mining Company, wholly owned; Dawn Mining Company, 51% owned; and Idarado Mining Company, 80.1% owned. Resurrection Mining Company, a wholly owned subsidiary, has a joint venture with ASARCO which is producing lead and zinc concentrates from a mine near Leadville, Colorado; production began early in 1971.

Newmont is engaged in petroleum and natural gas exploration and production in the U.S. and Canada. It also owns, jointly with Cerro Corporation, Atlantic Cement Company.

Investments in other companies are substantial and, as of December 31, 1972, had a market value of more than $350 million. Investments include 18.8% ownership of Canadian Export Gas & Oil Ltd.; 4.2% of Continental Oil Co.; 32.8% of Foote Mineral Co.;* 11.9% of Highveld Steel & Vanadium Corp., Ltd; 28.6% of Palabora Mining Co., Ltd.; 8.1% of St. Joe Minerals Corp.; 39.7% of Sherritt Gordon Mines Ltd.; 10.3% of Southern Peru Copper Corp.; 34.6% of Tsumeb Corporation, Ltd.; 1.6% of Transcontinental Gas Pipe Line Corporation; 13.3% of Cassiar Asbestos Corp., Ltd.; and 3.4% of International Minerals and Chemical Corporation.

*Proposed merger into Newmont in 1973.

The consolidated financial statements include Newmont and all of the domestic and foreign subsidiaries in which Newmont's ownership is more than 50%. In 1972, Newmont adopted the practice of accounting on an equity basis for investment in companies owned 20% to 50%. Newmont's equity in their net income was $13.0 million in 1972. Investments in companies owned less than 20% are recorded at cost. The latter accounted for $5.5 million in dividends paid to Newmont in 1972.

With respect to the impact of pollution control regulations, Newmont stated in its 1972 report to stockholders that a major unresolved problem remains – the establishment of regulations to be prescribed for Magma Copper Company (and other U.S. copper smelters) in achieving either federal or state air quality standards.

In March, 1973, the Arizona State Hearing Board granted Magma a one-year renewal of its conditional operating permit, based on a $30 million plan to meet air pollution standards by installing an acid plant for conversion of the sulfur dioxide in the converter gas to sulfuric acid which is expected to remove up to 70% of the smelter's SO_2 emission. The plan includes a revised collection and cooling system for the converter gases. The acid plant is now under construction, and an ambient air monitoring and weather forecasting system has been installed around San Manuel to aid in control of the smelter to meet Arizona and federal ambient air quality standards. Arrangements have been made to dispose of up to 500,000 tons of acid annually from the production of Magma's new sulfuric acid plant through a long-term sales contract with a major company.

In May, 1972, the EPA rejected parts of Arizona's implementation plan for air pollution control, including regulations covering existing copper smelters. The EPA then proposed to establish regulations of its own that would have imposed fixed emission limitations on each individual smelter. These regulations would have required Magma to be able by mid-1977 to recover 96.4% of all sulfur contained in the smelter feed in order to meet only the federal primary ambient air standards. Magma has stated it believes no known technology is available to attain such a level of emission control except at prohibitive cost; both the copper industry and the State of Arizona challenged the proposed regulations in court. The Company's management believes EPA's proposals were inadvertently based on erroneous data.

With respect to financing, Newmont took steps in 1972 to restructure its corporate debt. A loan of $50 million from a leading insurance company in New York was closed in November, 1972, in the form of 12-year notes, with repayment beginning in December, 1978. Simultaneously, the $130 million revolving credit, placed in 1971 with a group of New York banks, was restructured to reduce the principal amount to $100 million and to include the right, within five years, to permit conversion to a five-year term loan. In 1972, Magma negotiated with a major New York bank and the State of Arizona the purchase of a Pinal County pollution control revenue bond issue of $30 million. The funds are to be used for Magma's air pollution control program.

22. OGLEBAY NORTON COMPANY

INTRODUCTION

Iron Ore

Oglebay Norton is the managing agent for Eveleth Taconite Company, which mines taconite iron ore on the Mesabi Range near Eveleth, Minnesota. Eveleth Taconite Company is 85% owned by Ford Motor Company and 15% by Oglebay Norton. In addition to the mine site, Eveleth Taconite Company owns and operates a processing plant near Forbes, Minnesota, with a production capacity of approximately 2.4 million tons of iron ore pellets per year.

With three major steel producers* the Company formed in 1974 a partnership, Eveleth Expansion Company, to develop and construct a mine and related facilities which will increase its capacity, at operations managed and partially owned by the Company, to approximately six million tons of pellets per year. The Company's participation in the partnership is 20.5% and its share of output has been sold under long-term contract.

Other Mining and Minerals

The Saginaw Mining Company subsidiary was formed in 1974 to operate the Saginaw Mine, located near St. Clairsville, Ohio. This is a bituminous coal mine producing about 500,000 tons per year of steam coal under a long-term contract to a major electric utility.

The Company owns an undeveloped 7,500 acres of coal reserve known as the Rock Creek property located in Boone County, West Virginia. At Ceredo, West Virginia, the Company owns a dock, rail transfer, and river loading facility capable of loading approximately four million tons of coal per year into barges for shipments on the Ohio River. This facility is undergoing an expansion anticipated to be completed by the end of 1975, which will result in increasing its transfer capacity to eight million tons per year.

The Central Silica Company subsidiary is engaged in the mining of sandstone for processing into quartz sands used principally in the glass, paint, ceramic, and foundry industries. It has two operating divisions located at Glass Rock, Ohio, and Millwood, Ohio.

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*Armco, Dominion Foundries, and Steel Company of Canada, Ltd.

At Brownsville, Texas, the Company operates a fluorspar briquetting facility which is designed for annual production of 35,000 tons of metallurgical fluorspar briquettes for customers in the steel industry.

The Company also acts as an agent for the sale of coal and broker for taconite pellets, fluorspar, phosphate rock, and other raw materials produced by others and used in the steel, chemical, glass and ceramic industries.

LAKE TRANSPORTATION

The Columbia Transportation Division operates a fleet of 18 vessels consisting of seven bulk freighters, nine self-unloaders and two crane vessels engaged in the transportation of iron ore, coal and other dry bulk cargo on the Great Lakes. In 1974, Oglebay Norton's vessels carried about 17,000,000 tons of commodities. Of the Company's 1974 revenues from vessel operations, approximately 35% came from transportation of iron ore for Armco Steel under a long-term contract, and approximately 6% came from a similar contract with J&L Steel.

The bulk freighter vessels customarily carry iron ore from ore loading ports on Lake Superior to unloading docks at Lake Erie ports. (Approximately 5,400,000 gross tons of iron ore were carried in 1974.) The self-unloader vessels are equipped with a cargo hold conveyor system and a self-unloader boom. They normally carry coal, sand, stone, slag, and other bulk cargoes. The crane vessels are equipped with revolving cranes to handle pig iron, scrap, and finished steel. The self-unloaders and crane ships combined carried 11,500,000 tons of cargo.

The Company also operates two docks on the Great Lakes, located at Saginaw and Bay City, Michigan. Each dock is engaged in and equipped to handle overseas as well as lake cargo traffic.

MANUFACTURING

Ferro Engineering Division and its Canadian subsidiary design, manufacture and market a wide variety of hot top types as well as various products used in steel castings. Ferro Engineering operates three manufacturing plants in the United States, two located in Cleveland, Ohio, and one in Calumet City, Illinois. The Canadian subsidiary operates a similar manufacturing plant near Hamilton, Ontario.

The T & B Foundry Company subsidiary owns and operates a well-established gray and ductile iron foundry in Cleveland, Ohio. This facility manufactures high-tensile iron castings for a variety of industrial uses, including machine tools, forgings, heavy electrical equipment, pumps, valves, printing machinery, and hot tops for the steel industry.

The Cleveland Metal Stamping Company subsidiary is engaged in tool and die making, the production of metal stampings, spot weldings, assemblies, and wiper strips used in the manufacture of hot tops.

SOURCES OF EARNINGS BY LINES OF BUSINESS

Oglebay Norton had sales and revenues of $87.1 million in 1974, and net income after taxes of $8.7 million.

The approximate percent of total consolidated sales and revenues (including sales commissions, royalties and management fees) and total consolidated profit from operations for the five years ended December 31, 1974, attributable to each of the Company's lines of business are shown in Table A-22.1.

A five-year financial review is presented in Table A-22.2. The Company employs about 1550 persons.

NOTES ON OGLEBAY NORTON'S BALANCE SHEET AND INVESTMENTS

The Company has no long-term debt. Investments include $5.4 million at December 31, 1974 representing the 15% interest in Eveleth Taconite Company. The investment is stated at cost which is the equity in underlying net assets. Eveleth has no income as the stockholders reimburse it for all costs incurred in proportion to their ownership, and the production of the mine is taken by the stockholders in like proportion.

The Eveleth Expansion Company partnership completed long-term financing arrangements for the expansion project with a group of insurance companies, to finance the project solely with proceeds from the issuance of long-term debt securities aggregating $195 million ($56,250,000 issued at December 31, 1974). Agreements relating to the expansion project provide, among other things, for the participants, in proportion to their ownership, to furnish any additional funds necessary to complete the project and purchase pellets produced at prices sufficient to cover all costs of production, which include debt service requirements. The project is expected to be completed in 1976.

A "Capital Construction Fund" (shown as an asset) consists of marketable securities and was created in connection with the provisions of the Merchant Marine Act of 1970. Maximum deposits to the fund are limited to taxable income from vessel operations and may be deducted from such taxable income in the year earned. Deposits and fund earnings amounted to $11.1 million in 1974 and $9.4 million in 1973. Amounts in the fund may be withdrawn for investment in vessels without incurring income tax liability. Such withdrawlas amounted to $15.3

TABLE A-22.1

OGLEBAY NORTON SALES AND REVENUE

	Sales and Revenues as a Percent of Consolidated Sales and Revenues	Profit from Operations as a Percent of Consolidated Profit from Operations (1)
Minerals		
1974	30%	31%
1973	27%	17%
1972	34%	31%
1971	31%	24%
1970	33%	29%
Lake Transportation		
1974	45%	58%
1973	45%	64%
1972	43%	61%
1971	45%	69%
1970	40%	64%
Manufacturing		
1974	25%	11%
1973	28%	19%
1972	23%	8%
1971	24%	7%
1970	27%	7%

(1) Certain corporate general and administrative expenses and dividends, interest and miscellaneous income cannot be allocated to any division in a practicable manner The profit from operations' percentage shown above excludes these items

Source: Oglebay Norton Annual Report 1974.

TABLE A-22.2

OGLEBAY NORTON COMPANY FIVE YEAR FINANCIAL REVIEW

	1974	1973	1972	1971	1970
OPERATIONS					
Gross operating income	**$ 87,062,323**	$72,717,870	$66,314,840	$63,131,407	$60,710,933
Income before income taxes and extraordinary items	**14,332,686**	10,127,164	7,893,689	6,919,338	7,116,795
Income before extraordinary items	**8,659,686**	6,077,164	4,728,689	4,150,338	4,350,766
Extraordinary items, less applicable taxes	**—**	—	(1,800,000)	—	—
Net income	**8,659,686**	6,077,164	2,928,689	4,150,338	4,350,766
Cash dividends paid	**2,917,745**	2,499,398	2,365,324	2,387,074	2,468,164
Net income invested in the business	**5,741,941**	3,577,766	563,365	1,763,264	1,882,602
Depreciation, amortization and depletion	**4,194,847**	3,918,752	4,004,466	3,901,352	3,885,355
Expenditures for properties and equipment, including investment in the Eveleth Taconite Company	**18,239,883**	9,724,613	2,513,804	4,436,201	7,647,569
FINANCIAL POSITION					
Current ratio	**2.35**	4 30	4 24	4.10	5.12
Working capital	**25,658,434**	26,036,995	23,431,073	22,951,937	23,393,777
Total properties, net	**58,593,794**	44,964,580	42,624,278	46,015,838	45,720,378
Total assets	**117,765,745**	97,411,257	89,404,397	87,566,313	83,491,567
Total stockholders' equity	**76,284,617**	70,518,908	66,974,392	66,679,902	66,064,388
Common stockholders' equity	**66,837,117**	61,071,408	57,526,892	57,232,402	56,616,888
DATA PER SHARE OF COMMON STOCK (*)					
Income before extraordinary items	**8.78**	6.01	4.54	3 88	3.92
Extraordinary items, less applicable taxes	**—**	—	(1.94)	—	—
Net income	**8.78**	6.01	2.60	3.88	3.92
Cash dividends paid	**2.60**	2 15	2.00	2 00	2.00
Equity per common share	**72.16**	65 99	62 09	61.28	58.36
OTHER STATISTICS					
Preferred shares outstanding at year-end	**188,950**	188,950	188,950	188,950	188,950
Shares of Common Stock outstanding at year-end	**926,218**	925,481	926,481	933,981	970,101
Number of stockholders at year-end	**1,154**	1,196	1,201	1,246	1,241

(*) Per share figures, except equity per sha[illegible]t Common Stock, are based on the average number of Common Stock shares outstanding during each year and hav[illegible]n computed after provision for annual preferred dividends and stock options. Equity per share of Common Stock is [illegible]l on the actual number of shares of Common Stock outstanding at year-end

Source: Oglebay Norton Annual Report 1974.

million in 1974 and $7.7 million in 1973. However, the depreciable tax basis of the vessels is reduced by the amount of such investment.

The Company's return on stockholders' equity has been in an uptrend for the past five years, and exceeded 12% after taxes for 1974.

23. PHELPS DODGE CORPORATION (PD)

Phelps Dodge is the second largest domestic copper producer. Sales and operating revenues in 1972 were $766 million. Net income after taxes was $82 million. Sales of Phelps Dodge-mined copper in 1972 were 328,000 tons, compared to 289,000 tons in 1971. The Company has approximately 16,000 employees.

The principal business of Phelps Dodge is the production of copper from mines located in the United States, the sale of part of such copper as refinery shapes or as rods, and the fabrication of the remainder of such copper (as well as copper purchased from others) for sale as wire, cable, and tubular products. PD also does smelting and refining of copper and rolling of copper rod on toll for others.

COPPER MINING

Phelps Dodge fills most of its copper requirements from its own open-pit mines at Morenci, Ajo, and Bisbee, Arizona; Tyrone, New Mexico; and underground mines at Bisbee.

During 1971 and 1972, mine output of copper averaged close to 300,000 short tons. Some 40% was produced at the Morenci mine, 20% from Ajo, 20% at Bisbee, and 20% at Tyrone. Reserves are large, with the exception of the Bisbee mine. Additional capacity is expected to be brought in during the early 1970's to replace the Bisbee operations, raising overall capacity to 330,000 tons a year.

In general, PD is thought to be one of the lowest cost copper producers. The Company has reported that production costs, per pound of copper mined, are lowest at Morenci, and are by far the highest at the Bisbee mines. Costs at Ajo and Tyrone are somewhat higher than at Morenci and are about the same as the average costs of all PD operating mines.

The Tyrone mine has been expanded to 100,000 tons annual production capacity. PD expects to shut down the open-pit mine at Bisbee due to exhaustion of economical ore reserves in the near future. It appears likely that the Bisbee underground mines will also shut down at that time, unless the price of copper is high enough to make their operation economic for a while longer.

A new mine near Morenci, Arizona, to be known as the Metcalf mine, is expected to be ready for production in late 1974 with an estimated annual rate of production in excess of 50,000 tons of copper. The cost of developing the Metcalf will be about $180 million of which about $80 million was expended through December 31, 1972. Unit production costs at Metcalf are expected to be similar to those at Ajo and Tyrone.

All the ore at PD's mines is classified as sulfide ore, except for some oxide ores at the Bisbee underground mines. As of early 1973, PD estimated the copper ore reserves at its properties to be approximately 1,580,000,000 tons of ore, containing 9.4 million tons (18.8 billion pounds) of recoverable copper. The Morenci property, the largest of PD's mines, also holds about 60% of PD's reserves.

COPPER SMELTING

PD's copper smelters are located at Morenci, Ajo, and Douglas, Arizona. Production of the Morenci mine and most of that from Tyrone is treated at the Morenci smelter, which has the capacity to treat approximately 900,000 tons annually of new metal-bearing material (that is, copper-bearing materials such as concentrates, ore, and scrap). Production of the Ajo mine, and a portion of the Tyrone production, is treated at the Ajo smelter which has the capacity to treat approximately 300,000 tons of new metal-bearing material annually. Production from the Bisbee mines and a portion of that from Tyrone, as well as custom material and scrap, is treated at the Douglas smelter which has the current capacity to treat approximately 860,000 tons of new metal-bearing material annually. The smelters produce anode copper which is then shipped to PD refineries. When the Metcalf development has been completed, Metcalf concentrates will be smelted at Morenci. The latter plant is a custom operation, processing copper for other producers and treating scrap.

Refinery capacity is located at El Paso (electrolytic and fire-refined) and Laurel Hill, New York (74,000 tons electrolytic and 20,000 tons fire-refined). Refined production including custom output totalled 552,000 tons in 1970. Wire mills are located in New York (4), New Jersey (2), Indiana (2), Kentucky, and Arkansas. Tube mills are in California and New Jersey. A brass foundry is operated in Alabama and interests are held in 13 foreign fabricating operations.

PD is building a new smelter in Hidalgo County, New Mexico, in order to have capacity available to treat concentrates from Tyrone after production begins at Metcalf. The cost of the new smelter, which is the first in the U.S. to use the flash process, is estimated at well over $100 million. This sum includes a townsite and a 36-mile railroad connection.

Substantial capital expenditures, as well as increased operating expenses, will be required to enable PD to comply with existing Arizona air quality regulations at its smelters. Construction of air pollution control facilities at the Ajo smelter, the Company's smallest smelter, is under way at an estimated cost of $28 million. The proposed programs at Morenci and Douglas are more complicated because the material being treated contains more sulfur per ton of copper than at Ajo and because the design of those smelters will necessitate the replacement of basic furnace units.

The program at Ajo includes new converter flues with waste heat boilers, improved electrostatic precipitators, an absorption plant – of a size beyond any ever tried before – to concentrate the SO_2, and a large sulfuric acid plant.

During 1971 installation of new electrostatic precipitators, either replacing or supplementing less efficient existing units at the Morenci and Douglas smelters, and construction of a new reverberatory furnace with improved emission control equipment was begun at Morenci. Detailed engineering and cost studies were completed for additional emission control facilities that may be required at these two smelters.

POLLUTION CONTROL AND RELATED FINANCING

PD stated the following in its 1972 reports:

With respect to air quality control at PD's smelters, efforts in 1972 were complicated by uncertainties and conflicts that developed during the year in the establishment of state and federal regulations. The Arizona regulations were amended in May 1972. While the amended regulations maintain stringent ambient air quality standards, they eliminate the 90% sulfur removal requirement and allow smelter operators some flexibility in selecting means for achieving new standards. However, the EPA, which has the duty under the Federal Clean Air Act either to approve a state's regulations or to establish its own regulations applicable to that state, has not yet found Arizona's amended regulations to be acceptable. On the contrary, in July 1972, EPA proposed sulfur emissions limitations for copper smelters that in most cases are even more stringent than the original Arizona requirement. However, EPA is now reviewing further evidence presented at hearings held in September, and whether Arizona's regulations will ultimately be approved remains to be decided, possibly by the courts.

Notwithstanding these uncertainties, PD's air quality program made substantial progress in 1972. Installation of emissions control facilities at the Ajo smelter is being completed at an estimated cost of $28 million. At the Morenci and Douglas smelters, programs are going forward to enable compliance with the Arizona regulations, at an estimated cost of $85 million at Morenci and $15 million at Douglas. Thus, the total cost of the program is now estimated at $128 million. Of this amount, $41.2 million had been spent by the end of 1972. PD has been issued permits under the Arizona Air Quality Law to operate its smelters at Ajo, Morenci, and Douglas. These permits are conditioned upon satisfactory performance under a separate plan for each smelter to comply with the state's air quality standards, as amended in May 1972. If the more stringent requirements proposed by the EPA last July should ultimately prevail, substantial additional expenditures would be needed at Morenci, and the Douglas smelter would be forced to shut down because large additional expenditures there cannot be justified.

PD had $181 million in long-term debt outstanding December 31, 1972, compared to $166 million at December 31, 1971. Reports to the Securities and Exchange Commission showed that, as of September 30, 1973, long-term debt had increased to $288 million primarily as a result of the issuance of nearly $100 million in pollution control obligations, as follows:

Pollution Control Obligations Issued 1973:

	Amount ($MM)
4-3/8% Bond due 1980	26.6
7% Loan due 1987	10.0
Series A Note securing bonds of the following maturities of Industrial Development Authority of Greenlee, Arizona:	
– 5.6% Pollution Control Revenue Bonds Series A due 1983	1.0
– 6% Pollution Control Revenue Bonds Series A due 1993	9.0
– 6-1/4% Pollution Control Revenue Bonds Series A due 2003	50.0
Total	96.6

INVESTMENTS AND HOLDINGS IN OTHER COMPANIES

PD's investments and stock holdings in other corporations as of December 31, 1971, included the following:

	Percent of Voting Power
American Metal Climax	3%
Southern Peru Copper Corporation	16
Allied Nuclear Corporation (Wyoming)	34
Consolidated Aluminum Corporation (N.Y.)	40
Metminco Incorporated (Delaware)	43
PD Enfield Corporation (Delaware)	71
PD Svenska Metallverken International Corporation (Delaware)	67

Western Nuclear, Inc., was acquired by merger in 1971 and operates as a wholly owned subsidiary.

24. REYNOLDS METALS COMPANY

Reynolds Metals Company is the second largest U.S. producer of primary aluminum and manufactures aluminum products for a broad variety of industries.

Reynolds' rated annual domestic primary aluminum capacity of 975,000 tons was approximately 20.4% of the reported total rated domestic capacity of 4,771,000 tons as of December 31, 1972.

Reynolds distributes its industrial-related products principally through direct sales from its manufacturing plants to converters, fabricators, and distributors, and its consumer-related products principally through sales to wholesale and retail distributors.

Net sales for the five years ended December 31, 1972, are presented in Table A-24.1.

The net income after taxes for Reynolds was only $0.19 million in 1972, compared to $5.6 million in 1971 and $46.9 million in 1970. Included in these was equity in income to subsidiaries and associated companies of $40.4 million in 1972, $37.4 million in 1971, and $50.5 million in 1970 – each larger than Reynolds' pre-tax income in the respective years, indicating the poor results of Reynolds' domestic aluminum business.

Looking at the consolidated statements, the overall pre-tax income was $5.1 million deficit in 1972, $5.5 million in 1971, and $69.5 million in 1970. In the consolidated statements, the equity in income of unconsolidated subsidiaries and associated companies added only $7 million in 1970, $3.9 million in 1971, and $5.5 million in 1972; however, the latter was still large compared to 1972 net results.

PROPERTIES

Reynolds mines bauxite in Jamaica, Arkansas, Haiti, and Guyana. It produces alumina at Hurricane Creek, Arkansas; Corpus Christi, Texas; and Nain, Jamaica. Reynolds Jamaica Alumina, Ltd., a wholly owned subsidiary of Reynolds, formed a partnership, Alumina Partners of Jamaica, with Anaconda Jamaica, Inc., a wholly owned subsidiary of The Anaconda Company and Kaiser Jamaica Corporation, a wholly owned subsidiary of Kaiser Aluminum and Chemical Corporation, under the laws of the State of Delaware, for the processing of bauxite into alumina at Nain, Jamaica. Primary aluminum is produced at Listerhill, Alabama; Longview, Washington; Jones Mills and Arkadelphia, Arkansas; Troutdale, Oregon; Corpus Christi, Texas; Massena, New York; and Baie Comeau, Canada. Primary aluminum production for Reynolds in 1972 was 938,501 short tons.

TABLE A-24.1

REYNOLDS METALS COMPANY

NET SALES

	Primary Aluminum (1) Tons (2)	Amounts	Aluminum Fabricated Products	Other Sales	Total Net Sales
		(In Millions of Dollars)			
1968	304.6	$143.1	$613.8	$ 86.9	$ 843.8
1969 (2)	474.3	232.9	683.0	96.7	1,012.7
1970	495.2	255.2	664.6	115.3	1,035.2
1971	376.2	185.5	759.1	148.6	1,093.2
1972	357.0	164.2	863.3	134.7	1,162.2

(1) Includes small quantities of secondary aluminum.

(2) Includes Canadian Reynolds Metals Company, Ltd. from 1969.

Additionally, Reynolds' proportionate share in primary aluminum capacity of foreign companies (other than Canadian Reynolds Metals Company Limited) in which it has varying degrees of interest is 121,700 tons.

LONG-TERM DEBT

Reynolds owns all of its principal plants and machinery except that part of the land and buildings of certain can plants held under a long-term lease. Substantially all the land, buildings, and equipment of the Reynolds Metals Company in the United States are subject to the lien of the mortgage securing its First Mortgage Bonds.

Reynolds' property additions and retirements are shown in Table A-24.2. Reynolds has built up a very high debt-to-equity ratio and this, combined with the extremely high capital intensity of the primary aluminum business, provides enormous leverage in Reynolds' financial outlook. A very small change in the operating rate or cost or price of aluminum will be magnified in the resulting changes in Reynolds' earnings and profitability.

TABLE A-24.2

REYNOLDS METALS COMPANY

PROPERTY ADDITIONS AND RETIREMENTS

Year	Additions	Retirements	Net Additions
		(In Thousands of Dollars)	
1968	$127,372	$14,330	$113,042
1969	128,600	13,765	114,835
1970	112,670	13,183	99,487
1971	79,319	10,736	68,583
1972	70,079	11,913	58,166
Total	$518,040	$63,927	$454,113

Source: Reynolds Annual Reports 1968-1972.

25. ST. JOE MINERALS CORPORATION

The principal products of St. Joe Minerals Corporation and its subsidiaries are metallic lead and zinc and lead and zinc oxides and alloys (sold to consumers or to or through distributors), iron ore pellets (sold to or by Bethlehem Steel Corporation) and oil and gas (sold to distributors). St. Joe is one of the largest producers and sellers of lead, zinc, and zinc oxide in the United States. The Corporation believes that Meramec Mining Company (owned 50% by the Corporation and 50% by Bethlehem Steel Corporation) is one of the smaller producers and sellers of iron ore pellets in the United States. CanDel (93.6% owned by the Corporation) is one of the smaller producers of oil and gas in Canada. Net sales, excluding operations sold in 1972, were $205 million, and net income for 1972 was $26 million. Although St. Joe has embarked on an acquisition and diversification program, lead and zinc still account for about 80% of consolidated sales and more than 80% of profits.

The principal markets for lead and lead oxide are for use in batteries, cable coverings, ceramics, construction items, motor fuel additives, and pigments; for zinc and zinc oxide, for use in ceramics, die casting, galvanizing, manufacture of brass and bronze, paints, pharmaceuticals, photocopying, and rubber compounding; and for iron ore pellets, for use in the manufacture of steel.

The EPA has published a recommended schedule under which the permissible lead content in gasoline would be progressively reduced between 1974 and 1977, and certain state and local agencies have prohibited or limited the use of lead fuel additives. Widespread prohibitions or limitations on the use of tetraethyl lead as a fuel additive could adversely affect the market for lead. St. Joe's sales of refined lead to tetraethyl lead manufacturers in 1972 amounted to approximately 8.2% of its total dollar sales for the year, as compared with approximately 5.5% in 1971.

Raw materials for St. Joe's lead, zinc, and zinc oxide are lead and zinc ore obtained from the Corporation's own mines, and zinc concentrates purchased from others. Meramec Mining Company produces its iron ore pellets using iron ore from its mine. All raw materials are readily available at present.

The Corporation and its domestic subsidiaries employed 3,963 persons as of December 31, 1972.

The approximate percentage of total sales contributed by each class of similar products was as follows:

Product	For the Year Ended December 31, 1972	
	1972	1971
Lead and Lead Oxides	31%	30%
Zinc and Zinc Oxides	49%	50%
Iron Ore Pellets	6%	8%
Oil and Gas	3%	0%
Others	11%	12%
Total	100%	100%

Properties

Zinc Mining and Smelting. The Corporation owns and operates underground zinc mines in the Balmat-Edwards mining district in St. Lawrence County in northern New York State. In addition, the Corporation's mines in Missouri, described below under "Lead Mining and Smelting," yield zinc as well as lead. In 1972, 84% of the recoverable zinc from the Corporation mines came from the Balmat-Edwards district and 16% came from Missouri. The mill at Edwards has a capacity of 600 tons of ore per day. A new mill, opened in 1971 at the site of the Corporation's new Number 4 shaft at Balmat, processes ore from the Balmat shafts and has a capacity in excess of 4,300 tons of ore per day. The Balmat-Edwards Division is installing mechanical mining operations at its older mines. As a result of the new shaft and mill, the Corporation expects to increase the recoverable zinc content from Balmat-Edwards from 63,500 tons in 1972 to approximately 100,000 tons in 1973.

Substantially all of the zinc concentrates produced at the Balmat-Edwards and Missouri mines are used by the Corporation's Zinc Smelting Division, which runs a smelter near Monaca, Pennsylvania, approximately 30 miles northwest of Pittsburgh. Production from the Balmat-Edwards and Missouri mines accounted for approximately 44% of the zinc concentrates used by the Corporation's Zinc Smelting Division in 1972. The Corporation anticipates that the increase in zinc production from the new shaft and mill at Balmat-Edwards will increase the percentage of Corporation-produced zinc concentrates used by the Zinc Smelting Division to approximately 70%, thereby increasing the profitability of the Corporation's zinc business.

The Zinc Smelting Division presently has an aggregate monthly productive capacity of 17,500 tons of zinc metal, 3,000 tons of American Process zinc oxide, 4,500 tons of refined zinc and 1,800 tons of French Process zinc oxide. The Zinc Smelting Division also has facilities for the small-scale commercial production of lead alloy strip as well as a pilot galvanizing facility to investigate hot-dip galvanizing problems and applications.

Out of the Corporation's total capital expenditures of $31 million budgeted for 1972, approximately $5 million was expended to enable the Zinc Smelting Division to improve environmental aspects of its operations. It is estimated that an additional $8.5 million will be spent for this purpose in 1973, and that a total of approximately $22.5 million will be spent for this purpose during the years 1972-1977. The Corporation expects to finance much of such expenditures from the proceeds of the 5.60% Pollution Control Revenue Bonds, due December 1, 1997, issued by the Beaver County Industrial Development Authority in December 1972 in the aggregate amount of $22.5 million and backed by the Corporation's credit.

Listed below are the quantities of zinc ore mined at the Balmat-Edwards Division and the quantities of slab zinc and zinc oxide produced at the Zinc Smelting Division for each of the past five years:

Year	Ore Mined	Slab Zinc Production	Zinc Oxide Production
1968	797,469	206,259	33,851
1969	751,750	221,739	35,160
1970	753,364	192,847	34,802
1971	789,765	213,275	37,647
1972	869,229	229,709	52,730

Sulfuric acid, cadmium, and mercury are produced as by-products at the Division's smelter. In 1972, 262,944 tons of sulfuric acid (100% base; sold to a single customer under a contract terminable by either party upon twelve months' notice), 677 tons of cadmium and 76 flasks of mercury (76 pounds per flask) were produced. Ore mined at the Balmat-Edwards Division also contains small amounts of lead, and the lead concentrates produced at the Division are sent to the Corporation's smelter at Herculaneum, Missouri.

Lead Mining and Smelting: The Corporation's Southeast Missouri Mining and Milling Division operates underground lead mines in southeastern Missouri. Although lead is the most important product, the Division's mines also produce small amounts of zinc and copper concentrates. Listed below is the mineral production from the Division for each of the past five years:

Year	Lead Concentrates	Zinc Concentrates	Copper Concentrates
1968	249,536	21,661	18,849
1969	349,209	33,398	22,725
1970	313,189	31,649	19,903
1971	301,655	25,315	16,684
1972	310,632	23,247	13,623

In December 1972, the surface plant facilities of the Southeast Missouri Mining and Milling Division were comprised of three mills having an aggregate daily capacity of 15,000 tons. On October 1, 1972, the Federal mill, with a daily capacity of 12,000 tons, was permanently shut down because of the closure of the Federal mines. It is expected that in May 1973 the Brushy Creek mill, with a daily capacity of 5,000 tons, will start operation.

Approximately one-third of the Division's current ore production comes from land belonging to the United States Forest Service and leased to the Corporation under 20-year leases, renewable for successive 20-year periods. Under the terms of these leases and certain development contracts relating thereto between the Corporation and the Federal Government, the Corporation pays to the Bureau of Land Management a royalty of between 4% and 5% of the gross value of the mineral products produced at the processing mill.

In addition to the Missouri mines now in operation in the New Lead Belt mining district, the Corporation has continued development of a new mine at Brushy Creek, Missouri, within the New Lead Belt, on lands leased from the United States Forest Service. The Corporation has completed a mine shaft and has substantially completed a mill and other surface facilities with a planned capacity of 50,000 tons of lead per year, at a total estimated cost of $19 million. Production from Brushy Creek, began early in 1973, and replaced production from the Old Lead Belt, which ceased during September 1972. St. Joe anticipates that production costs at Brushy Creek will approximate those at St. Joe's present operations in the New Lead Belt and will be substantially lower than those in the Old Lead Belt. As a consequence of the shutdown of the Old Lead Belt and of the continuing development at the Brushy Creek property, lead production is expected to be reduced temporarily in 1973. By the end of 1973, Brushy Creek production is expected to reach full capacity and to produce some 50,000 tons of lead annually as compared with 38,000 tons produced in the last full year of operation of the Corporation's mine in the Old Lead Belt.

Almost all of the lead concentrates produced by the Corporation's Missouri mines are smelted at the Corporation's Lead Smelting Division at Herculaneum, Missouri. Production from the Corporation's Missouri lead and New York zinc mines accounted for all of the lead concentrates used at the Lead Smelting Division in 1972.

The Herculaneum smelter has an annual capacity of approximately 225,000 tons of pig lead. A sulfuric acid plant utilizing waste gas from the smelter in 1972 produced 55,089 tons of sulfuric acid (100% base; sold to a single customer under a contract terminable by either party upon 24 months' notice).

In 1972, the Corporation spent approximately $3.4 million at its Herculaneum smelter to improve environmental aspects of its operations. Construction continued on a $4.5 million facility which will double the smelter's gas cleaning capacity. Major alterations have been made in the sulfuric acid plant to improve sulfur dioxide recovery, and in-plant water treatment facilities have been upgraded. It is anticipated that the Corporation will expend approximately $2.0 million in 1973 to improve environmental aspects of operations of the Herculaneum smelter and that a total of approximately $16 million will be expended for this purpose through 1979. Compliance with state or federal environmental regulations may require further substantial expenditures at the Herculaneum and Monaca smelters. Such expenditures may be financed out of general corporate funds or through the issuance of pollution control revenue bonds.

Listed below are the quantities of lead ore mined at the Southeast Missouri Mining and Milling Division, the quantities of lead concentrates produced therefrom, and the production of pig lead at the Lead Smelting Division for each of the past five years:

Year	**Ore Mined**	**Lead Concentrates**	**Pig Lead Production**
1968	6,209,814	259,536	170,799
1969	6,249,963	349,209	223,540
1970	5,978,760	313,189	196,628
1971	5,230,358	301,655	222,006
1972	4,875,072	310,632	209,987

FINANCIAL NOTES

All subsidiaries of the Corporation except its South American subsidiaries are included in the financial statements relating to periods subsequent to January 1, 1971.

In May, 1972, the Corporation acquired 93.6% of the outstanding stock of CanDel Oil Ltd., a Canadian oil and gas production company, from Sohio Petroleum Company for approximately $47 million. Approximately $27.6 million was paid in cash obtained from short-term bank borrowings, and approximately $19.4 million by a note to Sohio paid in December, 1972. The results of CanDel's operations since the date of acquisition have been included in the consolidated income statement. For the year 1972, CanDel had sales of approximately $9.3 million ($5.1 million from crude oil and natural gas liquids and $4.2 million from natural gas) and net income of approximately $3.1 million. St. Joe itself is also participating in worldwide oil and gas exploration, and expects to spend $4-5 million annually for this purpose, commencing in 1973.

In October, 1972, the Corporation sold the capital stock of Lead Belt Water Company for $1.4 million in cash, an amount substantially in excess of its book value.

In October, 1972, the Corporation sold the capital stock of Quemetco, Inc., (a manufacturer of lead oxides and secondary lead alloys which St. Joe had purchased in December, 1970) in which it had invested approximately $20 million to RSR Corporation for $20 million in cash, a $2 million subordinated note payable in October, 1977, and the assumption by RSR of St. Joe's contingent obligations as guarantor of Quemetco's leases of certain of its plants. Notwithstanding such assumption, St. Joe remains contingently liable as guarantor of such leases. Rental payments under such leases are approximately $315,000 per year for initial lease term, which ends in 1997.

On March 6, 1973, the Corporation acquired 55.46% of the outstanding stock of Energy Research Corporation for $1 million. The results of the Energy Research Corporation since the date of acquisition have been included in the consolidated income statement.

On September 6, 1973, St. Joe and A. T. Massey Coal Company announced negotiations for St. Joe's acquisition of Massey on the basis of the exchange of five shares of St. Joe for each share of Massey, subject to adjustment in certain circumstances. Negotiations and further investigations are currently in process. A.T. Massey is a privately owned corporation producing coal of both metallurgical and steam grades in West Virginia and Eastern Kentucky and also selling coal as an agent in the United States and overseas. Massey had sales, as principal or agent, totalling approximately $63 million for the six months ended June 30, 1973.

In 1972, Beaver County Industrial Development Authority sold $22.5 million of 5.6% Pollution Control Revenue Bonds to provide funds for the construction of pollution control facilities at the Corporation's zinc smelter near Monaca, Pennsylvania. The bonds are due December 1, 1997; however, they are subject to optional redemption commencing December 31, 1982, and to mandatory redemption in accordance with sinking fund provisions under the Indenture, commencing December 1, 1988. The Authority and St. Joe have entered into an Installment Agreement whereby St. Joe is unconditionally obligated to make payments to the Trustee sufficient (together with other available funds) to pay all amounts due on the bonds. Title to the project remains with the Authority until the bonds are fully paid.

For accounting purposes, the pollution control facilities are capitalized and depreciated, and the bonds are shown as long-term debt in the consolidated balance sheet. The debt at December 31, 1972 represents the amount of proceeds from the sale of bonds applied to construction payments; the balance of the proceeds are held and invested by the Trustee pending disbursement and, if not applied toward construction payments, are available to service the debt.

26. SUNSHINE MINING COMPANY

Sunshine Mining Company operates the Sunshine Unit Area silver producing property (in the Coeur d'Alene Mining District of Idaho) which accounted for 3.8 million ounces of silver in 1974, of which Sunshine's share was 2.2 million ounces worth $9.7 million. Sunshine has numerous other mining and mineral interests, including: garnet production in Idaho, and oil and gas production in Alberta; electrolytic antimony production; exploration on properties in Montana (gold), Alaska (copper, zinc, and silver), and elsewhere.

However, the bulk of Sunshine's business today comprises the manufacture and sale of *chain link fencing* and fence parts, through its subsidiary, Anchor Post Products, Inc. It also manufactures electronic components including quartz crystals, and precision-built enclosures, panels, slides, and fans.

Table A-26.1 presents the consolidated statement of income for 1974. Table A-26.2 presents line-of-business information.

Sunshine's year-end balance sheet showed $57 million in assets, with $25 million in net working capital. Long-term debt was $21 million, nearly equal to stockholders' equity of $25 million. Capital spending has been modest the last few years.

The dividend paid on Sunshine's common stock was reduced for the fourth quarter of 1974. According to the Company, this was primarily because of a new agreement entered into with American Smelting and Refining Company (ASARCO) which substantially increased refining costs and adversely affected cash flow by deferring ore pricing and payments for three months.

Nevertheless, cash dividends for 1974 were the highest Sunshine has paid since 1940.

SUNSHINE'S EXPLORATION PROGRAM IN ALASKA*

Sunshine's main exploration effort during 1974 was in Alaska. By the end of the working season more than two dozen mineral occurrences had been located on the approximately 24,000 acres under Sunshine's control. Preliminary drilling in one area disclosed interesting zinc-copper-lead-silver mineralization.

Further exploration in this area will require major expenditures and late in 1974 Sunshine began discussions with The Anaconda Company. In February,

*Information taken from 1974 Annual Report.

TABLE A-26.1

SUNSHINE MINING COMPANY

Consolidated Statements of Income
For the years ended December 31, 1974

Operating Revenue	
Mining and Oil	$12,676,989
Manufacturing	47,271,250
	59,948,239
Operating Costs	
Mining and Oil	7,030,266
Manufacturing	34,117,451
Depreciation, depletion and amortization	1,032,586
	42,180,303
Gross Profit	17,767,936
Exploration, intangible drilling costs and abandonments including depreciation and amortization (1974, $109,569; 1973, $109,740)	1,036,419
Selling, administration and general	7,893,077
	8,929,496
Income from Operations	8,838,440
Other deductions (income):	
Interest expense	1,470,319
Interest income	(1,350,821)
Miscellaneous, net	205,059
	324,557
	8,513,883
Gain on completion of silver concentrate sale	—
Income before Provision for Income Taxes	8,513,883
Provision for income taxes	3,475,000
Net Income	$ 5,038,883

Source: Sunshine Mining Co., Annual Report 1974.

TABLE A-26.2

SUNSHINE MINING COMPANY
LINE-OF-BUSINESS INFORMATION

	Years ended December 31				
	1974	1973	1972	1971	1970
Total Revenues:					
Mining and Oil (1)	21.1%	14.1%	10.2%	19.6%	24.3%
Fencing Products	68.6%	74.9%	77.4%	69.0%	62.0%
Electronic Products	10.3%	11.0%	12.4%	11.4%	13.7%
Income (2):					
Mining and Oil	39.1%	51.0%	47.0%	39.6%	72.6%
Fencing Products	49.2%	38.9%	20.0%	49.8%	22.5%
Electronic Products	11.7%	10.1%	33.0%	10.6%	4.9%

(1) Sales of silver concentrates (included in the mining and oil line of business) accounted in the aggregate for approximately 17%, 12%, 7%, 16% and 20% of the Company's sales in 1974, 1973, 1972, 1971, and 1970, respectively. It should be noted that the Sunshine Mine, from which these revenues are derived, was closed by a fire on May 2, 1972 and did not reopen until late in 1972 and was shut down by a strike from March 11, 1973 to July 16, 1973. In 1974, revenues derived from the mine reflect a full year's production as well as higher average silver prices.

(2) Before income taxes and general corporate administration expenses, interest expense, miscellaneous income, and realized loss and provision for unrealized loss on investments, none of which has been allocated to lines of business. The Company maintains a general corporate staff to service the needs of its various divisions. In addition, all significant borrowings and investment of funds not needed for daily operations are made at the general corporate level. Consequently, it is impractical to allocate these items to particular lines of the Company's business.

Income in 1972 is before extraordinary items. Mining and oil income in 1973 includes gain on completion of sale of silver concentrates delivered in 1968 and 1969 which had been written down to prevailing market prices in 1970 and 1971.

Source: Sunshine Mining Company 1974 Annual Report.

1975, the Company entered into a letter agreement with Anaconda and a formal contract is expected to be signed in the near future incorporating the terms of the letter.

Thereunder Anaconda becomes the operator of the exploration project committing itself to expenditures of at least $500,000 for exploration this year. Anaconda may terminate the agreement at the end of any 12-month period after giving proper notice, but should it decide to go through with all of the terms of the agreement it could be extended as long as twenty-five years and involve the expenditure of up to $11,000,000 by Anaconda. Anaconda could earn a 75% interest in the mining claims with Sunshine retaining a minimum 25% carried interest in the Alaskan properties. When Anaconda has spent a total of $3,000,000 on exploration, it will have earned a 51% interest in the property and from then on its share would increase 3% with each additional $1,000,000 invested up to 24%.

If the properties are brought into commercial production, Sunshine would be reimbursed for the $1,000,000 it has expended so far on exploration, on a pro-rata basis and Anaconda would get back its exploratory costs on the same basis before the net operating revenue is divided.