

062006

FEASIBILITY STUDY
of
ZINC-LEAD SMELTING COMPLEX
for
CYPRUS ANVIL MINING CORPORATION
VANCOUVER, B. C.
August 1, 1974

FEASIBILITY STUDY
of
ELECTROLYTIC ZINC AND ELECTRIC LEAD SMELTER
COMPLEX
at
LITTLE SALMON in the YUKON

for the
CYPRUS ANVIL MINING CORPORATION
VANCOUVER, B.C.

August 1, 1974

JAN H. REIMERS AND ASSOCIATES LIMITED

METALLURGICAL CONSULTING ENGINEERS
260 CHURCH STREET, OAKVILLE, ONTARIO, CANADA
CABLES: METCONSULT OAKVILLE
TELEPHONE: (416) 845-5301

August 1, 1974

Mr. R. E. Thurmond, President
Cyprus Anvil Mining Corporation
1550 Alberni Street
Vancouver, B. C. V6G 1A5

Zinc-Lead Smelter Study

Dear Mr. Thurmond:

In August 1973 we were commissioned to study the technical and economic feasibility of a zinc-lead smelter complex, in the Yukon, to process concentrates from the Anvil Mine near Faro, and we are now pleased to submit our report on this project.

Capital and operating cost estimates are presented for two production levels which will amount to 70,000 and 51,550 STPY of slab zinc and refined lead respectively in the first case, and 140,000 and 103,100 STPY respectively for the second case. A 25 % contingency has been applied to the capital cost estimates. For the operating cost estimates we have included a 10 % contingency.

The highest indicated discounted cash flow was 7.5 % which is only one-half of the 15 % considered as the economic minimum in your agreement with the Government of Canada. This low return reflects the fact that this project would suffer from several economic disadvantages as compared with most zinc and lead smelters, in particular

- (1) High capital and operating costs in a remote area of Northern Canada.
- (2) Short life of the project due to limited ore reserves of the Anvil ore body.
- (3) No markets for sulphuric acid within economic shipping distance. This makes it necessary to neutralize acid at great cost, instead of selling it at a profit or at least at a price offsetting recovery costs.

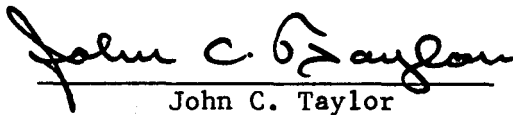
Mr. R. E. Thurmond
Cyprus Anvil Mining Corporation - 2 -

August 1, 1974

Under these circumstances the proposed zinc-lead project does not appear to be economically viable.

We hope that this report provides the information you require at this time to assess the feasibility of a smelting complex in the Yukon.

Yours sincerely,


John C. Taylor


Jan H. Reimers

Distribution:

Cyprus Anvil Mining Corporation, Vancouver	30 copies
Los Angeles	3 copies
File	4 copies

LIST OF CONTENTS

	<u>Page</u>
Introduction	I
Summary	II
Raw materials	1
Review of zinc and lead extraction processes	3
Process description	41
Environmental control and sulphur recovery	54
Metallurgical calculations	
Analysis of raw materials	56
Material and product quantities	57
Losses and recoveries	59
Capital cost estimates	
Summary of combined zinc-lead smelter complex	61
Combined smelter capital cost breakdown	62
Separate electrolytic zinc plant with acid recovery and neutralization	65
Separate electric lead smelter and refinery with acid recovery and neutralization	67
Operating cost estimates (@ 1.5 ¢/KWH power cost)	
Summary of total complex	69
Combined smelter complex	
Electrolytic zinc plant	70
Electric lead smelter	72
Summary of separate plants	75
Separate zinc plant	76
Separate lead smelter	78

continued

LIST OF CONTENTS (cont'd)

	<u>Page</u>
Operating cost estimates (@ 2.33 c/KWH power cost)	
Summary of total complex	81
Combined smelter complex	
Electrolytic zinc plant	82
Electric lead smelter	84
Summary of separate plants	87
Separate zinc plant	88
Separate lead smelter	90
Operating cost estimates (applicable to all cases)	
Hourly labour distribution	93
Hourly labour annual cost	95
Salaried staff	97
Summary of jobs and payroll	
Combined complex	103
Separate plants	104
Comments on estimates	106
Economic feasibility	111
Details of annual cash generation and cash flows	118
Value of zinc concentrates - Japanese terms	128
Value of lead concentrates - Japanese terms	129
Breakdown of plant operating costs	130
Power rates	131
Capital cost	132
Breakdown of working capital	134
Breakdown of townsite capital cost	136

continued

LIST OF CONTENTS (cont'd)

	<u>Page</u>
Process flowsheets	
New Jersey Zinc Company vertical retort process	137
St. Joe electrothermic process	138
Electrolytic process - conventional	139
Pressure leach - electrolytic process	140
Jarosite process	141
Akita - Sherritt residue treatment process	142
Blast furnace lead smelting	143
Electric lead smelting	144
Lead refining	145
Imperial smelting process	146

Drawings

Drawing No.

Electrolytic zinc plant process flowsheet	AM - 1
Electric lead smelter process flowsheet	AM - 2
Plant layout	AM - 3
Pictorial view of plant layout	AM - 4
Site location map	AM - 5

INTRODUCTION

Following the meeting held in Vancouver on August 28, 1973 with R. E. Thurmond, President of Cyprus Anvil Mining Corporation; James F. Olk, Vice President - Administrative; R. Hoffner, Vice President and General Manager; N. Cornish, Production Manager - Metallurgy; W. Krats, Chief Engineer; and U. Jansons, Chief Geologist; Jan H. Reimers and Associates Limited were commissioned to carry out an order-of-magnitude study for a zinc and lead smelting complex in the Yukon which could treat concentrates from the Cyprus Anvil Mining Corporation mill near Faro. The plant is to be capable of producing 70,000 short tons per year of slab zinc and 50,000 short tons per year of refined lead in the first case and 140,000 and 100,000 short tons per year respectively in the second case.

While out west Mr. Jan H. Reimers visited the operations at Faro and toured several possible sites for the smelting complex.

On April 25, 1974 the preliminary report was reviewed at a meeting in our office attended by R. E. Thurmond, J. F. Olk, and R. L. Cook. At that time it was decided to update the staff salaries and present the capital and operating cost estimates on the basis of (a) a combined zinc-lead complex, (b) a separate zinc plant with acid recovery and neutralization, and (c) a separate lead smelter and refinery with acid recovery and neutralization.

In the course of this study we have kept in close contact with Mr. James F. Olk, Vice President - Administrative, and Mr. Robert L. Cook, Treasurer of Cyprus Anvil Mining Corporation.

SUMMARY

ZINC-LEAD SMELTING COMPLEX

The study has been presented to show three possibilities for treating zinc and lead concentrates from Cyprus Anvil Mining Corporation's concentrator at Faro. The possibilities for the two production levels studied are shown below with the annual tonnages of final products in short tons per year. In all three the electrolytic zinc plant will operate 365 days per year while the electric lead smelter and refinery will operate 340 days per year since some shutdowns will be required for maintenance.

Case	I		II	
Annual Production, STPY	<u>Slab zinc</u>	<u>Refined lead</u>	<u>Slab zinc</u>	<u>Refined lead</u>
(a) Combined zinc-lead complex	70,000	51,500	140,000	103,100
(b) Separate electrolytic zinc plant	70,000	-	140,000	-
(c) Separate electric lead smelter and refinery	-	50,000	-	100,000

An electrolytic zinc process with Jarosite precipitation was selected as being the most suitable for Anvil zinc concentrate and the remote location. For the lead concentrate an electric smelting process, similar to that used by Boliden, was selected. For the combined complex both plants discharge sulphur dioxide to a common sulphuric acid plant, the separate plants each have their own sulphuric acid production facilities.

At present it does not appear practical to market sulphuric acid from such a remote location in the quantities anticipated. Therefore, neutralization facilities are provided in all cases which will neutralize excess acid and acidic effluents from each plant.

SITE AND PLANT LAYOUT

The smelting complex in all cases, including sulphuric acid plant and acid neutralization facilities, has been located for estimating purposes at Little Salmon. This location is close to sources of limestone and silica flux while minimizing the haulage of concentrate from Faro. In addition the ground conditions appear to be the most suitable of all the sites inspected. Soil investigations will of course be required, should it be decided to proceed at this location.

A typical site layout of the combined complex, along with a map of the area, are attached showing the combined zinc plant and the lead smelter with auxiliary facilities. The location of this plant on the actual site will depend, as indicated on the layout, on the prevailing wind direction. The electrolytic zinc cells and refined metal storage areas should be located upwind from the concentrate handling and pyrometallurgical facilities. This would also apply should separate plants be installed on this site.

RAW MATERIALS

The concentrates for the smelting complex will be drawn from Anvil's concentrator outside of Faro. It has been assumed that the bulk lead-zinc concentrate will be separated at the mill and combined with the existing concentrates to provide a zinc concentrate averaging 52 % Zn and 33 % S and a lead concentrate averaging 66 % Pb and 18 % S.

Limestone for flux in the lead smelter and acid neutralization, averaging 82 % CaCO_3 , will be quarried at Eagles Nest Bluff. Silicious flux averaging over 80 % SiO_2 will be mined from a deposit west of Carmacks.

It has been assumed that all raw materials will be trucked to the smelting complex at an average moisture of 5.5 %.

EMPLOYMENT

Estimated payroll for the smelting complex, including the sulphuric acid plant and excess acid neutralization is shown below.

	<u>Case</u>	<u>Total salaried staff</u>	<u>Total hourly rate labour</u>	<u>Total payroll</u>
(a) Combined zinc-lead complex	I	75	318	393
	II	86	466	552
(b) Separate electrolytic zinc plant	I	47	178	225
	II	55	255	310
(c) Separate electric lead smelter with refinery	I	48	163	211
	II	59	235	294

These figures include our estimate of the staff and hourly rate labour required for a reasonable level of maintenance.

RECOVERIES AND MAIN PRODUCTS

Zinc plant

Recovery of zinc contained in concentrate is estimated at 94.0 % and the recovery of cadmium at 80 % giving the following tonnages of products in short tons per year.

<u>Case</u>	<u>Zinc in concentrate</u>	<u>Slab zinc</u>	<u>Refined cadmium shapes</u>
I	74,470	70,000	81
II	148,930	140,000	162

Expected lead and precious metal recoveries are estimated at 75 % and will produce the following in the lead-silver leach residue, once it is processed through the lead smelter and refinery in the combined complex.

<u>Case</u>	<u>Lead, short tons/year</u>	<u>Silver, troy oz./year</u>	<u>Gold, troy oz./year</u>
I	1,550	159,200	640
II	3,100	318,300	1,270

Leach residue from a separate electrolytic zinc plant would be sold as a separate product.

Lead smelter

Recovery of lead contained in concentrate to refined lead is 95.1%, giving the following tonnages of refined lead pigs in short tons per year.

<u>Case</u>	<u>Lead in concentrate</u>	<u>Separate lead smelter Refined lead from lead concentrate</u>	<u>Combined Zinc-Lead complex Total refined lead</u>
I	52,860	50,000	51,550
II	105,730	100,000	103,100

The recovery of silver in the lead smelter is estimated at 98 % and will yield 1,430,400 and 2,861,000 troy ounces per year, for cases I and II, in Dore metal. The gold recovered in Dore metal would amount to 1,580 and 3,160 troy ounces per year. Zinc is lost in the electric furnace slag. Recovery by fuming is unattractive due to comparatively low zinc content of slag (15.3 % ZnO) and the high cost of coal.

Sulphur

Sulphur recovery in the form of sulphuric acid, using one single conversion contact acid plant to serve both the zinc plant and the lead smelter is estimated as follows:

(a) As % of sulphur in zinc concentrate	88.6 %
(b) As % of sulphur in lead concentrate	94.4 %
(c) As % of sulphur in zinc and lead concentrates charged to the smelting complex	90.1 %

Total sulphur fixed in sulphuric acid and other products, such as slag, residue, etc., has been estimated at 95.5 %.

ENVIRONMENTAL CONTROL

As well as fixing over 95 % of the sulphur entering the smelting complex facilities have been provided for the removal of any mercury contained in the smelter gases using the process developed by Outokumpu. These facilities may not be necessary where the acid is being neutralized but they have been included in the event that a market develops for the acid. Impure wash acid and excess sulphuric acid are neutralized and disposed of along with the Jarosite residue in a suitable disposal area outside the battery limits of the complex.

CAPITAL COST

Estimated capital costs for a battery limits smelting complex, including sulphuric acid and neutralizing plants, are summarized below in Canadian dollars.

Case	I	II
(a) <u>Combined Zinc-Lead Complex</u>		
Slab zinc produced, STPY	70,000	140,000
Refined lead produced, STPY	<u>51,550</u>	<u>103,100</u>
Zinc plant and lead smelter with refinery, including auxiliary facilities	77,265,000	123,020,000
Sulphuric acid plant	6,453,000	9,673,000
Excess acid neutralization	<u>3,264,000</u>	<u>5,158,000</u>
Total combined complex	86,982,000	137,851,000

continued

Case	I	II
(b) <u>Separate Zinc Plant</u>		
Slab zinc produced, STPY	<u>70,000</u>	<u>140,000</u>
Zinc plant including auxiliary facilities	51,124,000	82,508,000
Sulphuric acid plant to serve zinc plant only	5,485,000	8,221,000
Excess acid neutralization	<u>2,774,000</u>	<u>4,385,000</u>
Total separate zinc plant	59,383,000	95,114,000
(c) <u>Separate Lead Smelter and Refinery</u>		
Refined lead produced, STPY	<u>50,000</u>	<u>100,000</u>
Lead smelter and refinery	29,502,000	45,617,000
Sulphuric acid plant to serve lead smelter only	3,226,000	4,836,000
Excess acid neutralization	<u>1,632,000</u>	<u>2,579,000</u>
Total separate lead smelter	34,360,000	53,032,000

These costs include an allowance of 38 % for engineering and construction supervision, an allowance for purchase of technical knowhow, and a 25 % contingency. No costs have been included however for site acquisition or indirects such as townsite, working capital, etc. These items are however included in the economic feasibility.

continued

OPERATING COST (@ 1.5 c/KWH power cost)

Operating costs have been estimated as follows:

Case	I	II
(a) <u>Combined Zinc-Lead Complex</u>		
Slab zinc produced, STPY	70,000	140,000
Refined lead produced, STPY	<u>51,550</u>	<u>103,100</u>
<u>Canadian \$ per year</u>		
Zinc plant	9,645,780	17,219,540
Lead smelter	4,380,290	7,251,560
Lead refinery	<u>1,584,670</u>	<u>2,567,100</u>
Total lead smelter and refinery	5,964,960	9,818,660
Sulphuric acid plant	711,500	1,051,410
Excess acid neutralization	<u>1,105,290</u>	<u>2,068,620</u>
Total operating cost	17,427,530	30,158,230
(b) <u>Separate Zinc Plant</u>		
Slab zinc produced, STPY	<u>70,000</u>	<u>140,000</u>
<u>Canadian \$ per year</u>		
Zinc plant including auxiliaries	9,824,020	17,455,320
Sulphuric acid plant	619,690	886,970
Excess acid neutralization	<u>828,330</u>	<u>1,520,650</u>
Total operating cost	11,272,040	19,862,940
(c) <u>Separate Lead Smelter and Refinery</u>		
Refined lead produced, STPY	<u>50,000</u>	<u>100,000</u>
<u>Canadian \$ per year</u>		
Lead smelter including auxiliaries	4,637,190	7,607,050
Lead refinery with bismuth removal	<u>1,570,440</u>	<u>2,540,350</u>
Smelter with refinery	6,207,630	10,147,400
Sulphuric acid plant	413,810	531,060
Excess acid neutralization	<u>429,370</u>	<u>747,440</u>
Total operating cost	7,050,810	11,425,900

continued

In terms of pounds of metal produced the above operating costs are:

Case	I	II
(a) <u>Combined Zinc-Lead Complex</u>		
Zinc plant, ¢/lb. slab zinc		
Electrolytic zinc plant	6.89	6.15
Sulphuric acid production	0.37	0.27
Neutralization of excess acid	<u>0.55</u>	<u>0.52</u>
Total cost of slab zinc, ¢/lb.	7.81	6.94
Lead smelter and refinery, ¢/lb. refined lead		
Electric lead smelter	4.25	3.52
Lead refinery (standard)	1.22	0.99
Debismuthizing, labour and supplies	<u>0.32</u>	<u>0.25</u>
Lead smelter with refinery, ¢/lb.	5.79	4.76
Sulphuric acid production	0.19	0.14
Neutralization of excess acid	<u>0.32</u>	<u>0.30</u>
Total cost of refined lead, ¢/lb.	6.30	5.20
(b) <u>Separate Zinc Plant, ¢/lb slab zinc</u>		
Electrolytic zinc plant	7.02	6.23
Sulphuric acid production	0.44	0.32
Excess acid neutralization	<u>0.59</u>	<u>0.54</u>
Total cost of slab zinc, ¢/lb.	8.05	7.09
(c) <u>Separate Lead Smelter, ¢/lb. refined lead</u>		
Electric lead smelter	4.64	3.80
Lead refinery (standard)	1.25	1.02
Debismuthizing, labour and supplies	<u>0.32</u>	<u>0.25</u>
Smelter with refinery	6.21	5.07
Sulphuric acid production	0.41	0.27
Excess acid neutralization	<u>0.43</u>	<u>0.37</u>
Total cost of refined lead, ¢/lb.	7.05	5.71

Included in the above costs is an allowance for maintenance labour and supplies, royalty on the Jarosite process, and a 10 % contingency.

Excluded are such items as property taxes, insurance, legal and consulting fees, research, development and sales costs. These items are added for the economic feasibility.

ECONOMIC FEASIBILITY

The economic feasibility of the various possibilities for treating zinc and lead concentrates has been analyzed, in conjunction with Anvil, and in accordance with the agreement between the Government of Canada and Cyprus Anvil Mining Corporation, dated August 21, 1967.

In order to assess the economics the capital and operating costs summarized above were increased to cover site acquisition, townsite, working capital and such items as property taxes, insurance, administration and sales costs. The latter were estimated by Ametalco of New York, and are detailed in their report. Both capital and operating costs, with the exception of the working capital, were escalated by 10 % per year for $3\frac{1}{2}$ years, the estimated time required for construction of a smelting complex.

Cash flow

Four levels of zinc and lead prices were used, the highest being zinc @ 49 ¢/lb and lead @ 43 ¢/lb, which when combined with two possible periods for the amortization of the power facilities resulted in 48 cases being examined. Only six of these showed a return on investment.

The maximum discounted cash flow of 7.5 % was achieved in the two cases summarized below, based on the higher metal prices.

<u>Case</u>	<u>Plant</u>	<u>Power amortized over</u>	<u>Production STPY</u>		<u>D.C.F. %</u>
			<u>Slab zinc</u>	<u>Refined lead</u>	
2	Combined zinc-lead complex	40 years	140,000	103,100	7.5
5	Separate electrolytic zinc plant	40 years	140,000	-	7.5

It is apparent that 100 % of the mine production is required to generate a DCF of even 7.5 %. However the economics of Case 5, the separate electrolytic zinc plant, could well change since our calculations assume that corresponding production of lead concentrate can be marketed under terms and conditions comparable to those presently in existence. In all likelihood this would not be the case since these conditions are based on using Anvil's zinc production as a lever to market the corresponding lead concentrate.

CONCLUSIONS

The results of this study lead to the following conclusions:

- (1) A separate smelter at any level of production is not economic.
- (2) Based on current metal prices, the construction of a smelting complex is not economic.
- (3) Even at the higher metal prices, the DCF of 7.5 % is only half that called for in the agreement between the Government of Canada and Cyprus Anvil Mining Corporation.
- (4) The DCF from the separate electrolytic zinc plant is approximately the same as that from the combined zinc lead complex.

RAW MATERIALS

The concentrates used for this study are produced in the Faro area. The grades provided by Cyprus Anvil Mining Corporation are shown in the table Analysis of Raw Materials.

As discussed at the meeting on August 28, 1973 the bulk lead-zinc concentrate presently produced by Anvil will be further treated to produce separate zinc and lead concentrates which will be combined with those presently produced to feed the complex with the following annual tonnages for the two cases studies.

Case:	I <u>Short tons</u>	II <u>Short tons</u>
Zinc concentrate (52 % Zn)	144,370	288,740
Lead concentrate (66 % Pb)	80,640	161,290

The zinc concentrate at 10 % iron and low contents of objectionable impurities is well suited for the electrolytic process including Jarosite precipitation which permits the recovery of silver and lead in a comparatively concentrated lead-silver residue.

FLUX AND LIMESTONE

Silicious flux for the electric furnace in the lead smelter will be supplied from the deposit approximately 35 miles west of Carmacks. This material runs at least 80 % silica and has been assumed to contain 10 % limestone. Since the deposit is relatively close to the proposed smelter site at Little Salmon, silicious flux can be provided at a relatively low cost.

For the same reason limestone for flux in the lead smelter and

neutralization of excess acid will be quarried from the Eagles Nest Bluff area approximately 20 miles east of Carmacks, on the Campbell highway. This will provide a cheap source of limestone averaging 82 % calcium carbonate which will substantially reduce the cost of acid neutralization. The annual tonnages of limestone required are shown below:

Case: Required:	I <u>Short tons</u>	II <u>Short tons</u>
Limestone flux - lead smelter	31,150	62,300
Limestone for excess acid neutralization	<u>212,470</u>	<u>424,940</u>
Total annual requirement	243,620	487,240

TRANSPORTATION

All raw materials will be trucked to the smelting complex. Since the concentrates are presently being dried at the Anvil concentrator, the moisture content of the concentrates and flux has been assumed to be 5.5 %, a level which will minimize transit losses but not cause serious problems during the winter.

REVIEW OF ZINC AND LEAD EXTRACTION PROCESSES

In order to provide some background for the processes selected for this study it would be appropriate to review both zinc and lead metallurgy. Block flowsheets for the commercial processes described are attached.

ZINC AND LEAD ORES

The early zinc and lead industry was based on the processing of rich and pure sulphide and oxide ores in which the main constituent was either lead or zinc. Later, mixed lead-zinc ores in which the two components were easily separated by flotation, were used. However, with growing demand for lead and zinc it has become increasingly necessary to utilize complex fine-grained ores in which the lead and zinc minerals are difficult to separate from each other and from other minerals often present such as pyrite and copper minerals. Also, it has become necessary to use ores containing a wide variety of impurities, often in large amounts. The zinc-lead industry is therefore today faced with the necessity of treating impure ores and concentrates and complex lead-zinc materials.

METAL QUALITY

At the same time as the quality of ores and concentrates has deteriorated, there has been a continuous increase in metal purity requirements and the lead-zinc industry has had to meet this challenge to respond to an increasingly demanding market. The following examples illustrate this trend.

Purity requirements for zinc used for continuous galvanizing are steadily increasing in the United States. At the present time, a lead

content of less than 0.1 % Pb is usually specified, whereas not so many years ago 0.2 to 0.4 Pb were generally accepted by the steel industry. In the case of cadmium, specifications now call for less than 0.03 % Cd in most cases, and less than 0.02 % Cd in some cases.

Rolling zinc specifications in the United States are now as follows:

Tin	less than 0.0001 %
Aluminum	less than 0.0003 %
Indium	less than 0.003 %

In Western Europe, purity requirements are generally less strict. For example, the limit for cadmium in zinc for continuous galvanizing is usually now 0.05 % in Great Britain, and the tin limit in rolling zinc is 0.003 %. However, Western Europe will undoubtedly follow the North American trend.

Quality requirements for Special High Grade (diecasting grade) zinc have also been raised in recent years as shown by the following specifications:

	United States		Great Britain	
	<u>previous</u>	<u>present</u>	<u>previous</u>	<u>present</u>
Zinc, minimum	99.99	99.99	99.99	99.99
Lead, maximum	0.006	0.003	0.006	0.003
Cadmium, maximum	0.004	0.004	0.004	0.002
Tin, maximum	0.003	0.001	0.003	0.001
Iron, maximum	0.005	0.003	0.005	0.003
Indium, maximum	not specified			0.001
Thallium, maximum	not specified			0.0005

For the purest grade of refined lead in the United States a maximum bismuth content of 0.05 % used to be specified and is still the official specification, but some large customers now specify as low as 0.0025 %.

DEVELOPMENT OF THE ZINC-LEAD INDUSTRY

The first industrial smelting method developed for zinc ores was horizontal retorting. This is a batch process requiring much labour under uncomfortable working conditions and producing an inferior quality of zinc by present standards. In the period from 1916 to 1930 three other zinc processes were developed: the electrolytic process simultaneously by Cominco in Canada and by Anaconda and Bunker Hill in the United States, the vertical retort process by New Jersey Zinc Company in the United States and the electrothermic process by St. Joseph Lead Company, also in the United States. All these processes use less labour and produce purer metal than the original horizontal retort process. All three processes have found wide acceptance throughout the world, in particular the electrolytic process which made it possible to utilize electric power for zinc production in areas where carbonaceous materials are deficient or expensive. The electrolytic process also produced on an industrial scale for the first time the high purity zinc which made possible the development of the zinc diecasting industry and continuous galvanizing in the period during the two world wars. So successful has the electrolytic process been that it now accounts for approximately 60 % of the world's zinc production. At the same time it became imperative to improve the quality of thermally produced zinc in order for it to compete with electrolytic zinc. This was achieved by the refluxing method developed by New Jersey Zinc Company in the 1930's, which is now in general use throughout the world for upgrading zinc produced by all thermal processes.

Early processing of lead ores on an industrial scale was based on Scotch or Newman hearth and blast furnace smelting; the latter is still

by far the most important lead smelting method in the world today. All lead smelting methods produce a crude metal known as lead bullion which since early times was refined to commercial lead by chemical treatment of the liquid bullion, this being facilitated by the low melting point of lead. Most impurities can be efficiently removed, and valuable byproducts such as silver and gold recovered from lead in this fashion. However, bismuth which occurs in certain lead ores, could not be removed by the early fire refining methods and the electrolytic lead refining process was therefore developed for the treatment of lead bullion with high bismuth content. In recent years fire refining methods suitable for high bismuth lead have also been developed but electrolytic lead refining is still of interest as the method which produced refined lead of the highest purity.

Zinc and lead sulphide ores must be roasted for sulphur removal before smelting. Until the last war this was done by sintering, mostly on Dwight-Lloyd travelling grate machines, in the case of lead concentrates, and on hearth roasters, mostly Herreshof type multi-hearth roasters, in the case of zinc concentrates.

This was then, in broad outline, the state of zinc and lead processing, around 1950.

RECENT TRENDS IN ZINC-LEAD TECHNOLOGY

ZINC ROASTING

Before the last war there was a trend from hearth roasters to other roaster designs giving higher unit throughput, richer SO₂ gas for sulphuric acid recovery, and lower residual sulphur content in calcine. The first intensive roaster for zinc sulphide concentrates, known as flash roaster, was developed by Cominco in Trail, Canada. This design was widely adopted all over the world between 1930 and 1960 for all pyrometallurgical zinc processes as well as electrolytic zinc plants.

Subsequently the fluid column roaster, in which a pelletized charge descends through a vertical shaft countercurrently to the roasting air was developed by New Jersey Zinc Company for use in connection with their vertical retort process. Roasting of a horizontal bed of pelletized concentrate was adopted by Overpelt in Belgium in connection with horizontal retorting and by Cerro de Pasco at La Oroya, Peru in connection with the electrolytic process. In all these cases the pelletized calcine must subsequently be ground before blending into the retort charge, or to give a large leaching surface in case of the electrolytic process.

The cost of first agglomerating the concentrate by pelletizing and subsequently grinding the calcine pellets was avoided by the subsequent development of a fluid bed roasting technique suitable for direct charging of zinc concentrates to the roaster. This was developed by the Dorr Company (now Dorr-Oliver Inc.) in close cooperation with leading Japanese zinc producers, and by the Vieille Montagne Company in Balen, Belgium, using a BASF fluid bed roaster, modified to meet the special requirements for

zinc concentrates. The Dorr zinc roaster design uses concentrate slurry feed, whereas the Balen-type roaster uses solid concentrate feed. In the last few years a number of Dorr-type zinc roasters have been installed, particularly in Japan, while the Balen-type fluid bed roaster has been preferred in North America and Western Europe. These fluid bed roasters have been designed for capacities up to about 600 tons per day of zinc concentrate. In several cases it has been possible to compare the performance of the fluid bed roasters with that of the flash roasters and it has been found that fluid bed roasting increases zinc solubility in the electrolytic process and that it is possible to obtain calcine with low sulphide sulphur content; however, the sulphate sulphur content is higher and this can be a disadvantage in those cases where there exist no natural SO_4 outlets, such as lead or calcium sulphate in the leach residue, from the electrolytic circuit.

That the fluid bed roaster has definitely replaced the former flash roaster is perhaps best shown by the fact that Cominco themselves have recently changed to fluid bed roasting at Trail.

THERMAL ZINC PROCESSES

Recent developments in the conventional thermal zinc processes, i.e. horizontal retorting, vertical retorting and electrothermic smelting, are briefly discussed below.

Horizontal retort process

This is the oldest zinc process, which is a batch distillation process using small retorts with individual condensers, arranged in batteries of usually 144 retorts. At the end of world war II a large

proportion of the world's zinc output was still being produced by this process but increasing working standards gradually made horizontal retorting uneconomical in industrially advanced countries, due to the increasing cost of labour and the difficulty of getting men to work under uncomfortable conditions prevailing around the horizontal retort furnaces.

The most uncomfortable and labour demanding operations, such as retort charging and residue removal, were mechanized, and zinc metal condensation was greatly improved by the introduction of condensing systems serving jointly a large number of retorts. Leading in these developments were Montepioni in Italy, National Zinc Company in the United States, and Vieille Montagne and Overpelt in Belgium, the latter company having developed the so-called curtain condenser.

These developments however only prolonged for a few years the life of a process doomed to extinction by present economic trends. In fact, practically all horizontal retort plants in industrially developed countries have now been permanently shut down.

Vertical retort process

Since first developing this process in the 1930's New Jersey Zinc Company have continuously worked on its improvement. The capacity of an individual retort has gradually been increased from the initial throughput of about 4 tons of zinc per day to a present peak output of about 10 tons per day; this has been achieved by both widening and lengthening the vertical retorts as well as better charge control, more uniform heating, etc. Other improvements introduced by New Jersey Zinc Company are the autogenous coker, in which the volatile matter released during coking of the briquettes is used as fuel for the coking process, and the

splash or dynamic condenser in which the retort gas is forced through a shower of molten zinc maintained by a graphite impeller in the condensed zinc bath.

In spite of these improvements the vertical retort process does not appear to be competitive under present conditions, as witnessed by the fact that two vertical retort plants were recently closed down in the United States.

Electrothermic processes

Since starting up the electrothermic process in Josephtown, Pennsylvania, St. Joe Company have gradually increased furnace throughput from initially about 25 tons per day to a present range of 50 to 80 tons per day. This has been achieved by increasing the diameter of the furnaces and particularly by increasing the power load from an initial 2500 KW to a present rating of 5,500 to 7,500 KW. At the same time, charge control has been improved so as to reduce the formation of accretions and other phenomena impeding the smooth working of the furnace. Overall zinc recovery has also been substantially improved in recent years, mainly through changes made in the residue treatment flowsheet, and is now probably the highest of any thermal zinc process. The St. Joe process seems to still be economically attractive under certain circumstances and St. Joe type electrothermic smelters are operating successfully in the United States and Japan.

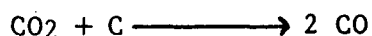
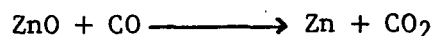
In the early post-war years New Jersey Zinc Company developed a different electrothermic zinc smelting and distillation furnace known as the Sterling process and a pilot furnace gave promising results at Palmerton, Pennsylvania. Subsequently two full size Sterling furnaces

were installed at Cerro de Pasco's La Oroya smelter in Peru but the hopes of successful commercial exploitation of this process were foiled when it was found that the reaction zone was concentrated around the electrodes so that full advantage could not be taken of the larger cross-section of the commercial furnace, and also because condensation of the distilled zinc proved difficult at the low atmospheric pressure prevailing at this high altitude in the Andes mountains. Since then, no further attempt has been made to use the Sterling process on a commercial scale.

It is interesting to note that Duisburger Kupferhütte in Germany are successfully operating a 9,000 KW furnace of a design much similar to that of the Sterling furnace. In this case, however, the charge is a high grade calcined zinc oxide with about 70 % Zn obtained as byproduct from the processing of impure pyrite cinders.

Horizons process

Horizons Research Laboratory in the United States have developed a direct zinc reduction process. Zinc oxide in the form of calcine is suspended in a molten bath of sodium chloride. Carbon monoxide gas is sparged through the bath in the form of very small bubbles. Electrodes, located in the bottom of the furnace, maintain the bath at slightly above 1000° C (1832° F). The ZnO reduced by CO gas to zinc metal vapour is carried out of the furnace by the effluent gases. A layer of charcoal covers the bath to react with any CO₂ formed and reduces it to CO. The chemical reactions are:



This process is believed to only have been investigated on laboratory scale and it is reasonable to expect that considerable problems will have to be overcome before it could be developed to a practical and reliable commercial process. At the present time it therefore seems doubtful that the Horizons process will achieve commercial significance in the future.

THERMAL ZINC REFINING (REFLUXING)

Thermal zinc extraction processes produce more or less impure zinc of which an increasing proportion must be refined to meet the growing demand for high purity zinc. This is done by the separation of impurities, primarily lead and cadmium, from zinc by fractional distillation, using variants of the refluxing process originally developed by New Jersey Zinc Company in the 1930's. Variants of the refluxing process have been developed by several companies such as Amax in the United States, Preussag in Germany and Overpelt in Belgium. Zinc refluxing is expensive as it requires high fuel consumption and capital investment, and maintenance costs are also high. Consequently, the necessity of refluxing to meet increasing zinc quality requirements is a serious disadvantage of thermal processes under present market conditions.

ELECTROLYTIC ZINC PROCESS

From its early beginnings the electrolytic process was developed in a number of alternatives, differing mainly on the following points:

Continuous versus batch leaching, residue filtration and purification

Current density in the electrolytic cells

Electrolyte cooling method (individual cells versus entire electrolyte stream)

The advantages and disadvantages of these alternatives are briefly discussed below in view of the present and future importance of the electrolytic process.

Leaching

Batch leaching has been adopted for several recently built plants because it is simpler to operate and control than continuous leaching. Furthermore, a batch operation has the advantage of positive end point control, i.e. the operation can be carried on until the batch has reached the point where it is suitable for transfer to the next processing step. Batch leaching is usually carried out as a cycle in which calcine is first fully extracted with excess acid in the form of spent electrolyte returned from the cell room, followed by a so-called neutral leach during which excess calcine is added to neutralize the acid solution and precipitate iron, arsenic and other impurities initially extracted. In practice this neutralization requires an excess of calcine resulting in some soluble zinc being lost in the leach residue.

Continuous leaching is usually carried out as a 2-stage (acid leach and neutral leach) counter-current operation and its main advantages are higher zinc extraction because the excess calcine used in the neutral leach is subsequently extracted in the acid leach stage, and better suitability for integration with high extraction processes involving a strong acid leach step such as the Jarosite process described below. The two-stage continuous leach requires additional equipment because a solid/liquid separation must be inserted between the two leaching stages. Furthermore,

accurate and preferably automatic control systems, based on pH or redox potential are required to ensure continuous optimum leaching conditions.

Residue filtration

Batch filtration and washing of leach residue in Burt filters is still conventional practice in the Western Hemisphere. This method fits well in with batch leaching but Burt filters are expensive and require considerable maintenance. The future trend will probably be towards continuous filtration on vacuum, drum or leaf filters, and it is also probable that this will be combined with continuous leaching so as to avoid intermediary storage of leached pulp, as already adopted for all recent electrolytic zinc projects in Western Europe and Japan.

Solution purification

Solution purification with zinc powder is still carried out as a batch operation in most plants. Again, batch operation has the advantage of a positive end control of the purified solution before its transfer to the cell room. However, continuous purification has been introduced in several plants in recent years. The success of continuous purification depends to a large degree on the ability to continuously determine impurities at very low concentrations in the solution and this has been made possible by recent developments in analytical methods and equipment.

Current density

From the viewpoint of investment and utilization of existing facilities it is advantageous to use the highest possible current density. On the other hand, high current density increases heat generation and

attach on the lead anodes, resulting in lower zinc purity. In older plants the electrolytic cells are individually cooled by immersed cooling water coils and the electrolyte flow is quite slow. When increasing the current density to high levels it became necessary to remove larger quantities of heat; this has been achieved by greatly increasing the electrolyte flow and cooling it in large evaporative coolers outside the cells. This development, together with control of dissolved lead by addition of barium or strontium salts has made it possible to operate successfully at current densities up to 85 amperes per sq. ft. (915 amperes per m²). In spite of these improvements it is still much easier to produce a good and thick zinc deposit at high current efficiency when operating at a low current density and it is therefore not necessarily economically advantageous to operate at high current density. In this connection it must be remembered that the operations requiring most labour in an electrolytic zinc plant are the stripping of cathodes, and the maintenance of anodes and cathodes. Labour requirements for these operations are reduced when a thick zinc deposit is produced and when cathode and anode corrosion is at a minimum, and these results are most easily achieved at low current density.

It must here be pointed out that all these various alternatives have been used in plants recently built and opinions vary considerably amongst electrolytic zinc plant operators as to which alternatives are the best. Consequently no definite trend is discernable in electrolytic zinc processing except the previously mentioned trends towards fluid bed roasters, and of course the general trend towards increased mechanization, instrumentation and automation.

Cellroom mechanization

Labour requirements have in recent years been greatly reduced for all electrolytic zinc plant operations except the handling and stripping of cathodes in the cellroom. These remain the most labour demanding operations and it is therefore logical that great efforts are now being made to mechanize and automate these operations. The amount of work involved becomes apparent when one considers that thousands of cathodes have to be handled and stripped every 8 to 72 hours in an electrolytic zinc plant.

The Bunker Hill Company in Kellogg, Idaho have recently mechanized cathode handling in their Kellogg, Idaho plant, where this is particularly important in view of the 8-hour cathode cycle used there on account of very high current density. Bunker Hill have experimented with hydraulic stripping of zinc from cathodes, using high pressure water jets.

The first mechanical zinc stripping machine was probably developed by Mitsui at their Kamioka plant in Japan during the early 1960's. The initial machine did not appear to be sufficiently reliable for commercial use but the design may have been improved since then. Other mechanical stripping machines have been developed by Monteponi in Italy, by Vieille Montagne in Belgium and by Akita Zinc Co. in Japan. Of these, the latter two appear to have the best designs, Akita for conventional size cathodes and Vieille Montagne for their system based on large cathodes.

Approximately 4 years ago Vieille Montagne started up at their Balen plant in Belgium a new cell where both cathode handling and stripping has been mechanized and where full advantage has been taken of this mechanization using very large ("jumbo") cathodes and correspondingly large electrolytic cells and high cell amperage.

The Akita Zinc Co. Ltd. have developed a machine which strips the cathode in three steps. This unit has been in operation for about two years now and is considered a practical and efficient installation.

Most electrolytic zinc plants in the world still use hand stripping and manual handling of cathodes but it is reasonable to expect that future plants will be based on extensive mechanization and automation of these operations, and that stripping machines also will be installed in existing plants.

In recent years mechanical equipment, with some degree of automation, has been developed for the maintenance of the lead anodes and aluminum cathodes. Akita Zinc have developed good reliable machines for both applications. Vieille Montagne have developed similar equipment for the maintenance of their jumbo anodes and cathodes.

Finally the newest electrolytic zinc plants, such as Akita and Vieille Montagne, have successfully mechanized the transportation of the cathodes from the cells to the stripping machines and cathode melting. This eliminates all manual handling of the cathodes from the cell room to the casting of slab zinc.

PRESSURE LEACHING

Pressure leaching of zinc concentrate with elemental sulphur recovery has recently been developed by Sherritt Gordon Mines Limited in Canada and this process has also been investigated by others. The zinc sulphide concentrate is leached with sulphuric acid, in the form of recycled spent electrolyte, at elevated temperature under controlled oxidizing conditions whereby zinc is oxidized to soluble zinc sulphate while sulphide

sulphur is only oxidized to the elemental sulphur stage. The main advantages of the process are high zinc extraction also in the case of zinc concentrate with high iron content (since no insoluble zinc ferrite is formed as is the case in roasting), and the possibility of recovering elemental sulphur. Consequently the pressure leaching process could be of interest for future electrolytic zinc projects, particularly in cases where marmatitic zinc concentrates have to be treated and where no market exists for byproduct sulphuric acid.

Roasting is probably not entirely eliminated by this process since a certain amount of calcine is required to neutralize excess acid in the leach solution. Also, it should be mentioned that certain technical aspects, such as the separation of elemental sulphur from leach residue and the behaviour of various impurities, require further investigations before pressure leaching can be considered ready for commercial use.

It was announced in late 1970 that Hudson Bay Mining & Smelting Company had signed an agreement with Sherritt Gordon Mines Limited to investigate the adaptability of this process to Hudson Bay's zinc concentrates and that a \$ 1,200,000 pilot plant would be built at Flin Flon, Manitoba for this purpose.

This project is still underway and it will be some time before it can be considered a proven commercial process. At this time an electrolytic zinc project must be based on sulphur fixation as sulphuric acid.

LEAD TECHNOLOGY

Lead smelting and refining technology has remained basically unchanged. In other words, even the most recent lead plants are still

based on conventional sintering, blast furnace smelting, and in most cases, fire refining. However, these conventional processes have been improved in recent years and development work is proceeding on various new processes which might radically change lead smelting technology in the future.

The most fundamental technological development in recent years is the Imperial smelting process which for the first time has made it possible to produce lead and zinc from a single unit, thereby making it possible to process complex lead-zinc raw materials which cannot be treated efficiently by separate lead and zinc processes.

LEAD SMELTING

Improvements in recent years have been mainly directed towards better materials handling methods, mechanization and process control in connection with conventional sintering and blast furnace smelting. In addition to this there have been some significant developments which should be mentioned.

Lead sintering

Conventional sintering of lead concentrates on Dwight-Lloyd machines was carried out by drawing air from above through the sinter bed. Because of the low melting point of lead compounds, and also because lead oxides, sulphides and sulphates inter-react to produce metallic lead, this practice resulted in molten metallic lead and lead compounds attacking the travelling grate and often dripping into the windboxes beneath the sinter strand. To improve sintering conditions and lower maintenance costs the updraft sintering method was developed by Broken Hill Associated Smelters

in Port Pirie, South Australia, which has been adopted for the most recently built lead smelters. In this sintering method an ignition layer of sulphide concentrate is first laid on the grate and downdraft ignited; the bulk of the charge is then placed on top of the ignited layer and the blast reversed to updraft, so that the heat is carried away from the grate. In this fashion the grate is protected and any molten lead compounds are solidified by the cold blast on their way down through the charge.

In order to ensure the high mechanical strength required for sinter in a blast furnace it is usual to dilute high grade lead sulphide concentrates charged to the sinter machine, due to the low melting point of lead sulphide (PbS). Rich lead sulphide concentrates, containing say 55 to 75 % Pb, are therefore usually downgraded with limestone and silica to give sinters with 35 to 40 % Pb. This is obviously not economically attractive since it increases the blast furnace burden and hence coke consumption, and increases lead slag loss because of the greater slag volume produced. To overcome this problem the Boliden Mining Company in Sweden developed some years ago a method for producing high grade lead sinter by charging, to the sinter machine, balls with successive layers of recycled sinter material, fluxes and sulphide concentrates; these composite balls were built up in successive pelletizing drums. In this way it was possible to produce a sinter with high Pb content from rich sulphide concentrates. However, Boliden have since developed a method for direct smelting of high grade lead sulphide concentrate and have therefore abandoned this sintering method.

Continuous blast furnace tapping

American Smelting & Refining Company (Asarco) have developed

at their East Helena, Montana smelter, a continuous tapping method for lead blast furnaces which reduces labour requirements and improves blast furnace efficiency by ensuring continuously uniform smelting conditions. The flow of slag and lead bullion continuously tapped from the furnace is controlled by placing a box-shaped trap with an adjustable weir around the taphole.

Oxygen lead smelting

American Smelting & Refining Company (Asarco) made a full scale test of oxygen enrichment of blast furnace air at their East Helena, Montana lead smelter in 1962 and similar test results were reported in 1959 from the Ust-Kamenogorsk Lead-Zinc Combine in the Soviet Union. Oxygen enrichment gave a substantial increase in smelting rate and a considerable decrease in coke consumption.

Cominco recently announced the construction of a pilot plant at Trail, B. C. with a daily capacity of 60 tons of lead bullion to test a new oxygen lead smelting process.

Direct smelting of lead concentrates

St. Joseph Lead Company have recently investigated the direct smelting of lead concentrates in a pilot plant at Herculaneum, Missouri. The process consists of blowing concentrates beneath the surface of a molten lead bath by means of a stream of air. The reaction vessel is designed like a side-blown converter. The desired reaction:



proceeds at a high rate and a high degree of completeness. The main problem has been how to keep a refractory lining in the tuyere area, and more work

remains to be done on finding the best way to dispose of the slag forming constituents in the concentrates. It therefore cannot be considered a reliable and economic lead smelting method at this time.

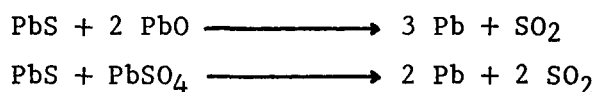
In the lead smelting method now used by Boliden, dried high grade lead sulphide concentrate, mixed with fluxes and a small amount of coke breeze, is flash smelted in vertical air jets down into an electric furnace. Most of the sulphur is oxidized before the concentrate reaches the slag surface in the furnace. The equilibrium diagrams show that at 1150°C (2102°F) and an SO_2 content of 10 % in the gas phase, the reaction of PbS with a stoichiometric amount of air should produce only metallic lead and SO_2 gas. In practice some oxidized lead compounds are formed and the inclusion of a small amount of carbonaceous reductant in the charge is therefore needed to complete the reduction to metal and limit the lead content of the slag. This smelting method has now been successfully operated at Rönnskär in Northern Sweden since 1963 at a rate of 40,000 to 50,000 tons of lead annually, using an 8,000 KVA furnace equipped with 3 Soderberg electrodes in line. Lead recovery is of the order of 98 %.

The Finnish company Outokumpu Oy has for a number of years used a flash smelting process for treating copper and nickel sulphide concentrates. At their research station in Pori, Finland this company has tested on a pilot plant scale the application of their flash smelting process to lead sulphide concentrates. It has been found that lead concentrates can be successfully flash smelted but the dust circulation is very high due to the high volatility of lead compounds under these smelting conditions.

Self-fluxing lead smelting in rotary furnace

Since about 1960 Rudniki Svinca in Topilnica Mezica, Yugoslavia

have used a short rotary furnace for producing approximately 60 tons per day of lead from a self-fluxing sinter charge. The sinter mix is composed of galena concentrate, return fines, flue dust and lead sulphate sludge, and the sintered product contains 78 - 83 % Pb and 4 - 5 % Zn. Sinter is charged at one-hour intervals to the rotating furnace which is kept at about 1000° C (1832° F). Lead is formed according to the reactions:



If necessary, a small amount of carbonaceous reductant is also added. After 4 to 5 cycles of charging and lead tapping, the furnace contains a large quantity of lead and zinc-bearing residues and slag. Now the "slag smelting" i.e. the reduction of the residues is carried out by adding pelletized NaOH and Na₂CO₃ and some reduction coal. The rotary furnace is fuel oil or gas fired.

Fire refining of lead

Fire refining continues to be the most used refining method for lead bullion because it requires much lower investment than electrolytic refinery and also because operating costs are lower than for electrolytic refining except in comparatively rare cases where high bismuth and antimony contents result in high fire refining costs. In fire refining the most important recent developments have been vacuum de-zincing (following de-silverizing of molten lead bullion with metallic zinc) and continuous de-copperizing; both processes were originally developed by Broken Hill Associated Smelters at Port Pirie, South Australia. Bismuth removal is the most difficult and costly step in fire refining, as already mentioned and requires expensive reagents such as calcium, magnesium and potassium

in various combinations. This type of bismuth removal process was developed before the last war and was known as the Kroll-Betterton process and used calcium and magnesium as reagents. More recently, a variant using magnesium and potassium, known as the Penarroja-Jollivet process, has been developed in France, and was used for some time at Penarroja's lead refinery at Noyelles-Godault in France.

Electrolytic lead refining

Electrolytic lead refining technology has remained virtually unchanged and all refineries now in operation are believed to be based on the conventional hydrofluosilicic acid electrolyte originally developed by Betts. At the San Garino plant in Sardinia, Italy, Monteponi and Monteverchio SpA used a sulphamic acid electrolyte on a commercial scale from 1957 but reverted in 1960 to the hydrofluosilicic acid process. The main reasons for abandoning the sulphamic acid process were lower electric conductivity and the instability of lead sulphamate.

Lead extraction and refining by amine leaching

Some years ago Sherritt Gordon Mines Ltd., in Canada, developed a lead refining method based on the solubility of lead sulphate and lead oxide in organic amines, in particular ethylene diamine (EDA) and diethylene triamine (DETA). The proposed process comprised the following steps.

- (1) Acid pressure oxidation in aqueous solution to convert PbS to $PbSO_4$.
- (2) Leaching the $PbSO_4$ and PbO in aqueous solutions of alkylene amines at room temperature to form soluble Pb-amine complexes.
- (3) Carbonation of the Pb-amine complex solutions at room temperature by adding CO_2 to precipitate pure basic lead carbonate.

- (4) Reduction of the basic lead carbonate at a suitable temperature with carbon or another reducing agent to produce CO_2 and high purity Pb.
- (5) Regeneration of the amine leach solution with CaO at room temperature, the $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ being discarded.

The process tested on pilot plant scale by the Bunker Hill Company in the United States and by the Dowa Mining Company in Japan for the treatment of complex Pb-Zn-Cu concentrates and residues, but has apparently been abandoned by both companies because of technical problems and high costs.

COMBINED ZINC-LEAD PROCESSING

It has already been explained that the zinc-lead industry must increasingly depend on complex zinc-lead ores giving lead concentrates with high zinc content and vice-versa, or even mixed zinc-lead concentrates. The combination of separate zinc and lead processes, and the use of the joint lead-zinc Imperial smelting process have therefore acquired increased importance in recent years.

In zinc processing the lead present in the zinc concentrate usually reports in the retort or leach residue, in the latter case in the form of insoluble lead sulphate. Most residue treatment processes recover this lead in the form of an impure lead oxide or sulphate which can be added to the lead smelter charge for further processing to metallic lead.

In lead smelting the zinc present in lead concentrates reports in the lead furnace slag, from which the zinc can be recovered by the process known as slag fuming. This normally produces an impure zinc oxide which can be further processed to metallic zinc by any of the thermal pro-

cesses or the electrolytic process - usually the latter.

Slag fuming and zinc plant residue treatment, as well as the Imperial smelting process, are therefore discussed in other sections of this report.

IMPERIAL SMELTING PROCESS

This is the most recent basically new process and it has achieved wide commercial application in the lead-zinc industry. This process was developed by Imperial Smelting Corporation at its Avonmouth smelter in England. In the last 15 years or so a number of Imperial smelters have been built in various parts of the world.

The Imperial process is the only commercial process for simultaneous recovery of metallic lead and zinc from a charge containing both metals. The iron content of the charge has only a small effect on metal recoveries, in contrast to the retort and electrolytic processes where zinc recovery and maintenance costs are seriously affected by iron. The Imperial process is therefore particularly attractive when treating a mixed charge of lead and zinc concentrates, impure concentrates including those with high iron content, and lead-zinc bulk concentrates, provided coke is available at a reasonable price.

In the Imperial process the lead and zinc concentrates with fluxes are sinter-roasted on a Dwight-Lloyd type sintering machine. The sinter is reduced with preheated coke in a blast furnace of special design. The volatilized zinc is condensed in molten lead, from which the zinc separates by cooling. The lead contained in the charge is recovered from the bottom of the blast furnace in the form of molten lead bullion.

The zinc metal is quite impure, due to a high lead content originating from the condensing method. Refining of the metal is therefore required for all grades other than the most lead-rich type of G.O.B. (Prime Western) metal. The lead bullion contains the silver and gold present in both lead and zinc concentrates, as well as the usual impurities in blast furnace lead bullion. It is therefore necessary to refine the lead and at the same time recover the valuable byproducts collected by the lead bullion.

The Imperial smelting process has been described in greater detail in many technical papers in recent years but it might nevertheless be worthwhile to mention the most important recent developments.

Single condenser

The original Imperial furnace design had two condensers, one on each side of the shaft. Recent furnaces have been equipped with a single large condenser, and this simplifies the gas handling system and lowers the overall capital cost of the furnace installation. The single condenser has now become standard.

Increased blower capacity

The production capacity of the Imperial furnace is a function of its carbon burning rate. It has been found that this can be increased by increasing the blower capacity, and it is possible that the furnace capacity can be further extended in the future in this way.

Air preheat temperature

In the early days of the Imperial process the furnace air

blast was preheated to about 500° C (930° F) in continuous tubular air preheaters built of heat resistant steel. The air temperature was gradually raised and is currently 650 - 700° C (1200 - 1290° F) in most plants equipped with this type of air preheater. Recently built Imperial plants have been equipped with refractory bricked Cowper stoves designed for air preheat temperatures of 850° C (1560° F) and possibly higher. As the Cowper stove air preheat temperature is gradually pushed up, this is expected to further increase zinc output per furnace day and per ton coke.

Oxygen enrichment

Preliminary tests with oxygen-enriched furnace blast conducted on the experimental blast furnace in Avonmouth in 1962 indicated that carbon burning rate and hence the zinc output of the Imperial furnace might be increased by this method. In order to obtain more reliable information on this subject a number of oxygen enrichment tests were run on the standard size furnace at Swansea in 1965, the last one lasting six weeks. Test results indicated that carbon burning rate and zinc output could be increased by about 30 % when the oxygen content of the blast was increased to 27 %.

Further test work is required in this field but it is reasonable to expect that oxygen enrichment could improve the economy of the Imperial smelting process in locations where the power cost is sufficiently cheap for low cost tonnage oxygen production.

Campaign life

The Imperial furnace campaign duration is an important economic factor because of the lost production and the cost of cleaning out the furnace and auxiliary equipment between campaigns. The periodical

shutdowns are caused by accretions which lower the furnace efficiency. Up to 1962 the campaigns rarely exceeded 3 months but through improved process control it is claimed that much longer campaigns - up to 18 months or even more - can now be achieved.

Larger unit size

Until 1969 all Imperial smelter projects were based on the standard size Imperial furnace, which has a shaft cross-section of 185 sq. ft. However, in December 1967 Imperial Smelting Corporation commissioned a considerably larger furnace at the Avonmouth plant. It has a cross-section of 292 sq. ft. and a rated capacity of 100,000 tons of zinc and 50,000 tons of lead per year.

Computer control

The large new furnace (No. 4 I.S.F.) at Avonmouth has been equipped with an instrument system capable of direct digital control (DDC). This control is a recent and advanced automation technique in which a computer replaces the conventional controllers. In addition to carrying out the DDC and sequencing functions, the computer is installed to perform an alarm-scanning routine and data-logging role. The next step will be computerized process control to optimize both the sintering and smelting operations. Optimization of profitability is one of the main aims of the new control system; other plans include control of blast distribution to the furnace tuyeres and control of gas temperature at the top of the furnace charge. It is felt that these functions will enable the smelting conditions in the shaft to approach an ideal state.

The computer control system installed for the new Avonmouth plant is quite complicated and it will probably still take some time before the operation can fully benefit from it.

Vacuum dezincing

The zinc produced by the Imperial furnace contains about 1.2 % Pb and this grade is too low for most applications today, and the situation will worsen as the trend towards purer metals will undoubtedly persist in the future. It is possible to obtain high purity zinc by refining in refluxing columns but refluxing adds significantly to the zinc production cost and there are obvious attractions in a simpler, cheaper treatment which could yield an intermediate grade metal suitable for the electrolytic galvanizing and brass markets.

In the search for an alternative method of purification, Imperial Smelting Processes Ltd. have developed a process based on continuous vacuum dezincing of the stream of hot zincy lead emerging from the Imperial furnace condenser. A 1½-ton per hour pilot unit gave good results at Avonmouth some years ago. A full-scale unit was then installed on one of the Swansea furnace condensers and began production of high grade zinc in April, 1967. Operating at a rate of 3.25 - 3.5 long tons per hour the unit produced VDZ (for vacuum dezincing) metal of the following quality:

Pb	0.03 %
Fe	0.003 %

The Cd content depends on the cadmium content of the raw materials smelted since cadmium is volatilized with the zinc. In order to produce cadmium-free zinc it is therefore necessary to further refine the VDZ metal by

passing it through a decadmiumizing column similar to that used in the New Jersey Zinc Company refluxing process.

Although vacuum dezincing has now been proven in a large unit, several factors still need further investigation in order to obtain a reliable technical and economic picture of the process. In particular it will take some time to develop markets for VDZ metal, since its quality is different from established zinc grades.

ZINC RECOVERY FROM SLAGS AND RESIDUES BY VOLATILIZATION

Lead blast furnace slags contain up to 19 % Zn, retort residues up to 15 % Zn and leach residues from electrolytic plants up to 28 % Zn. Methods based on the high volatility of zinc at elevated temperatures have been developed for recovering the zinc and incidentally also the cadmium and lead from such materials. Unfortunately, it is difficult in practice to recover metallic zinc due to the ease with which the zinc vapour re-oxidizes as soon as liberated. The product is therefore a fine zinc oxide fume which is recovered by filtering of the gas. This fume contains, also as oxides, the lead and cadmium in the charge.

It should be mentioned that St. Joseph Lead Co. in the United States succeeded a number of years ago in recovering metallic zinc from molten slag in an electrothermic unit at their Herculaneum, Missouri smelter. This was a great technological achievement but technical difficulties and costs were so great that the process was abandoned. A similar process is however used in Japan on a small scale.

Slag fuming

The slag fuming process was originally developed by the

Anaconda Company at their East Helena, Montana smelter. In this process a coal and air mixture is blown into a molten slag bath contained in a completely water-jacketed vessel. The coal:air ratio is regulated so as to burn a substantial proportion of the coal to carbon monoxide, which reduces zinc oxide and silicate in the slag to metallic zinc vapour. At the same time, combustion of the coal provides the heat required to maintain the slag bath in a fluid state. On reaching the slag surface, the zinc vapour is immediately oxidized to zinc oxide which is carried away with the combustion gases. The combustion gases are cooled, usually by passing through a waste heat boiler, and zinc oxide fume is then recovered from the cooled gas in a baghouse. The collected zinc oxide fume is a very light powder which must be densified, so as to reduce its bulk, if it is shipped elsewhere for further processing. Densification is achieved by heating the primary fume with a small amount of coke fines in a kiln. This treatment removes at the same time most of the lead and volatile impurities, which is beneficial for further processing of the fume.

The slag fuming process is quite flexible with respect to coal quality, and sub-bituminous coal has been used successfully at the Trail smelter in British Columbia, Canada. It may also be possible to use fuel oil instead of coal.

A number of slag fuming plants are now in operation. Most of these are in North America (Canada, Mexico and the United States). Slag fuming plants incorporating new design features have recently been built by the Boliden Mining Company in Sweden, and by Broken Hill Associated Smelters in Australia.

The Waelz process

The Waelz process was developed to extract zinc from solid materials such as calamine ores, residues and cold slag, which are not suitable for direct utilization in the conventional zinc processes. In this process the zinciferous materials are mixed with fine coke or coal and heated in a rotary kiln. The zinc is reduced and immediately reoxidized to zinc oxide fume which is recovered from the combustion gases in the same way as already described in connection with slag fuming.

Since the raw materials are cold in this case, it is desirable to carry out the reduction at the lowest possible temperature in order to save fuel, and the process is usually carried out below the melting point.

The Waelz process has been used extensively for recovering zinc values from residues with high zinc content. Several Waelz plants have been shut down in recent years because improved zinc metallurgy resulted in less zinc-rich residues being available for Waelz treatment. However, there are still some Waelz plants in operation in Mexico, Japan, Poland and Germany.

Blast furnace fuming

For a number of years Vieille Montagne have been treating old slag dumps containing about 15 % Zn in a blast furnace where the crushed slag is reduced with coke and the zinc recovered as a zinc oxide fume. The process is still used at Balen in Belgium but several changes have been made in recent years to reduce the coke consumption. Oxygen enriched air is now used, and a proportion of the coke has been replaced with coal which is mixed with residues and shaped into briquettes before being charged to

the blast furnace.

The rapid reaction process

Some years ago a process based on the flash smelting of ground slag mixed with fine coke was invented by Lange and Barthel in Freiberg, East Germany, and further developed by Lurgi in Frankfurt, West Germany. A considerable amount of fuel oil or gas is also needed to provide the necessary heat for volatilization of zinc and lead. Gases leave the reactor at a considerably higher temperature than in the Waelz process, so that waste heat recovery in the form of steam or electric power becomes feasible in this case.

The process has been investigated on a pilot plant scale but practical problems seem to have prevented its commercial application to date.

Cerro's Zileret process

This process was developed by Cerro de Pasco Corporation at La Oroya, Peru during the period 1956 - 1962. A pilot plant treating 50 tons per day of electrolytic zinc plant residue was built in 1965 - 1967 and has been in operation since then.

In the Zileret process leach residue is first pelletized and a carbonaceous reductant incorporated in the pellets. These are then fed with additional reductant to a kiln where solid phase reduction takes place at about 1100° C (2012° F). Zinc, lead, cadmium and indium are volatilized, recovered as an oxide fume and separated by hydrometallurgical methods. Copper and silver remain in the solid kiln product, which is still in pellet form and in which a large proportion of the iron is present in the metallic

state. In Peru this sponge iron will be used for recovery of copper from mine waters by cementation, whereby the copper and silver values in the residue will be recovered in course of the normal smelting and refining of this cement copper. This utilization of the sponge iron is particularly suited to Cerro de Pasco but it may be possible to recover the copper and silver values in other ways which would broaden the application potential of the process.

HYDROMETALLURGICAL RESIDUE TREATMENT

In the conventional leaching of zinc calcine Pb, Ag, Au, In, Sn, SiO₂, Al₂O₃, CaO (as CaSO₄) remain insoluble in the residue. A proportion of the zinc and copper also remain as insoluble ferrites, as well as part of the cadmium. A proportion of the iron and arsenic are initially dissolved in the acid leaching stage but re-precipitated during the neutral phase of the leach and consequently also end up in the leach residue.

Electrolytic zinc plant leach residue is therefore a very complex material and it is correspondingly expensive to treat. Residue treatment is therefore only economically feasible if recoverable values are sufficiently high; often this is not the case and many electrolytic zinc plants therefore send the leach residue to waste without further treatment.

Many leach residue treatment methods have been proposed, of which comparatively few have actually been used commercially. The choice depends mainly on residue composition and local conditions. A few of the newest methods are reviewed here.

Acid re-leaching processes

A multitude of processes based on re-leaching with acid have

been proposed for breaking up the insoluble zinc ferrite but only processes based on sulphuric acid seem practical and economical because they yield a zinc sulphate solution which can be added to the electrolytic zinc plant circuit.

The main problem is that a large amount of iron is dissolved with the zinc. After filtration of a lead-silver residue the dissolved iron can be removed from the zinc solution by neutralization with calcine and precipitation as ferric hydroxide. Unfortunately such an iron precipitate has usually very poor settling, filtering and washing characteristics. However, in the last few years several processes have been developed for removal of iron in a filterable form, thus making it possible to take advantage of greatly increased extraction of zinc, copper and cadmium by strong acid leaching. These processes precipitate the iron in the form of Jarosite, goethite and hematite.

Jarosite process

Recently two companies, Det Norske Zinkkompani in Norway and Electrolytic Zinc Company of Australasia in Tasmania, simultaneously but independently developed an elegant residue treatment process based on the elimination of iron from the leach solution in the form of insoluble double sulphates of trivalent iron and alkali metals such as sodium, potassium and ammonium. Compagnie Royal Asturienne des Mines in Belgium and Asturiana de Zinc in Spain are connected with Det Norske Zinkkompani and also share the rights to the Jarosite process.

In practice the residue is leached with sulphuric acid, in the form of strengthened spent electrolyte, close to the boiling point but

still at atmospheric pressure. Under these conditions zinc ferrite is decomposed and both zinc and iron go largely into solution; at the same time a secondary residue, containing the lead and silver values in a concentrated form, is obtained. The acid sulphate solution, containing zinc and iron as well as copper and cadmium is neutralized with zinc oxide in the form of low-iron calcine or fume, whereupon iron is precipitated with ammonium, potassium or sodium sulphate. The Jarosite precipitate is crystalline and therefore easily filtered and washed. The resulting neutral and practically iron-free zinc sulphate solution is joined with the main leach solution and further processed by normal purification and electrolysis.

Overall efficiency of the process is improved and costs reduced by integration of the hot acid leach and Jarosite precipitation steps in a continuous calcine leaching circuit. This is of course easier to do in a new rather than in an existing plant.

Goethite process

Societe de la Vieille Montagne have succeeded in precipitating the iron from such a solution in the form of crystalline Goethite $\text{FeO}(\text{OH})$ which is claimed to be easily filtered and washed. Vieille Montagne have recently adopted this practice at their Balen plant in Belgium. Also in this case it is advantageous to include the process in an integrated continuous calcine leaching circuit.

Pressure leaching - Hematite process

Pressure leaching of residue with sulphuric acid solution has been proposed by various companies including American Zinc, Lead & Smelting

Co. in the United States, Electrolytic Zinc Company of Australasia Ltd. in Australia, and Noranda Mines Limited and Sherritt Gordon Mines in Canada. However, it is believed that the only commercial operation to date based on pressure leaching is that of Akita Zinc Co. in Japan. Their process, developed in cooperation with Sherritt Gordon, consists of the following steps:

- (1) Pressure leaching with SO_2 gas in an autoclave at $95 - 100^\circ \text{C}$, whereby more than 90 % of iron, zinc, cadmium and copper are dissolved.
- (2) Precipitation of copper with hydrogen sulphide, and filtration of leach residue containing precious metals together with copper and lead sulphides.
- (3) Neutralization of leach solution with lime in two stages, and removal of gallium, germanium, indium, arsenic, tin, etc. in the second gypsum precipitate.
- (4) Removal of iron from the solution in autoclaves by precipitation of hematite Fe_2O_3 with air at about 200°C . More than 90 % of the iron is precipitated and the recovered zinc sulphate solution is recycled to the calcine leaching circuit.

This process is more complicated and therefore probably more costly than the Jarosite and Goethite processes but it also recovers additional values, such as gallium and indium, and iron in a more acceptable form, and could therefore be preferable in certain cases.

GENERAL PICTURE

Conventional sintering and blast furnace smelting practice is still prevalent and if large lead smelters are built in the immediate future they will probably be based on this technology, but including of course

modern materials handling and control methods. Oxygen enrichment may possibly be used in future blast furnace plants, and added to existing plants to increase output and reduce coke consumption.

A modern sinter plant requires a substantial investment which is economically justifiable only for a reasonably large output. New processes which do not require sintering, such as the Boliden, Outokumpu and St. Joseph Lead Company processes, and possibly the new Cominco oxygen lead smelting process, might therefore be chosen in the future, particularly for smaller projects. Of these, only the Boliden process is fully developed at the present time.

Fire refining will undoubtedly be used for refining lead in the future, and these lead refineries will include modern features such as vacuum dezincing and continuous decopperizing if of sufficient capacity.

In zinc smelting the trend in recent years has favoured the electrolytic and Imperial smelting processes, as shown by the following figures giving the distribution of processes used in the world (in % of total world zinc production capacity):

<u>Process</u>	1959	1968	1972	Estimated 1973
	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
Electrolytic	51.0	59.2	61.6	69.8
Imperial smelting process	0.6	10.5	11.4	11.2
Electrothermic	4.1	5.7	7.3	7.0
Vertical retorting	10.9	8.6	8.1	6.1
Horizontal retorting	33.4	16.0	11.6	5.9

During the 1960's the growth of the Imperial smelting process was spectacular. From a new process only used in a couple of plants belonging to Consolidated Zinc Corporation (now Rio Tinto Zinc), the organization

which developed and owned the process, the Imperial smelting process became an accepted process in most parts of the world where lead and zinc are processed, with the notable exceptions of the United States and the Soviet Union. The Imperial smelting process will remain stationary or continue to grow slowly in the immediate future as one or two Imperial smelters are still in the construction and planning stages, while others might be shut down as the Swansea smelter in Wales or converted to straight lead smelting as the Belledune smelter in New Brunswick.

However, by far the largest share of current and future zinc plant expansion is based on the electrolytic process, mainly for the following reasons:

- (1) The electrolytic process produces directly zinc of the highest purity and this is very important in view of the continuing trend towards higher purity requirements for all metals, including zinc.
- (2) The electrolytic process is based on comparatively small production units (electrolytic cells) and therefore can be gradually expanded as required.
- (3) With new residue treatment processes now available, such as the Jarosite, Goethite and Pressure Leaching processes, the electrolytic process provides the highest obtainable overall recoveries for zinc and other values in zinc concentrates.

In contrast, the Imperial smelting process produces the lowest grade of zinc on the market, of which an increasing proportion will have to be refined in the future; several existing Imperial smelters are therefore now installing or expanding zinc refining facilities. Other disadvantages are the high cost of coke, which has now become the most expensive form of

energy for metallurgical operations, high maintenance cost, and poor working conditions. Finally, the process requires a minimum amount of lead - say one part lead to three parts zinc - for profitable operation.

The horizontal retort process is rapidly moving towards total extinction, while the vertical retort and electrothermic processes appear marginal or unprofitable in some cases but still profitable in other locations.

Pressure leaching of zinc concentrates with elemental sulphur recovery offers interesting possibilities, particularly from the viewpoint of pollution control. However, the process is not yet ready for commercial use.

SELECTION OF ZINC AND LEAD TREATMENT PROCESSES

GENERAL

At present Anvil produces separate zinc and lead concentrates and a lesser tonnage of bulk lead-zinc concentrate. One method which would treat this bulk concentrate is the Imperial smelting process. This however cannot be justified in view of the small tonnage available and the reasons discussed below. It is our understanding that Anvil Mining Corporation can separate the bulk concentrate into zinc and lead concentrates of the grades assumed for this study, by selective flotation at the Faro concentrator. This study and the process selection is based on treating only separate zinc and lead concentrates.

SELECTION OF ZINC PROCESS

There exist a number of thermal zinc processes, including the

Imperial smelting process which is a combined zinc-lead smelting process, and the electrolytic zinc process. In recent years the trend has favoured the electrolytic and Imperial smelting processes.

The horizontal retort process, which is the oldest process, is doomed to complete extinction in spite of improvements made after World War II. Most horizontal retort plants in the United States have been closed down, and the few remaining ones are not expected to remain in operation much longer. Other thermal processes such as the vertical retort and electro-thermic processes are more competitive; zinc smelters using these processes will continue to operate economically or may be forced to close down, depending on size, fuel cost and degree of mechanization.

During the 1960's there was a spectacular growth of the Imperial smelting process. Since then, however, there has been a definite shift towards the electrolytic process, for the following reasons:

- (1) The electrolytic process produces directly zinc of the highest purity. This is very important in view of the continuing trend towards higher purity requirements for all metals, including zinc.
- (2) An electrolytic plant consists of comparatively small units - such as electrolytic cells, solution tanks, filters, etc. - and can therefore be gradually expanded as required. In other words, the electrolytic process provides a particularly flexible plant.
- (3) New residue treatment processes, of which the Jarosite process is most widely used, result in the highest obtainable overall recoveries for zinc and other values - such as copper, cadmium and silver - in zinc concentrates.

- (4) Recent developments in materials handling and mechanization, such as mechanical cathode stripping, have significantly reduced labour requirements. In its modern version the electrolytic process requires the least manhours per ton zinc produced; this is an extremely important factor since labour is today the most inflationary item in metal production costs.
- (5) Electric power is the most desirable energy source from the viewpoint of cost stability and security of future supply. In these respects, electric power is usually more attractive than coke, coal and anthracite required for thermal zinc processes.

In contrast, the Imperial smelting process produces the lowest grade of zinc on the market, of which an increasing proportion has to be further refined at additional cost. The fact that the Imperial smelting furnace is the largest zinc production unit available is a disadvantage from the viewpoint that an Imperial smelter can only expand in large steps of 60,000 to 90,000 tons of annual zinc production capacity. The Imperial smelting process uses coke which has shown a steep price increase in the last 10 - 15 years. This combined with the distance of the proposed site from sources of coke, coal, or anthracite would make the Imperial smelting process appear economically unattractive for the Anvil project.

These considerations, along with the potential for local hydro development, lead us to conclude the new zinc processing facilities, if planned at the present time, would have to be based on the electrolytic process. Furthermore, such an electrolytic plant should be provided with the Jarosite - or equivalent - process for high recovery of cadmium, copper and silver values present in the zinc concentrate, and be highly mechanized in view of Canadian labour costs which are high by international standards.

Consequently this study has been based on a modern version of the electrolytic zinc process.

SELECTION OF LEAD PROCESS

The most commonly used process for lead smelting is the blast furnace. Flotation concentrates are agglomerated either by pelletizing followed by sintering on a Dwight-Lloyd sinter machine or by sintering directly to provide a coarse charge, containing some sulphur, for the blast furnace. Agglomeration of some sort is necessary for blast furnace charge to minimize dusting.

There are a number of disadvantages to this approach. A sinter plant adds substantially to the capital and operating costs of the smelter. The travelling grate sinter machines introduce considerable volumes of false air making it difficult to produce an off-gas which is sufficiently concentrated to permit the economic recovery of the sulphur dioxide as sulphuric acid. According to downdraft sintering practice now generally adopted for lead concentrates, gas strengths of 5 to 6 % SO_2 can be delivered to the acid plant but this requires extreme care to minimize dilution air around the grate and in the gas cleaning system. The blast furnace has a relatively high coke requirement which is undesirable in view of rising costs for coke and coking coal. This combined with the distance of the smelting complex from known sources of these materials makes the lead blast furnace impractical for this study.

Selection of the electrolytic process for the zinc plant is predicated on electric power being made available at reasonable cost to the smelting complex at Little Salmon. Under these circumstances it is logical

to use electric energy also for lead smelting. Further advantage of electric lead smelting is to eliminate the sintering step. This will not only reduce capital and operating costs but will provide an off-gas of sufficient strength to permit the fixation of sulphur as sulphuric acid.

The study is therefore based on electric smelting followed by conventional fire refining of the crude lead.

PROCESS DESCRIPTION

ELECTROLYTIC ZINC PROCESS

General

The principle of the conventional electrolytic zinc process is to roast zinc sulphide concentrates whereby the zinc sulphide is converted to soluble zinc oxide. The calcine is then leached with sulphuric acid, in the form of spent electrolyte, and the leach solution is purified to provide the pure zinc sulphate solution suitable for electrolysis. Metallic zinc is extracted from the pure solution by electrowinning, and the spent acid electrolyte is returned to the calcine leaching step.

While there are many variations of the process the present study is based on a variant of the process which has been adopted for several of the electrolytic zinc plants built most recently in North America, Australia and Western Europe, where this type of plant has been adopted for the treatment of both zinc sulphide concentrates and zinc oxide fumes.

Roasting

The sulphide flotation concentrate is first roasted to convert zinc sulphide to zinc oxide. Sulphide sulphur should be eliminated as far as possible in the roasting operation as zinc sulphide is insoluble in the sulphuric acid used for bringing zinc into solution. The roasting process is if possible carried out under conditions resulting in the formation of zinc sulphate to the extent required for balancing the sulphate losses in the electrolytic zinc plant. During the roasting a proportion of the iron present in the concentrate is also oxidized and forms insoluble zinc ferrite $ZnO.Fe_2O_3$ which represents a zinc loss unless the leach residue

is further processed.

Most recent electrolytic zinc plants have adopted the fluid bed roaster on which the present estimate is based. A substantial amount of steam, useful in the process, is obtained from waste heat boilers in which the roaster gases are cooled. Fluid bed roaster gas has a high SO_2 content and is therefore suitable for economic processing to sulphuric acid.

Leaching

The major portion of the roaster calcine (75 % assumed) is extracted using spent electrolyte containing 150 - 200 gpl free H_2SO_4 and 40 - 70 gpl Zn. The acid is heated close to the boiling point, but still at atmospheric pressure, and dissolves between 98 and 99 % of the zinc in the concentrate fed to the leaching circuit. The hot acid leach treatment breaks down zinc ferrite present in the calcine and puts most of the iron into solution leaving a high grade lead-silver residue. The lead as well as any calcium and barium present are in the form of insoluble sulphates which report to the residue.

The leach solution is then neutralized in preparation for purification. This acid sulphate solution is neutralized using the remainder of the roaster calcine (assumed 25 %) and the iron is precipitated with ammonia as ammonium Jarosite, which is a crystalline precipitate relatively easy to filter and wash. The Jarosite process is described in the previous review of zinc-lead extraction processes.

The present estimate is based on continuous hot acid leaching, neutralization and Jarosite precipitation following the steps described above.

Solution purification

The impure zinc solution is separated from the residue in a system of thickeners and filters, and the solution then enters the purification section where soluble impurities are removed before electrolysis. The purification methods depend on the impurities present in the solution, which always include some copper and cadmium and which may also include other impurities such as cobalt, nickel, germanium, arsenic and antimony.

These impurities are removed by precipitation with zinc dust specially produced in the plant for this purpose. The impurities can be selectively precipitated by adjusting the quantity of zinc dust, the treatment temperature, the pH of the solution, and by adding other reagents if necessary.

Copper and cadmium are valuable byproducts but do not represent substantial quantities in this case. It is however desirable to recover these without co-precipitating other impurities. This will be carried out in three stages. In the first stage the copper is removed by maintaining a high temperature 190 - 205° F (90 - 95° C) and adding coarse zinc dust to precipitate essentially all the impurities but the cadmium. This will be removed in the second stage by lowering the temperature to about 160° F (70° C) and adding fine zinc dust, small amounts of copper sulphate and other reagents. The third stage is a polishing step to which additional zinc dust is added to remove residual traces of cadmium and other impurities. The zinc dust from the third stage is recycled to the second stage.

Electrolysis

The purified, essentially iron-free, neutral zinc sulphate

solution is mixed with spent electrolyte which contains a considerable amount of free acid, to provide a suitable cell feed solution and flow rate. Cell feed solution analysis varies from one plant to another but 60 gpl Zn and 150 gpl free H_2SO_4 is a typical composition.

Addition agents such as glue and sodium silicate are added to improve current efficiency, and the quality of the electrolytic zinc deposit; barium and strontium compounds are added to limit lead pickup from the anodes. Electrolyte temperature must be closely controlled at 30 to 35 ° C to give a good cathode deposit and limit attack on the lead anodes. It is therefore necessary to cool the circulating electrolyte before it is returned to the electrolytic cells.

The electrolyte is fed to electrolytic cells equipped with insoluble lead-silver alloy anodes and aluminum cathodes. Through the action of the electric current passed through the solution, zinc deposits at the cathode whereas free sulphuric acid is formed at the anode. Average cell voltage is about 3.65 volts and current efficiency varies between 85 and 92 %; 88 % current efficiency is typical and has been assumed in the present study. The zinc deposit grade varies from 99.95 to 99.999 % Zn, depending on the care taken in solution purification and electrolysis.

High current density provides better utilization of cell room space and reduces the capital cost per ton year of zinc production capacity. On the other hand it is easier to obtain a dense cathodic deposit and achieve a high current efficiency when a lower current density is used. Current densities used in the industry vary from 30 to 100 amps per sq. ft. Successful mechanical stripping depends on a uniform dense cathode deposit; consequently a comparatively low current density is usually chosen for

zinc plants employing mechanical stripping machines.

Current densities in the range of 35 to 50 amps per sq. ft. are suitable for producing satisfactory cathodes for mechanical stripping. The present study is based on a current density of about 40 amps per sq. ft.

Melting, casting, zinc dust and dross handling

Zinc is deposited as a metallic sheet on both sides of the aluminum cathode. Cathodes are stripped at regular intervals, usually every 16 to 24 hours for high current density plants, and every 48 hours for low current density plants. The cathode zinc is remelted and cast into slabs. The present estimate is based on using electric induction furnaces and a straight-line casting machine for this purpose.

A small proportion of the zinc is made into zinc dust required for solution purification. This zinc is re-introduced into the solution and therefore ultimately recovered as cathodes; in other words, the zinc dust constitutes a circulating load and increases the power consumption per unit of slab zinc produced for sale.

Various methods are used for zinc dust production. A very reactive zinc dust can be produced by distilling zinc and condensing it directly to solid zinc by rapid quenching of the zinc vapour. This method has been used as basis for the present estimate.

During re-melting of cathode zinc a significant amount of the metal is oxidized and removed from the molten surface in the form of a zinc oxide dross. This dross is re-treated by trommeling and remelting in a liquating furnace for recovery of the metallic portion of slab zinc. The oxidized portion of the dross is recirculated through the roaster to remove

chlorine from the ammonium chloride treatment used to reduce metal oxidation in the cathode remelting furnace.

Copper and cadmium recovery

The primary copper cake from the first stage purification is treated with weak sulphuric acid in the form of spent electrolyte to dissolve the excess zinc and thus increase the copper grade. The washed copper cake, running between 50 and 60 % Cu, is then filtered and shipped to a copper smelter.

Cake from the second stage of purification contains about 20 % Cd and an excess of zinc. The cadmium is dissolved and reprecipitated with zinc dust to produce a final cake containing about 60 % Cd which is re-dissolved in sulphuric acid and the resulting solution is purified and electrolyzed in cells which are similar to the zinc cells to produce pure cadmium cathodes.

These are melted and cast into stick, ball, or other shapes ready for shipment to market.

ELECTRIC LEAD SMELTING (Boliden)

The Boliden Mining Company in Sweden has for a number of years smelted lead concentrate in an electric furnace. This is advantageous due to the high cost of coke and the availability of hydroelectric power in Northern Sweden, a situation similar to Cyprus Anvil Mining in the Yukon. Boliden have recently developed a process in which flotation concentrates are charged directly to an electric furnace, thus eliminating the need for agglomeration. This process has been successfully in use in Sweden since 1963.

Dried, fine lead concentrate is charged with preheated air into an electric furnace. Fluxes for forming slag of a suitable composition, are also added. Comparatively little coke is needed and it can be in the form of coke fines or rubble coke. This is a lower cost material than that required for blast furnace operation.

Lead tapped from the furnace still contains some sulphur which is removed in a converting operation similar to conventional copper matte converting. The converter product is a crude lead similar to lead bullion normally produced from a lead blast furnace. This crude lead is further processed to refined lead in the usual manner, which is described later.

The hot gas from the smelting furnace is cooled in a boiler and the steam used locally as required for heating purposes. The smelting furnace and converter gases both carry considerable amounts of dust and lead oxide fume which is recovered in a Cottrell and returned to the furnace charge. Converter and refinery drosses are also returned to the furnace charge.

Average furnace load has been calculated to approximately 8,000 KW requiring a furnace capacity of 12,000 KVA for the first case and 24,000 KVA for the second case. The proposed furnace is of rectangular shape with 3 and 6 Soderberg electrodes, respectively, in line. The furnace is entirely lined with basic brick and the lining is further protected by water cooling in exposed areas.

The furnace lead is treated in two small Pierce-Smith type converters with special refractory lining. A travelling crane is provided in the converter aisle to handle molten lead in ladles.

The smelter gases are cooled and cleaned in hot Cottrells and wet scrubbers for recovery of dust and fume.

Refining of lead

Crude lead from the converters contains most of the silver and gold contained in the lead concentrate and various impurities such as antimony, bismuth, and small amounts of arsenic and zinc.

The refining process consists of the following steps:

- (1) Removal of copper as a dross or a matte which is reverted to the electric furnace.
- (2) Softening and working up of antimonial lead. This step removes arsenic and iron, besides antimony.
- (3) Desilverizing with zinc and working up the silver crusts either to a Dore bullion or to silver and gold by parting.
- (4) Removal of the excess zinc by vacuum dezincing and treatment with caustic soda. Alternately, dezincing with chlorine can be used.
- (5) Based on a bismuth content of 0.008 % Bi in concentrate, the lead bullion will contain approximately 0.012 % Bi. This is a fairly low bismuth level but it will nevertheless probably be necessary to put the lead through a debismuthizing treatment.

The molten lead is then cast to refined lead pigs.

ENVIRONMENTAL CONTROL AND SULPHUR RECOVERY

The zinc concentrate contains about 33 % sulphur while the lead concentrate contains 18 %. It is assumed that most of this sulphur will be recovered by processing the roaster, electric furnace and converter gases to sulphuric acid. This recovery of byproduct sulphuric acid is not economically attractive in a location such as Little Salmon which is so remote from the established markets, but is considered necessary, or in any case desirable, from the viewpoint of environmental control.

A single conversion sulphuric acid plant of standard design has a conversion efficiency of approximately 97.5 % which means that 2.5 % of the sulphur input is expelled to atmosphere in the form of sulphur dioxide in acid plant tail gas. Such a plant should be adequate to meet the environmental requirements in the Yukon. It has therefore been assumed that a single conversion plant will be sufficient for a zinc-lead complex in the Yukon.

Control of sulphur emission to atmosphere through processing of furnace gases to sulphuric acid is the dominant environmental control item for a zinc-lead smelting complex. Of next importance is the removal of mercury from these gases. To accomplish this equipment has been included in the zinc plant and the lead smelter to remove mercury from the gases using the Outokumpu method. The process is based on scrubbing the mercury from the gases, with concentrated sulphuric acid from the acid plant, and precipitating the mercury as HgSO_4 .

Impure wash acid from the acid plant washing system, bleed streams from the electrolyte system as well as various residue wash waters,

along with acid, in excess of that required in the processes, will be neutralized with limestone before final disposal in the form of gypsum slurry.

CYPRUS ANVIL MINING CORPORATION

ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

METALLURGICAL CALCULATIONS - ANALYSIS OF RAW MATERIALS

	<u>Zinc</u> <u>concentrate</u> %	<u>Lead</u> <u>concentrate</u> %	<u>Silica</u> <u>flux</u> %	<u>Limestone</u> <u> </u> %
Zinc	51.58	5.48		
Lead	1.50	65.55		
Copper	0.51	0.29		
Iron	10.02	6.38		
Silica	1.24	0.38	80	10
Calcium carbonate	-	-	10	82
Cadmium	0.07	-		
Sulphur	32.98	17.56		
Arsenic	0.04	0.02		
Antimony	0.003	0.08		
Cobalt	0.002	-		
Nickel	0.001	-		
Barium oxide	0.30	0.28		
Mercury	224 ppm	24 ppm		
Bismuth	<0.005	0.008		
Chlorine	0.004	0.001		
Fluorine	0.002	0.001		
Germanium	0.004	-		
Tin	0.001	0.002		
Lime	0.20	0.20		
Magnesium oxide	0.05	0.10		
Alumina	0.10	0.02		
Selenium	<0.002	0.003		
Tellurium	<0.00002	<0.00002		
Manganese	1.00	0.20		
Silver oz/ton	1.50	18.1		
Gold oz/ton	0.006	0.02		
Assumed average moisture	5.5	5.5	5.5	5.5

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

METALLURGICAL CALCULATIONS - MATERIAL AND PRODUCT QUANTITIES

Annual quantities, in dry short tons, of the most important materials are shown below.

Case:	I	II
Slab zinc production, STPY (365 operating days/year)	70,000	140,000
Refined lead production, STPY (340 operating days/year)	<u>51,550</u>	<u>103,100</u>

RAW MATERIALS

Zinc concentrate	144,370	288,740
Lead concentrate	80,640	161,290
Sulphuric acid (100 % H ₂ SO ₄)	11,572	23,145
Ammonia	1,157	2,314
Coke	2,600	5,200
Silica flux @ 80 % SiO ₂	12,650	25,300
Limestone @ 82 % CaCO ₃	31,150	62,300

PRODUCTS

Slab zinc (99.99 % Zn)	70,000	140,000
Total refined lead (99.99 % Pb)	51,500	103,100
Refined cadmium	81	162
Copper contained in copper matte	140	281

RESIDUES PRODUCED

Lead-silver residue (24 % Pb, 24 oz/ST Ag)	6,785	13,570
Jarosite residue (28.5 % Fe)	40,605	81,211

SULPHURIC ACID (100 % H₂SO₄)

Recovered from zinc and lead plants	169,542	339,085
Less required for acid leach	11,572	23,145

EXCESS ACID NEUTRALIZATION

Excess acid to neutralization	159,970	315,940
Limestone @ 82 % CaCO ₃	212,470	424,940

SMELTER SLAG

Electric furnace slag to dump	47,230	94,460
-------------------------------	--------	--------

continued

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

METALLURGICAL CALCULATIONS - MATERIAL AND PRODUCT QUANTITIES (cont'd)

Annual quantities, in dry short tons, of the most important materials are shown below.

Case:	I	II
Slab zinc production, STPY (365 operating days/year)	70,000	140,000
Refined lead production, STPY (340 operating days/year)	<u>51,550</u>	<u>103,100</u>

PRECIOUS METALS

	<u>ounces (troy)/year</u>	
Silver from lead-silver residue	159,200	318,300
Silver from lead concentrate	<u>1,430,400</u>	<u>2,861,000</u>
Total silver recovered in Dore metal	<u>1,589,600</u>	<u>3,179,300</u>
Gold from lead-silver residue	640	1,270
Gold from lead concentrate	<u>1,580</u>	<u>3,160</u>
Total gold recovered in Dore metal	<u>2,220</u>	<u>4,430</u>

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

METALLURGICAL CALCULATIONS - LOSSES AND RECOVERIES

The figures shown below are percentages of the element in concentrate

	<u>From zinc concentrate</u>	<u>From lead concentrate</u>
	<u>%</u>	<u>%</u>
<u>ZINC</u>		
<u>Losses</u>		
Lead-silver residue	0.4	
Jarosite residue	4.6	
		All zinc is lost in electric furnace slag
Dust and handling(*)	<u>1.0</u>	
	6.0	
<u>Recovery</u>	94.0	nil
<u>LEAD</u>		
<u>Losses</u>		
Jarosite residue	25.0	-
Electric furnace slag	-	3.9
Dust and handling loss	-	<u>1.0</u>
	<u>25.0</u>	4.9
<u>Recovery</u>	75.0	95.1
<u>SILVER AND GOLD</u>		
<u>Losses</u>		
Jarosite residue	25.0	-
Electric furnace slag	-	1.0
Dust and handling loss	-	<u>1.0</u>
	<u>25.0</u>	2.0
<u>Recovery</u> in lead-silver residue	75.0	-
in Dore metal from lead refinery		98.0
<u>CADMIUM</u>		
<u>Losses</u>		
Jarosite residue	20	
<u>Recovery</u>	80	

continued

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

METALLURGICAL CALCULATIONS - LOSSES AND RECOVERIES (cont'd)

The figures shown below are percentages of the element in concentrate

	<u>From zinc concentrate</u>	<u>From lead concentrate</u>
<u>SULPHUR</u>		
<u>Fixed in</u>		
Jarosite residue	10.9	-
Handling loss in zinc plant	0.5	-
Concentrate handling loss -		
lead smelter	-	1.0
Electric furnace slag	-	0.3
	<u>11.4</u>	<u>1.3</u>
<u>Recovered</u>		
As sulphuric acid from zinc		
plant	88.6	-
As sulphuric acid from lead		
smelter	-	94.4

(*) Includes solution and melting losses in zinc plant.

CYPRUS ANVIL MINING CORPORATION

CAPITAL COST SUMMARY

In Canadian Dollars

Plant	<u>Combined Electrolytic Zinc Plant & Electric Lead Smelter</u>		<u>Separate Electrolytic Zinc Plant</u>		<u>Separate Electric Lead Smelter & Refinery</u>	
	I	II	I	II	I	II
Case						
Slab zinc produced STPY	70,000	140,000	70,000	140,000	-	-
Refined lead produced STPY	<u>51,550</u>	<u>103,100</u>	-	-	<u>50,000</u>	<u>100,000</u>
<u>PLANT COSTS</u>						
Site preparation for complex	2,030,000	3,075,000	1,523,000	2,306,000	1,015,000	1,535,000
Zinc plant	21,727,000	35,339,000	21,727,000	35,339,000	-	-
Lead smelter and refinery	11,412,000	17,811,000	-	-	11,412,000	17,811,000
Auxiliary services	<u>8,666,000</u>	<u>13,613,000</u>	<u>5,720,000</u>	<u>9,142,000</u>	<u>4,386,000</u>	<u>6,661,000</u>
	43,835,000	69,838,000	28,970,000	46,787,000	16,813,000	26,010,000
Engineering & construction overhead @ 38 %	16,657,000	26,538,000	11,009,000	17,779,000	6,389,000	9,854,000
Contingency @ 25 %	15,123,000	24,094,000	9,995,000	16,142,000	5,800,000	8,973,000
Purchase of technical knowhow	<u>1,650,000</u>	<u>2,550,000</u>	<u>1,150,000</u>	<u>1,800,000</u>	<u>500,000</u>	<u>750,000</u>
Total smelting complex	77,265,000	123,020,000	51,124,000	82,508,000	29,502,000	45,617,000
Sulphuric acid plant	5,162,000	7,738,000	4,388,000	6,577,000	2,581,000	3,869,000
Contingency @ 25 %	<u>1,291,000</u>	<u>1,935,000</u>	<u>1,097,000</u>	<u>1,644,000</u>	<u>645,000</u>	<u>967,000</u>
	6,453,000	9,673,000	5,485,000	8,221,000	3,226,000	4,836,000
Excess acid neutralization	1,892,000	2,990,000	1,608,000	2,542,000	946,000	1,495,000
Engineering & construction overhead @ 38 %	719,000	1,136,000	611,000	966,000	360,000	568,000
Contingency @ 25 %	<u>653,000</u>	<u>1,032,000</u>	<u>555,000</u>	<u>877,000</u>	<u>326,000</u>	<u>516,000</u>
	3,264,000	5,158,000	2,774,000	4,385,000	1,632,000	2,579,000
Total production complex	86,982,000	137,851,000	59,383,000	95,114,000	34,360,000	53,032,000
<u>OTHER COSTS⁽¹⁾</u>						
Townsite	18,252,000	24,950,000	11,176,000	15,194,000	10,594,000	14,086,000
Access road	200,000	200,000	200,000	200,000	200,000	200,000
Water supply	300,000	300,000	300,000	300,000	300,000	300,000
Waste disposal	500,000	500,000	500,000	500,000	500,000	500,000
Working capital ⁽²⁾	-	-	-	-	-	-
TOTAL CAPITAL COST (excl. working capital)	106,234,000	163,801,000	71,559,000	111,308,000	45,954,000	68,118,000

Remarks: (1) Capital costs supplied by Cyprus Anvil Mining Corporation, details shown under Economic Feasibility.

(2) Working capital depends on metal prices, is excluded here, but is added for the Economic Feasibility calculations along with the escalation.

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

CAPITAL COST ESTIMATE BREAKDOWN

Case:	I	II
Slab zinc produced STPY (365 op. days/yr)	70,000	140,000
Refined lead produced STPY (340 op. days/yr)	<u>51,550</u>	<u>103,100</u>
Site preparation for complex(1)	2,030,000	3,075,000
<u>ELECTROLYTIC ZINC PLANT</u>		
Concentrate handling and storage	1,524,000	2,324,000
Roaster and equipment	4,100,000	6,234,000
Calcine grinding and storage	675,000	1,015,000
Leaching and residue separation	3,987,000	6,056,000
Jarosite process	1,270,000	2,094,000
Solution purification	1,270,000	1,929,000
Electrolytic refining	6,071,000	11,231,000
Melting, casting and dross treatment	1,802,000	2,742,000
Zinc dust plant	381,000	647,000
Copper and cadmium recovery	<u>647,000</u>	<u>1,067,000</u>
Total zinc plant	21,727,000	35,339,000
<u>ELECTRIC LEAD SMELTER AND REFINERY</u>		
Raw materials handling and storage	1,339,000	2,031,000
Concentrate dryer and dust collection	440,000	670,000
Air preheater	260,000	400,000
Electric furnace	2,085,000	3,160,000
Converters including air supply	600,000	912,000
Crane	315,000	315,000
Gas cooling and dust recovery	1,343,000	2,038,000
Smelter buildings incl. ventilation	1,418,000	2,150,000
Conveyors material handling & weighing	611,000	926,000
Slag disposal	188,000	285,000
Standard lead refining plant	2,513,000	4,524,000
Allowance for debismuthizing	<u>300,000</u>	<u>400,000</u>
Total lead smelter and refinery	11,412,000	17,811,000

continued

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

CAPITAL COST ESTIMATE BREAKDOWN (cont'd)

Case:	I	II
Slab zinc producted STPY (365 op. days/yr)	70,000	140,000
Refined lead producted STPY (340 op. days/yr)	<u>51,550</u>	<u>103,100</u>
<u>AUXILIARY SERVICES(3)</u>		
Electrical distribution and substation	3,801,000	5,782,000
Plant services, shops, office, gatehouse & laboratory	2,934,000	4,457,000
Mercury removal	1,528,000	2,763,000
Effluent pollution control facilities	<u>403,000</u>	<u>611,000</u>
Total auxiliary services for complex	8,666,000	13,613,000
TOTAL DIRECT COST ZINC-LEAD COMPLEX	43,835,000	69,838,000
Engineering and construction overhead @ 38 %	16,657,000	26,538,000
Contingency @ 25 %	15,123,000	24,094,000
Purchase of technical knowhow	<u>1,650,000</u>	<u>2,550,000</u>
TOTAL COST ZINC-LEAD SMELTER	77,265,000	123,020,000
<u>SULPHURIC ACID PLANT</u>		
Plant to handle zinc and lead plant gases on a turnkey basis (2) (3)	5,162,000	7,738,000
Contingency @ 25 %	<u>1,291,000</u>	<u>1,935,000</u>
Total sulphuric acid plant	6,453,000	9,673,000
<u>EXCESS ACID NEUTRALIZATION</u>		
Neutralization plant (3)	1,892,000	2,990,000
Engineering & construction overhead @ 38 %	719,000	1,136,000
Contingency @ 25 %	<u>653,000</u>	<u>1,032,000</u>
Total acid neutralization	3,264,000	5,158,000
<u>TOTAL COST OF ZINC-LEAD COMPLEX</u>	86,982,000	137,851,000

continued

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

CAPITAL COST ESTIMATE BREAKDOWN (cont'd)

- Remarks:
- (1) No allowance has been made for site acquisition but does include service piping, roads and fences.
 - (2) No engineering or construction overhead charges made on turnkey jobs.
 - (3) Plants sized to meet the requirements of both the zinc plant and the lead smelter.

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTROLYTIC ZINC PLANT WITH ACID RECOVERY AND NEUTRALIZATION

CAPITAL COST ESTIMATE
In Canadian Dollars

Case	I	II
Slab zinc produced, STPY	<u>70,000</u>	<u>140,000</u>
<u>DIRECT COST</u>		
Plant site preparation (1)	1,523,000	2,306,000
<u>ZINC PLANT</u>		
Concentrate handling & storage (3)	1,524,000	2,324,000
Roaster and equipment	4,100,000	6,234,000
Calcine grinding & storage	675,000	1,015,000
Leaching & residue separation	3,987,000	6,056,000
Jarosite process	1,270,000	2,094,000
Solution purification	1,270,000	1,929,000
Electrolytic refining	6,071,000	11,231,000
Melting, casting & dross treatment	1,802,000	2,742,000
Zinc dust plant	381,000	647,000
Copper and cadmium recovery	647,000	1,067,000
<u>AUXILIARY SERVICES (3)</u>		
Electrical distribution & substation	2,843,000	4,329,000
Plant services, shops, office, gatehouse & Laboratory	1,956,000	2,971,000
Mercury removal	<u>921,000</u>	<u>1,842,000</u>
Total direct cost	28,970,000	46,787,000
Engineering & construction overhead @ 38%	11,009,000	17,779,000
Contingency @ 25%	<u>9,995,000</u>	<u>16,142,000</u>
	49,974,000	80,708,000
Purchase of technical knowhow	<u>1,150,000</u>	<u>1,800,000</u>
TOTAL ZINC PLANT	51,124,000	82,508,000
<u>SULPHURIC ACID PLANT</u>		
Plant to handle zinc plant gas - turnkey basis (2) (3)	4,388,000	6,577,000
Contingency @ 25%	<u>1,097,000</u>	<u>1,644,000</u>
TOTAL SULPHURIC ACID PLANT	5,485,000	8,221,000

continued

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTROLYTIC ZINC PLANT WITH ACID RECOVERY AND NEUTRALIZATION

CAPITAL COST ESTIMATE (cont'd)

In Canadian Dollars

Case	I	II
Slab zinc produced, STPY	<u>70,000</u>	<u>140,000</u>
<u>EXCESS ACID NEUTRALIZATION</u>		
Neutralization plant (3)	1,608,000	2,542,000
Engineering & construction overhead @ 38%	611,000	966,000
Contingency @ 25%	<u>555,000</u>	<u>877,000</u>
TOTAL ACID NEUTRALIZATION	2,774,000	4,385,000
<u>TOTAL ZINC PLANT COST</u>	59,383,000	95,114,000

- Remarks:
- (1) No allowance has been made for site acquisition but does include service piping, roads and fences.
 - (2) No engineering or construction overhead charges made on turnkey jobs.
 - (3) Plants sized to handle the requirements of the zinc plant only.

CYPRUS ANVIL MINING CORPORATION
SEPARATE ELECTRIC LEAD SMELTER AND REFINERY
WITH ACID RECOVERY AND NEUTRALIZATION

CAPITAL COST ESTIMATE
In Canadian dollars

Case	I	II
Refined lead produced from lead concentrate, STPY	<u>50,000</u>	<u>100,000</u>
<u>DIRECT COST</u>		
Plant site preparation (1)	1,015,000	1,538,000
<u>LEAD SMELTER AND REFINERY</u>		
Raw materials handling & storage (3)	1,339,000	2,031,000
Concentrate dryer & dust collection	440,000	670,000
Air preheater	260,000	400,000
Electric furnace	2,085,000	3,160,000
Converters including air supply	600,000	912,000
Crane	315,000	315,000
Gas cooling & dust recovery	1,343,000	2,038,000
Smelter buildings inc. ventilation	1,418,000	2,150,000
Conveyors, material handling & weighing	611,000	926,000
Slag disposal	188,000	285,000
Standard lead refining plant	2,513,000	4,524,000
Allowance for debismuthizing	300,000	400,000
<u>Auxiliary services (3)</u>		
Electrical power supply & distribution	1,811,000	2,752,000
Mercury removal unit	607,000	921,000
Effluent pollution control facilities	403,000	611,000
Plant services, shops, office, laboratory	<u>1,565,000</u>	<u>2,377,000</u>
Total direct cost	16,813,000	26,010,000
Engineering & construction overhead @ 38%	6,389,000	9,384,000
Contingency @ 25%	<u>5,800,000</u>	<u>8,973,000</u>
Lead smelter and refinery	29,002,000	44,867,000
Purchase of technical knowhow	<u>500,000</u>	<u>750,000</u>
TOTAL LEAD SMELTER AND REFINERY	29,502,000	45,617,000

continued

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTRIC LEAD SMELTER AND REFINERY
WITH ACID RECOVERY AND NEUTRALIZATION

CAPITAL COST ESTIMATE (cont'd)
In Canadian Dollars

Case	I	II
Refined lead produced from lead concentrate, STPY	<u>50,000</u>	<u>100,000</u>
<u>SULPHURIC ACID PLANT</u>		
Plant to handle lead smelter gas on a turnkey basis (2) (3)	2,581,000	3,869,000
Contingency @ 25%	<u>645,000</u>	<u>967,000</u>
TOTAL SULPHURIC ACID PLANT	3,226,000	4,836,000
<u>EXCESS ACID NEUTRALIZATION</u>		
Neutralization Plant (3)	946,000	1,495,000
Engineering and construction overhead @ 38%	360,000	568,000
Contingency @ 25%	<u>326,000</u>	<u>516,000</u>
TOTAL ACID NEUTRALIZATION	1,632,000	2,579,000
<u>TOTAL LEAD SMELTER AND REFINERY COST</u>	34,360,000	53,032,000

- Remarks:
- (1) No allowance has been made for site acquisition, but does include service piping, roads and fences
 - (2) No engineering and construction overhead charges made on turnkey jobs.
 - (3) Plants sized to handle the requirements of the lead smelter alone.

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SUMMARY OF ANNUAL OPERATING COST ESTIMATES

In Canadian Dollars

Assumed power cost 1.5¢ per KWH

Case	I	II
Slab zinc produced, STPY (365 op.days/yr)	70,000	140,000
Refined lead produced, STPY (340 op.days/yr)	<u>51,550</u>	<u>103,100</u>
<u>ZINC PLANT</u>		
Production of slab zinc	9,645,780	17,219,540
<u>LEAD SMELTER & REFINERY</u>		
Lead smelter	4,380,290	7,251,560
Lead refinery (with bismuth removal)	<u>1,584,670</u>	<u>2,567,100</u>
Production of refined lead	5,964,960	9,818,660
<u>SULPHURIC ACID PLANT</u>		
Production of 100 % Sulphuric Acid	711,500	1,051,410
<u>EXCESS ACID NEUTRALIZATION</u>		
Neutralization of acid not required for zinc plant	<u>1,105,290</u>	<u>2,068,620</u>
Total complex	17,427,530	30,158,230
<u>ZINC PLANT, ¢/lb. slab zinc</u>		
Zinc plant	6.89	6.15
Sulphuric acid production	0.37	0.27
Neutralization of excess acid	<u>0.55</u>	<u>0.52</u>
Total cost of slab zinc ¢/lb.	7.81	6.94
<u>LEAD SMELTER AND REFINERY, ¢/lb. refined lead</u>		
Lead smelter	4.25	3.52
Lead refinery (standard)	1.22	0.99
Debismuthizing, labour & supplies	<u>0.32</u>	<u>0.25</u>
Smelter with refinery	5.79	4.76
Sulphuric acid production	0.19	0.14
Neutralization of excess acid	<u>0.32</u>	<u>0.30</u>
Total cost of refined lead, ¢/lb.	6.30	5.20

Note: Costs include an allowance for maintenance labour and supplies and a contingency of 10 %.

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL OPERATING COST ESTIMATE - ELECTROLYTIC ZINC PLANT

In Candian Dollars
Assumed power cost 1.5¢ per KWH

Case		I		II	
Slab zinc produced, STPY (365 op. days/year)		70,000		140,000	
<u>Cost item</u>	<u>Unit cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>ZINC PLANT</u>					
<u>Labour</u>					
Operating	\$ 6.45/hour	187,160	1,207,180	273,744	1,765,660
Indirect	\$ 6.45/hour	24,160	155,830	30,400	196,070
<u>Supervision</u>					
Proportion of General Plant	various	50 % of 27	266,790	50 % of 33	314,790
Zinc plant supervision	various	18	355,170	20	388,800
<u>Utilities</u>					
Electric power	1.5 c/KWH	279,026,370	4,185,390	558,052,740	8,370,790
Light industrial fuel oil	31 c/Imp. gal.	925,455	286,890	1,863,676	577,740
Water	Included in power and operating supplies				
<u>Process supplies</u>					
Sulphuric acid	no cost	11,572	-	23,145	-
Ammonia	\$ 120/ton	1,157	138,840	2,314	277,680
Other supplies & process reagents	\$ 8.64/ton slab zinc	70,000	604,800	140,000	1,209,600
<u>Maintenance</u>					
Labour & supplies	5 % p.a. of direct capital cost	28,800,000	1,440,000	46,531,000	2,326,550
<u>Office & Laboratory</u>					
Supplies	allowance	-	50,000	-	70,000
<u>Royalty</u>					
Jarosite process	DNZ-EZ formula	5,200(*)	78,000	10,430(*)	156,450
			8,768,890		15,654,130
			876,890		1,565,410
<u>Contingency, @ 10 %</u>					
TOTAL ZINC PLANT			9,645,780		17,219,540

continued

(*) Additional STPY zinc recovered by Jarosite process.

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL OPERATING COST ESTIMATE - ELECTROLYTIC ZINC PLANT (cont'd)

In Canadian Dollars
Assumed power cost 1.5¢ per KWH

Case		I		II	
Slab zinc produced, STPY (365 op. days/year)		70,000		140,000	
Cost item	Unit cost	Quantity	\$/year	Quantity	\$/year
<u>TOTAL ZINC PLANT (carried forward)</u>			9,645,780		17,219,540
<u>SULPHURIC ACID PLANT</u>					
Proportion of operating labour	\$ 6.45/hour	70 % of 19,600	88,490	70 % of 19,600	88,490
Proportion of supervision	various	70 % of 4	59,490	70 % of 4	59,490
Electric power	1.5 c/KWH	9,298,656	139,480	18,597,374	278,960
Water	Included in power and operating supplies				
Other operating supplies	allowance	-	15,000	-	20,000
Maintenance (labour & supplies)	70 % of the 4.5 % p.a. direct cost	232,290	162,600	348,210	243,750
			465,060		690,690
Contingency @ 10 %			46,510		69,070
<u>TOTAL SULPHURIC ACID PLANT</u>			511,570		759,760
<u>EXCESS ACID NEUTRALIZATION</u>					
Proportion of operating labour	\$ 6.45/hour	70 % of 12,920	58,330	70 % of 12,920	58,330
Supervision	various		Included in acid plant		
Electric power	1.5 c/KWH	70 % of 4,846,520	50,890	70 % of 9,693,039	101,780
Water	Included in power and operating supplies				
Limestone	\$ 3.50/ton	148,729	520,550	297,458	1,041,100
Other operating supplies	allowance		15,000		20,000
Maintenance (labour & supplies)	70 % of the 4.5 % p.a. direct cost	85,140	59,600	134,550	94,180
			704,370		1,315,390
Contingency @ 10 %			70,440		131,540
<u>TOTAL ACID NEUTRALIZATION</u>			774,810		1,446,930
<u>TOTAL OPERATING COST OF ZINC PLANT</u>			10,932,160		19,426,230
Cost in \$/short ton zinc concentrate			75.72		67.28
Cost in c/lb. of slab zinc			7.81		6.94

Note: Costs for acid production and neutralization are split between the zinc plant and the lead smelter on a 70/30 basis.

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL OPERATING COST ESTIMATE - ELECTRIC LEAD SMELTER WITH REFINERY

In Canadian Dollars

Assumed power cost 1.5¢ per KWH

Case			I		II
Refined lead produced (340 op. days/year)			<u>51,550</u>		<u>103,100</u>
<u>Cost item</u>	<u>Unit cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>LEAD SMELTER</u>					
<u>Labour</u>					
Operating	\$ 6.45/hour	107,600	694,010	166,400	1,073,270
Indirect	\$ 6.45/hour	19,160	123,580	23,320	150,410
<u>Supervision</u>					
Proportion of General Plant	various	50 % of 27	266,790	50 % of 33	314,790
Smelter & Refinery, supervision	various	19	372,870	22	424,190
<u>Utilities</u>					
Electric power	1.5 c/KWH	66,388,196	995,820	127,755,864	1,916,340
Light industrial fuel oil	31 c/Imp. gal.	269,844	83,650	539,688	167,300
Water	Included in power and operating supplies				
<u>Process materials</u>					
Coke	\$ 94.00/ton	2,600	244,400	5,200	488,800
Silica flux @ 80 % SiO ₂	\$ 9.26/ton	12,650	117,140	25,300	234,280
Limestone @ 82 % CaCO ₃	\$ 3.50/ton	31,150	109,030	62,300	218,050
Electrode paste	9.2 c/lb.	2,456,000	225,950	4,726,000	434,790
Other operating supplies	40¢ & 38¢/ton conc.	80,644	32,260	161,288	61,290
<u>Maintenance labour & supplies</u>					
Lead smelter and refinery	4.5 % p.a. of direct capital cost	15,035,000	676,580	23,307,000	1,048,820
<u>Office & laboratory</u>					
Supplies	allowance	-	40,000	-	60,000
			3,982,080		6,592,330
			<u>398,210</u>		<u>659,230</u>
<u>Contingency, @ 10 %</u>					
TOTAL LEAD SMELTER			4,380,290		7,251,560

continued

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL OPERATING COST ESTIMATE - ELECTRIC LEAD SMELTER WITH REFINERY (cont'd)

In Canadian Dollars

Assumed power cost 1.5¢ per KWH

Case		I		II	
		51,550		103,100	
Refined lead produced (340 op. days/year)					
<u>Cost item</u>	<u>Unit cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>LEAD REFINERY</u>					
<u>Labour</u>					
Operating (basic)	\$ 6.45/hour	98,840	637,520	141,750	914,300
Bismuth removal	\$ 6.45/hour	17,520	113,000	17,520	113,000
<u>Supervision</u>					
	Included in lead smelter				
<u>Utilities</u>					
Electric power	1.5 ¢/KWH	2,062,000	30,930	3,917,800	58,770
Light industrial oil	31 ¢/Imp. gal.	653,200	202,490	1,244,190	385,700
Water	Included in power and operating supplies				
<u>Process materials</u>					
Sulphur (pulverized)	\$ 67.90/ton	52	3,530	103	6,990
Soda ash (Na ₂ CO ₃)	\$ 99.48/ton	103	10,250	206	20,500
Caustic soda (NaOH)	\$ 158.00/ton	103	16,270	206	32,550
Metallic zinc from zinc plant	\$ 600.00/ton	155	93,000	310	186,000
Scrap iron	\$ 200.00/ton	210	42,000	420	84,000
Silica sand	\$ 9.26/ton	103	950	206	1,910
Coke breeze	\$ 94.00/ton	310	29,140	620	58,280
<u>Additional for debismuthizing</u>					
Metallic magnesium	\$ 1330/ton	52	69,160	103	136,990
Metallic calcium	\$ 2450/ton	26	63,700	52	127,400
Liquified chlorine	\$ 157/ton	310	48,670	620	97,340
Other operating supplies	allowance		40,000		50,000
<u>Maintenance</u>					
	Included under lead smelter above				
<u>Office & laboratory</u>					
Supplies	allowance		40,000		60,000
			1,440,610		2,333,730
<u>Contingency, @ 10 %</u>			144,060		233,370
TOTAL LEAD REFINERY			1,584,670		2,567,100
<u>TOTAL LEAD SMELTER WITH REFINERY</u>			5,964,960		9,818,660

continued

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL OPERATING COST ESTIMATE - ELECTRIC LEAD SMELTER WITH REFINERY (cont'd)

In Canadian Dollars

Assumed power cost 1.5¢ per KWH

Case			I		II
Refined lead produced (340 op. days/year)			51,550		103,100
Cost item	Unit cost	Quantity	\$/year	Quantity	\$/year
<u>TOTAL LEAD SMELTER WITH REFINERY (carried forward)</u>			5,964,960		9,818,660
<u>SULPHURIC ACID PLANT</u>					
Proportion of operating labour	\$ 6.45/hour	30 % of 19,600	37,930	30 % of 19,600	37,930
Proportion of supervision	various	30 % of 4	25,500	20 % of 4	25,500
Electric power	1.5 c/KWH	2,908,368	43,630	5,816,736	87,250
Water	Included in power and operating supplies				
Other operating supplies	allowance	-	5,000	-	10,000
Maintenance (labour & supplies)	30 % of the 4.5 % p.a. of direct cost	232,290	69,690	348,210	104,460
			181,750		265,140
Contingency, @ 10 %			18,180		26,510
<u>TOTAL SULPHURIC ACID PLANT</u>			199,930		291,650
<u>EXCESS ACID NEUTRALIZATION</u>					
Proportion of operating labour	\$ 6.45/hour	30 % of 12,920	25,000	30 % of 12,920	25,000
Supervision	various		Included in acid plant		
Electric power	1.5 c/KWH	30 % of 4,846,520	21,810	30 % of 9,693,039	43,620
Water	Included in power and operating supplies				
Limestone	\$ 3.50/ton	63,740	223,090	127,481	446,180
Other operating supplies	allowance		5,000		10,000
Maintenance (labour & supplies)	30 % of the 4.5 % p.a. of direct cost	85,140	25,540	134,550	40,370
			300,440		565,170
Contingency, @ 10 %			30,040		56,520
<u>TOTAL ACID NEUTRALIZATION</u>			330,480		621,690
<u>TOTAL OPERATING COST OF LEAD SMELTER WITH REFINERY</u>			6,495,370		10,732,000
Cost in \$/short ton lead concentrate			80.55		66.54
Cost in c/lb. of refined lead			6.30		5.20

Note: Costs for acid production and neutralization are split between the zinc plant and the lead smelter on a 70/30 basis.

CYPRUS ANVIL MINING CORPORATION

SUMMARY OF ANNUAL OPERATING COST ESTIMATES FOR SEPARATE PLANTS

In Canadian Dollars

Assumed power cost 1.5¢ per KWH

Case	I	II
<u>ZINC PLANT</u>		
<u>Slab zinc produced STPY</u>	<u>70,000</u>	<u>140,000</u>
Production of slab zinc	9,824,020	17,455,320
Sulphuric acid production (100% H ₂ SO ₄)	619,690	886,970
Excess acid neutralization	<u>828,330</u>	<u>1,520,650</u>
Total Zinc Plant	11,272,040	19,862,940
<u>Cost in ¢/lb slab zinc</u>		
Production of slab zinc	7.02	6.23
Sulphuric acid production	0.44	0.32
Excess acid neutralization	<u>0.59</u>	<u>0.54</u>
Total cost of slab zinc in ¢/lb	8.05	7.09
<u>LEAD SMELTER AND REFINERY</u>		
<u>Refined lead produced from concentrate STPY</u>	<u>50,000</u>	<u>100,000</u>
Lead smelter	4,637,190	7,607,050
Lead refinery (with bismuth removal)	<u>1,570,440</u>	<u>2,540,350</u>
Smelter with refinery	6,207,630	10,147,400
Sulphuric acid production (100% H ₂ SO ₄)	413,810	531,060
Excess acid neutralization	<u>429,370</u>	<u>747,440</u>
Total lead smelter & refinery	7,050,810	11,425,900
<u>Cost in ¢/lb refined lead</u>		
Lead smelter	4.64	3.80
Lead refinery (standard)	1.25	1.02
Debismuthizing, labour & supplies	<u>0.32</u>	<u>0.25</u>
Smelter with refinery	6.21	5.07
Sulphuric acid production	0.41	0.27
Excess acid neutralization	<u>0.43</u>	<u>0.37</u>
Total cost of refined lead in ¢/lb.	7.05	5.71

NOTE: Costs include an allowance for maintenance labour and supplies and a contingency of 10%.

CYPRUS ANVIL MINING CORPORATION
SEPARATE ELECTROLYTIC ZINC PLANT

ANNUAL OPERATING COST ESTIMATE
In Canadian Dollars
Assumed power cost 1.5¢ per KWH

Case		I		II	
(Slab zinc produced, STPY (365 op. days/year)		70,000		140,000	
Cost item	Unit cost	Quantity	\$/year	Quantity	\$/year
<u>ZINC PLANT</u>					
<u>Labour</u>					
Operating	\$ 6.45/hour	187,160	1,207,180	273,744	1,765,660
Indirect	\$ 6.45/hour	24,160	155,830	30,400	196,070
<u>Supervision</u>					
General Plant supervision	various	21	420,330	27	516,330
Zinc Plant supervision	various	18	355,170	20	388,800
<u>Utilities</u>					
Electric power	1.5 c/KWH	279,026,370	4,185,390	558,052,740	8,370,790
Light industrial fuel oil	31 c/Imp. gal.	925,455	286,890	1,863,676	577,740
Water	Included in power and operating supplies				
<u>Process supplies</u>					
Sulphuric acid	no cost	11,572	-	23,145	-
Ammonia	\$ 120/ton	1,157	138,840	2,314	277,680
Other supplies & process reagents	\$ 8.64/ton slab zinc	70,000	604,800	140,000	1,209,600
<u>Maintenance</u>					
Labour & supplies	5 % p.a. of direct capital cost	28,970,000	1,448,500	46,787,000	2,339,350
<u>Office & laboratory</u>					
Supplies	allowance	-	50,000	-	70,000
<u>Royalty</u>					
Jarosite process	DNZ-EZ formula	5,200(*)	78,000	10,430(*)	156,450
			8,930,930		15,865,470
			893,090		1,586,550
<u>Contingency, @ 10 %</u>					
			9,824,020		17,455,320
TOTAL ZINC PLANT					

(*) Additional STPY zinc recovered by Jarosite process.

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTROLYTIC ZINC PLANT

ANNUAL OPERATING COST ESTIMATE (cont'd)

In Canadian Dollars

Assumed power cost 1.5¢ per KWH

Case		I		II	
		70,000		140,000	
Slab zinc produced, STPY (365 op. days/year)					
<u>Cost item</u>	<u>Unit cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>TOTAL ZINC PLANT</u> (carried forward)			9,824,020		17,455,32
<u>SULPHURIC ACID PLANT</u>					
Operating labour	\$ 6.45/hour	19,600	126,420	19,600	126,420
Supervision	various	4	84,990	4	84,990
Electric power	1.5 c/KWH	9,298,656	139,480	18,597,374	278,960
Water	Included in power and operating supplies				
Other operating supplies	allowance	-	15,000	-	20,000
Maintenance (labour & supplies)	4.5 % p.a. of direct cost	4,388,000	197,460	6,577,000	295,970
			563,350		806,340
Contingency, @ 10 %			56,340		80,630
<u>TOTAL SULPHURIC ACID PLANT</u>			619,690		886,970
<u>EXCESS ACID NEUTRALIZATION</u>					
Proportion of operating labour	\$ 6.45/hour	12,920	83,330	12,920	83,330
Supervision	various		Included in acid plant		
Electric power	1.5 c/KWH	4,119,542	61,790	8,239,082	123,590
Water	Included in power and operating supplies				
Limestone	\$ 3.50/ton	148,729	520,550	297,458	1,041,100
Other operating supplies	allowance		15,000		20,000
Maintenance (labour & supplies)	4.5 % p.a. of direct cost	1,608,000	72,360	2,542,000	114,390
			753,030		1,382,410
Contingency, @ 10 %			75,300		138,240
<u>TOTAL ACID NEUTRALIZATION</u>			828,330		1,520,650
<u>TOTAL OPERATING COST OF ZINC PLANT</u>			11,272,040		19,862,940
Cost in \$/short ton zinc concentrate			78.08		68.79
Cost in c/lb. of slab zinc			8.05		7.09

CYPRUS ANVIL MINING CORPORATION
SEPARATE ELECTRIC LEAD SMELTER WITH REFINERY

ANNUAL OPERATING COST ESTIMATE
In Canadian Dollars
Assumed power cost 1.5¢ per KWH

Case		I 50,000		II 100,000	
Cost item	Unit cost	Quantity	\$/year	Quantity	\$/year
<u>LEAD SMELTER</u>					
<u>Labour</u>					
Operating	\$ 6.45/hour	107,600	694,010	166,400	1,073,270
Indirect	\$ 6.45/hour	19,160	123,580	23,320	150,410
<u>Supervision</u>					
General Plant supervision	various	21	420,330	27	516,330
Smelter & refinery, supervision	various	19	372,870	22	424,190
<u>Utilities</u>					
Electric power	1.5 ¢/KWH	66,388,196	995,820	127,755,864	1,916,340
Light industrial fuel oil	31 ¢/Imp. gal.	269,844	83,650	539,688	167,300
Water	Included in power and operating supplies				
<u>Process materials</u>					
Coke	\$ 94.00/ton	2,600	244,400	5,200	488,800
Silica flux @ 80 % SiO ₂	\$ 9.26/ton	12,650	117,140	25,300	234,280
Limestone @ 82 % CaCO ₃	\$ 3.50/ton	31,150	109,030	62,300	218,050
Electrode paste	9.2 ¢/lb.	2,456,000	225,950	4,726,000	434,790
Other operating supplies	40¢ & 38¢/ton conc.	80,644	32,260	161,288	61,290
<u>Maintenance labour & supplies</u>					
Lead smelter & refinery	4.5 % p.a. of direct capital cost	16,813,000	756,590	26,010,000	1,170,450
<u>Office & laboratory</u>					
Supplies	allowance	-	40,000	-	60,000
			4,215,630		6,915,500
<u>Contingency, @ 10 %</u>			421,560		691,550
TOTAL LEAD SMELTER			4,637,190		7,607,050

continued

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTRIC LEAD SMELTER WITH REFINERY

ANNUAL OPERATING COST ESTIMATE (cont'd)

In Canadian Dollars

Assumed power cost 1.5¢ per KWH

Case		I		II	
	Refined lead produced (340 op. days/year) from lead concentrate STPY	<u>50,000</u>		<u>100,000</u>	
<u>Cost item</u>	<u>Unit cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>LEAD REFINERY</u>					
<u>Labour</u>					
Operating (basic)	\$ 6.45/hour	98,840	637,520	141,750	914,300
Bismuth removal	\$ 6.45/hour	17,520	113,000	17,520	113,000
<u>Supervision</u>	Included in lead smelter				
<u>Utilities</u>					
Electric power	1.5 ¢/KWH	2,062,000	30,930	3,917,800	58,770
Light industrial oil	31 ¢/Imp. gal.	653,200	202,490	1,244,190	385,700
Water	Included in power and operating supplies				
<u>Process materials</u>					
Sulphur (pulverized)	\$ 67.90/ton	50	3,400	100	6,790
Soda ash (Na ₂ CO ₃)	\$ 99.48/ton	100	9,950	200	19,900
Caustic soda (NaOH)	\$ 158.00/ton	100	15,800	200	31,600
Metallic zinc from zinc plant	\$ 600/ton	150	90,000	300	180,000
Scrap iron	\$ 200/ton	203	40,600	407	81,400
Silica sand	\$ 9.26/ton	100	930	200	1,850
Coke breeze	\$ 94.00/ton	300	28,200	600	56,400
<u>Additional for debismuthizing</u>					
Metallic magnesium	\$ 1330/ton	50	66,500	100	133,000
Metallic calcium	\$ 2450/ton	25	61,250	50	122,500
Liquified chlorine	\$ 157/ton	300	47,100	600	94,200
Other operating supplies	allowance		40,000		50,000
<u>Maintenance</u>	Included under lead smelter above				
<u>Office & laboratory</u>					
Supplies	allowance		40,000		60,000
			1,427,670		2,309,410
<u>Contingency, @ 10 %</u>			142,770		230,940
<u>TOTAL LEAD REFINERY</u>			1,570,440		2,540,350
<u>TOTAL LEAD SMELTER WITH REFINERY</u>			6,207,630		10,147,400

continued

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTRIC LEAD SMELTER WITH REFINERY

ANNUAL OPERATING COST ESTIMATE (cont'd)

In Canadian Dollars

Assumed power cost 1.5¢ per KWH

Case		I		II	
		50,000		100,000	
Refined lead produced (340 op. days/year) from lead concentrate STPY					
<u>Cost item</u>	<u>Unit cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>TOTAL LEAD SMELTER WITH REFINERY (carried forward)</u>			6,207,630		10,147,400
<u>SULPHURIC ACID PLANT</u>					
Proportion of operating labour	\$ 6.45/hour	19,600	126,420	19,600	126,430
Proportion of supervision	various	4	84,990	4	84,990
Electric power	1.5 c/KWH	2,908,368	43,630	5,816,736	87,250
Water	Included in power and operating supplies				
Other operating supplies	allowance	-	5,000	-	10,000
Maintenance (labour & supplies)	4.5 % p.a. of direct cost	2,581,000	116,150	3,869,000	174,110
			376,190		482,780
Contingency, @ 10 %			37,620		48,260
<u>TOTAL SULPHURIC ACID PLANT</u>			413,810		531,060
<u>EXCESS ACID NEUTRALIZATION</u>					
Proportion of operating labour	\$ 6.45/hour	12,920	83,330	12,920	83,330
Supervision	various		Included in acid plant		
Electric power	1.5 c/KWH	2,423,260	36,350	4,846,519	72,700
Water	Included in power and operating supplies				
Limestone	\$ 3.50/ton	63,740	223,090	127,481	446,180
Other operating supplies	allowance		5,000		10,000
Maintenance (labour & supplies)	4.5 % p.a. of direct cost	946,000	42,570	1,495,000	67,280
			390,340		679,490
Contingency, @ 10 %			39,030		67,950
<u>TOTAL ACID NEUTRALIZATION</u>			429,370		747,440
<u>TOTAL OPERATING COST OF LEAD SMELTER WITH REFINERY</u>			7,050,810		11,425,900
Cost in \$/short ton lead concentrate			87.44		70.84
Cost in c/lb. of refined lead			7.05		5.71

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SUMMARY OF ANNUAL OPERATING COST ESTIMATES

In Canadian Dollars

Assumed power cost 2.33¢ per KWH

Case	I	II
Slab zinc produced, STPY (365 op.days/yr)	70,000	140,000
Refined lead produced, STPY (340 op.days/yr)	<u>51,550</u>	<u>103,100</u>
<u>ZINC PLANT</u>		
Production of slab zinc	12,193,290	22,314,570
<u>LEAD SMELTER & REFINERY</u>		
Lead smelter	4,986,410	8,417,970
Lead refinery (with bismuth removal)	<u>1,603,490</u>	<u>2,602,860</u>
Production of refined lead	6,589,900	11,020,830
<u>SULPHURIC ACID PLANT</u>		
Production of 100 % Sulphuric Acid	822,930	1,274,320
<u>EXCESS ACID NEUTRALIZATION</u>		
Neutralization of acid not required for zinc plant	<u>1,149,600</u>	<u>2,157,110</u>
Total complex	20,755,720	36,766,830
<u>ZINC PLANT, ¢/lb. slab zinc</u>		
Zinc plant	8.70	7.97
Sulphuric acid production	0.43	0.33
Neutralization of excess acid	<u>0.58</u>	<u>0.54</u>
Total cost of slab zinc ¢/lb.	9.71	8.84
<u>LEAD SMELTER AND REFINERY, ¢/lb. refined lead</u>		
Lead smelter	4.84	4.09
Lead refinery (standard)	1.24	1.01
Debismuthizing, labour & supplies	<u>0.31</u>	<u>0.25</u>
Smelter with refinery	6.39	5.35
Sulphuric acid production	0.22	0.17
Neutralization of excess acid	<u>0.33</u>	<u>0.31</u>
Total cost of refined lead, ¢/lb.	6.94	5.83

Note: Costs include an allowance for maintenance labour and supplies and a contingency of 10 %.

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL OPERATING COST ESTIMATE - ELECTROLYTIC ZINC PLANT

In Canadian Dollars

Assumed power cost 2.33¢ per KWH

Case		I		II	
Slab zinc produced, STPY (365 op. days/year)		<u>70,000</u>		<u>140,000</u>	
<u>Cost item</u>	<u>Unit Cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>ZINC PLANT</u>					
<u>Labour</u>					
Operating	\$ 6.45/hour	187,160	1,207,180	273,744	1,765,660
Indirect	\$ 6.45/hour	24,160	155,830	30,400	196,070
<u>Supervision</u>					
Proportion of General Plant	various	50 % of 27	266,790	50 % of 33	314,790
Zinc plant supervision	various	18	355,170	20	388,800
<u>Utilities</u>					
Electric power	2.33 ¢/KWH	279,026,370	6,501,310	558,052,740	13,002,630
Light industrial fuel oil	31 ¢/Imp. gal.	925,455	286,890	1,863,676	577,740
Water	Included in power and operating supplies				
<u>Process supplies</u>					
Sulphuric acid	no cost	11,572	-	23,145	-
Ammonia	\$ 120/ton	1,157	138,840	2,314	277,680
Other supplies & process reagents	\$ 8.64/ton slab zinc	70,000	604,800	140,000	1,209,600
<u>Maintenance</u>					
Labour & supplies	5 % p.a. of direct capital cost	28,800,000	1,440,000	46,531,000	2,326,550
<u>Office & Laboratory</u>					
Supplies	allowance	-	50,000	-	70,000
<u>Royalty</u>					
Jarosite process	DNZ-EZ formula	5,200 ^(*)	78,000	10,430 ^(*)	156,450
			11,084,810		20,285,970
			<u>1,108,480</u>		<u>2,028,600</u>
<u>Contingency, @ 10 %</u>			12,193,290		22,314,570
TOTAL ZINC PLANT					

continued

(*) Additional STPY zinc recovered by Jarosite process.

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL OPERATING COST ESTIMATE - ELECTROLYTIC ZINC PLANT (Cont'd)

In Canadian Dollars

Assumed power cost 2.33¢ per KWH

Case		I		II	
		70,000		140,000	
Slab zinc produced, STPY (365 op. days/year)					
Cost item	Unit cost	Quantity	\$/year	Quantity	\$/year
<u>TOTAL ZINC PLANT</u> (carried forward)			12,193,290		22,314,570
<u>SULPHURIC ACID PLANT</u>					
Proportion of operating labour	\$ 6.45/hour	70 % of 19,600	88,490	70 % of 19,600	88,490
Proportion of supervision	various	70 % of 4	59,490	70 % of 4	59,490
Electric power	2.33 c/KWH	9,298,656	216,660	18,597,374	433,320
Water	Included in power and operating supplies				
Other operating supplies	allowance	-	15,000	-	20,000
Maintenance (labour & supplies)	70 % of the 4.5 % p.a. direct cost	232,290	162,600	348,210	243,750
			542,240		845,050
Contingency @ 10 %			54,220		84,510
TOTAL SULPHURIC ACID PLANT			596,460		929,560
<u>EXCESS ACID NEUTRALIZATION</u>					
Proportion of operating labour	\$ 6.45/hour	70 % of 12,920	58,330	70 % of 12,920	58,330
Supervision	various		Included in acid plant		
Electric power	2.33 c/KWH	70 % of 4,846,520	79,100	70 % of 9,693,039	158,100
Water	Included in power and operating supplies				
Limestone	\$ 3.50/ton	148,729	520,550	297,458	1,041,100
Other operating supplies	allowance		15,000		20,000
Maintenance (labour & supplies)	70 % of the 4.5 % p.a. direct cost	85,140	59,600	134,550	94,180
			732,580		1,371,710
Contingency @ 10 %			73,260		137,170
TOTAL ACID NEUTRALIZATION			805,840		1,508,880
<u>TOTAL OPERATING COST OF ZINC PLANT</u>			13,595,590		24,753,010
Cost in \$/short ton zinc concentrate			94.17		85.73
Cost in c/lb. of slab zinc			9.71		8.84

Note: Costs for acid production and neutralization are split between the zinc plant and the lead smelter on a 70/30 basis.

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL OPERATING COST ESTIMATE - ELECTRIC LEAD SMELTER WITH REFINERY

In Canadian Dollars

Assumed power cost 2.33¢ per KWH

Case		I	II		
Refined lead produced (340 op. days/year)		<u>51,550</u>	<u>103,100</u>		
<u>Cost item</u>	<u>Unit cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>LEAD SMELTER</u>					
<u>Labour</u>					
Operating	\$ 6.45/hour	107,600	694,010	166,400	1,073,270
Indirect	\$ 6.45/hour	19,160	123,580	23,320	150,410
<u>Supervision</u>					
Proportion of General Plant	various	50 % of 27	266,790	50 % of 33	314,790
Smelter & Refinery, supervision	various	19	372,870	22	424,190
<u>Utilities</u>					
Electric power	2.33 ¢/KWH	66,388,196	1,546,840	127,755,864	2,976,710
Light industrial fuel oil	31 ¢/Imp. gal.	269,844	83,650	539,688	167,300
Water	Included in power and operating supplies				
<u>Process materials</u>					
Coke	\$ 94.00/ton	2,600	244,400	5,200	488,800
Silica flux @ 80 % SiO ₂	\$ 9.26/ton	12,650	117,140	25,300	234,280
Limestone @ 82 % CaCO ₃	\$ 3.50/ton	31,150	109,030	62,300	218,050
Electrode paste	9.2 ¢/lb.	2,456,000	225,950	4,726,000	434,790
Other operating supplies	40¢ & 38¢/ton conc.	80,644	32,260	161,288	61,290
<u>Maintenance labour & supplies</u>					
Lead smelter and refinery	4.5 % p.a. of direct capital cost	15,035,000	676,580	23,307,000	1,048,820
<u>Office & Laboratory</u>					
Supplies	allowance	-	40,000	-	60,000
			4,533,100		7,652,700
			<u>453,310</u>		<u>765,270</u>
<u>Contingency, @ 10 %</u>					
			4,986,410		8,417,970

TOTAL LEAD SMELTER

continued

.....

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL OPERATING COST ESTIMATE - ELECTRIC LEAD SMELTER WITH REFINERY (cont'd)

In Canadian Dollars

Assumed power cost 2.33¢ per KWH

Case		I		II	
Refined lead produced (340 op. days/year)		<u>51,550</u>		<u>103,100</u>	
<u>Cost item</u>	<u>Unit cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>LEAD REFINERY</u>					
<u>Labour</u>					
Operating (basic)	\$ 6.45/hour	98,840	637,520	141,750	914,300
Bismuth removal	\$ 6.45/hour	17,520	113,000	17,520	113,000
<u>Supervision</u>					
	Included in lead smelter				
<u>Utilities</u>					
Electric power	2.33 ¢/KWH	2,062,000	48,040	3,917,800	91,280
Light industrial oil	31 ¢/Imp. gal.	653,200	202,490	1,244,190	385,700
Water	Included in power and operating supplies				
<u>Process materials</u>					
Sulphur (pulverized)	\$ 67.90/ton	52	3,530	103	6,990
Soda ash (Na ₂ CO ₃)	\$ 99.48/ton	103	10,250	206	20,500
Caustic soda (NaOH)	\$ 158.00/ton	103	16,270	206	32,550
Metallic zinc from zinc plant	\$ 600.00/ton	155	93,000	310	186,000
Scrap iron	\$ 200.00/ton	210	42,000	420	84,000
Silica sand	\$ 9.26/ton	103	950	206	1,910
Coke breeze	\$ 94.00/ton	310	29,140	620	58,280
<u>Additional for debismuthizing</u>					
Metallic magnesium	\$ 1330/ton	52	69,160	103	136,990
Metallic calcium	\$ 2450/ton	26	63,700	52	127,400
Liquified chlorine	\$ 157/ton	310	48,670	620	97,340
Other operating supplies	allowance		40,000		50,000
<u>Maintenance</u>					
	Included under lead smelter above				
<u>Office & Laboratory</u>					
Supplies	allowance		<u>40,000</u>		<u>60,000</u>
			1,457,720		2,366,240
<u>Contingency, @ 10 %</u>			<u>145,770</u>		<u>236,620</u>
<u>TOTAL LEAD REFINERY</u>			1,603,490		2,602,860
<u>TOTAL LEAD SMELTER WITH REFINERY</u>			6,589,900		11,020,830

continued

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL OPERATING COST ESTIMATE - ELECTRIC LEAD SMELTER WITH REFINERY (cont'd)

In Canadian Dollars

Assumed power cost 2.33¢ per KWH

Case	I			II	
Refined lead produced (340 op.days/year)		51,550		103,100	
Cost item	Unit cost	Quantity	\$/year	Quantity	\$/year
TOTAL LEAD SMELTER WITH REFINERY (carried forward)			6,589,900		11,020,830
SULPHURIC ACID PLANT					
Proportion of operating labour	\$ 6.45/hour	30 % of 19,600	37,930	30 % of 19,600	37,930
Proportion of supervision	various	30 % of 4	25,500	20 % of 4	25,500
Electric power	2.33 c/KWH	2,908,368	67,960	5,816,736	135,530
Water	Included in power and operating supplies				
Other operating supplies	allowance	-	5,000	-	10,000
Maintenance (labour & supplies)	30 % of the 4.5 % p.a. of direct cost	232,290	69,690	348,210	104,460
			205,880		313,420
Contingency, @ 10 %			20,590		31,340
TOTAL SULPHURIC ACID PLANT			226,470		344,760
EXCESS ACID NEUTRALIZATION					
Proportion of operating labour	\$ 6.45/hour	30 % of 12,920	25,000	30 % of 12,920	25,000
Supervision	various		Included in acid plant		
Electric power	2.33 c/KWH	30 % of 4,846,520	33,880	30 % of 9,693,039	67,750
Water	Included in power and operating supplies				
Limestone	\$ 3.50/ton	63,740	223,090	127,481	446,180
Other operating supplies	allowance		5,000		10,000
Maintenance (labour & supplies)	30 % of the 4.5 % p.a. of direct cost	85,140	25,540	134,550	40,370
			312,510		589,300
Contingency, @ 10 %			31,250		58,930
TOTAL ACID NEUTRALIZATION			343,760		648,230
TOTAL OPERATING COST OF LEAD SMELTER WITH REFINERY			7,160,130		12,013,830
Cost in \$/short ton lead concentrate			88.79		74.49
Cost in c/lb. of refined lead			6.94		5.83

Note: Costs for acid production and neutralization are split between the zinc plant and the lead smelter on a 70/30 basis.

CYPRUS ANVIL MINING CORPORATION

SUMMARY OF ANNUAL OPERATING COST ESTIMATES FOR SEPARATE PLANTS

In Canadian Dollars

Assumed power cost 2.33¢ per KWH

Case	I	II
<u>ZINC PLANT</u>		
<u>Slab zinc produced STPY</u>	<u>70,000</u>	<u>140,000</u>
Production of slab zinc	12,371,540	22,550,340
Sulphuric acid production (100% H ₂ SO ₄)	704,580	1,056,770
Excess acid neutralization	<u>865,950</u>	<u>1,595,870</u>
Total Zinc Plant	13,942,070	25,202,980
<u>Cost in ¢/lb. slab zinc</u>		
Production of slab zinc	8.84	8.05
Sulphuric acid production	0.50	0.38
Excess acid neutralization	<u>0.62</u>	<u>0.57</u>
Total cost of slab zinc in ¢/lb.	9.96	9.00
<u>LEAD SMELTER AND REFINERY</u>		
<u>Refined lead produced from concentrate STPY</u>	<u>50,000</u>	<u>100,000</u>
Lead smelter	5,243,320	8,773,460
Lead refinery (with bismuth removal)	<u>1,589,260</u>	<u>2,576,110</u>
Smelter with refinery	6,832,580	11,349,570
Sulphuric acid production (100% H ₂ SO ₄)	440,350	584,170
Excess acid neutralization	<u>451,500</u>	<u>791,680</u>
Total lead smelter & refinery	7,724,430	12,725,420
<u>Cost in ¢/lb. refined lead</u>		
Lead smelter	5.24	4.39
Lead refinery (standard)	1.27	1.03
Debismuthizing, labour & supplies	<u>0.32</u>	<u>0.25</u>
Smelter with refinery	6.83	5.67
Sulphuric acid production	0.44	0.29
Excess acid neutralization	<u>0.45</u>	<u>0.40</u>
Total cost of refined lead in ¢/lb.	7.72	6.36

NOTE: Costs include an allowance for maintenance labour and supplies and a contingency of 10 %.

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTROLYTIC ZINC PLANT

ANNUAL OPERATING COST ESTIMATE

in Canadian Dollars

Assumed power cost 2.33¢ per KWH

Case		I		II	
(Slab zinc produced, STPY (365 op. days/year)		<u>70,000</u>		<u>140,000</u>	
<u>Cost Item</u>	<u>Unit cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>ZINC PLANT</u>					
<u>Labour</u>					
Operating	\$ 6.45/hour	187,160	1,207,180	273,744	1,765,660
Indirect	\$ 6.45/hour	24,160	155,830	30,400	196,070
<u>Supervision</u>					
General plant supervision	various	21	420,330	27	516,330
Zinc Plant supervision	various	18	355,170	20	388,800
<u>Utilities</u>					
Electric power	2.33 ¢/KWH	279,026,370	6,501,314	558,052,740	13,002,630
Light industrial fuel oil	31 ¢/Imp. gal.	925,455	286,890	1,863,676	577,740
Water	Included in power and operating supplies				
<u>Process supplies</u>					
Sulphuric acid	no cost	11,572	-	23,145	-
Ammonia	\$ 120/ton	1,157	138,840	2,314	277,680
Other supplies & process reagents	\$ 8.64/ton slab zinc	70,000	604,800	140,000	1,209,600
<u>Maintenance</u>					
Labour & supplies	5 % p.a. of direct capital cost	28,970,000	1,448,500	46,787,000	2,339,350
<u>Office & Laboratory</u>					
Supplies	allowance	-	50,000	-	70,000
<u>Royalty</u>					
Jarosite process	DNZ-EZ formula	5,200 ^(*)	78,000	10,430 ^(*)	156,450
			11,246,850		20,500,310
			<u>1,124,690</u>		<u>2,050,030</u>
<u>Contingency, @ 10 %</u>					
TOTAL ZINC PLANT			12,371,540		22,550,340

(*) Additional STPY zinc recovered by Jarosite process.

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTROLYTIC ZINC PLANT

ANNUAL OPERATING COST ESTIMATE (cont'd)

In Canadian Dollars

Assumed power cost 2.33¢ per KWH

Case	I			II	
Slab zinc produced, STPY (365 op. days/year)		<u>70,000</u>		<u>140,000</u>	
<u>Cost item</u>	<u>Unit Cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>TOTAL ZINC PLANT</u> (carried forward)			12,371,540		22,550,340
<u>SULPHURIC ACID PLANT</u>					
Operating labour	\$ 6.45/hour	19,600	126,420	19,600	126,420
Supervision	various	4	84,990	4	84,990
Electric power	2.33 ¢/KWH	9,298,656	216,660	18,597,374	433,320
Water	Included in power and operating supplies	-	15,000	-	20,000
Other operating supplies	allowance	-	197,460	6,577,000	295,970
Maintenance (labour & supplies)	4.5 % p.a. of direct cost	4,388,000	640,530		960,700
			<u>64,050</u>		<u>96,070</u>
Contingency, @ 10 %			704,580		1,056,770
TOTAL SULPHURIC ACID PLANT					
<u>EXCESS ACID NEUTRALIZATION</u>					
Proportion of operating labour	\$ 6.45/hour	12,920	83,330	12,920	83,330
Supervision	various		Included in acid plant		
Electric power	2.33 ¢/KWH	4,119,542	95,990	8,239,082	191,970
Water	Included in power and operating supplies				
Limestone	\$ 3.50/ton	148,729	520,550	297,458	1,041,100
Other operating supplies	allowance	-	15,000	-	20,000
Maintenance (labour & supplies)	4.5 % p.a. of direct cost	1,608,000	<u>72,360</u>	2,542,000	<u>114,390</u>
			787,230		1,450,790
Contingency, @ 10 %			<u>78,720</u>		<u>145,030</u>
TOTAL ACID NEUTRALIZATION					
TOTAL OPERATING COST OF ZINC PLANT					
			13,942,070		25,202,980
Cost in \$/short ton zinc concentrate			96.57		87.29
Cost in ¢/lb. of slab zinc			9.96		9.00

CYPRUS ANVIL MINING CORPORATION
SEPARATE ELECTRIC LEAD SMELTER WITH REFINERY

ANNUAL OPERATING COST ESTIMATE
In Canadian Dollars
 Assumed power cost 2.33¢ per KWH

Case		I	II
		<u>50,000</u>	<u>100,000</u>
Refined lead produced (340 op. days/year) from lead concentrate, STPY			
<u>Cost item</u>	<u>Unit cost</u>	<u>Quantity</u> <u>\$/year</u>	<u>Quantity</u> <u>\$/year</u>
<u>LEAD SMELTER</u>			
<u>Labour</u>			
Operating	\$ 6.45/hour	107,600 694,010	166,400 1,073,270
Indirect	\$ 6.45/hour	19,160 123,580	23,320 150,410
<u>Supervision</u>			
General Plant supervision	various	21 420,330	27 516,330
Smelter & refinery, supervision	various	19 372,870	22 424,190
<u>Utilities</u>			
Electric power	2.33 ¢/KWH	66,388,196 1,546,840	127,755,864 2,976,710
Light industrial fuel oil	31 ¢/Imp. gal.	269,844 83,650	539,688 167,300
Water	Included in power and operating supplies		
<u>Process materials</u>			
Coke	\$ 94.00/ton	2,600 244,400	5,200 488,800
Silica flux @ 80 % SiO ₂	\$ 9.26/ton	12,650 117,140	25,300 234,280
Limestone @ 82 % CaCO ₃	\$ 3.50/ton	31,150 109,030	62,300 218,050
Electrode paste	9.2 ¢/lb.	2,456,000 225,950	4,726,000 434,790
Other operating supplies	40¢ & 38¢/ton conc.	80,644 32,260	161,288 61,290
<u>Maintenance labour & supplies</u>			
Lead smelter & refinery	4.5 % p.a. of direct capital cost	16,813,000 756,590	26,010,000 1,170,450
<u>Office & Laboratory</u>			
Supplies	allowance	- 40,000	- 60,000
		4,766,650	7,975,870
		<u>476,670</u>	<u>797,590</u>
<u>Contingency, @ 10 %</u>			
		5,243,320	8,773,460
TOTAL LEAD SMELTER			

continued

CYPRUS ANVIL MINING CORPORATION
SEPARATE ELECTRIC LEAD SMELTER WITH REFINERY

ANNUAL OPERATING COST ESTIMATE (Cont'd)
 In Canadian Dollars
 Assumed power cost 2.33¢ per KWH

Case		I	II		
Refined lead produced (340 op. days/year) from lead concentrate, STPY		<u>50,000</u>	<u>100,000</u>		
<u>Cost item</u>	<u>Unit cost</u>	<u>Quantity</u>	<u>\$/year</u>	<u>Quantity</u>	<u>\$/year</u>
<u>LEAD REFINERY</u>					
<u>Labour</u>					
Operating (basic)	\$ 6.45/hour	98,840	637,520	141,750	914,300
Bismuth removal	\$ 6.45/hour	17,520	113,000	17,520	113,000
<u>Supervision</u>	Included in lead smelter				
<u>Utilities</u>					
Electric power	2.33 c/KWH	2,062,000	48,040	3,917,800	91,280
Light industrial oil	31 c/Imp. gal.	653,200	202,490	1,244,190	385,700
Water	Included in power and operating supplies				
<u>Process materials</u>					
Sulphur (pulverized)	\$ 67.90/ton	50	3,400	100	6,790
Soda Ash (Na ₂ CO ₃)	\$ 99.48/ton	100	9,950	200	19,900
Caustic soda (NaOH)	\$ 158.00/ton	100	15,800	200	31,600
Metallic zinc from zinc plant	\$ 600/ton	150	90,000	300	180,000
Scrap iron	\$ 200/ton	203	40,600	407	81,400
Silica sand	\$ 9.26/ton	100	930	200	1,850
Coke breeze	\$ 94.00/ton	300	28,200	600	56,400
<u>Additional for debismuthizing</u>					
Metallic magnesium	\$ 1330/ton	50	66,500	100	133,000
Metallic calcium	\$ 2450/ton	25	61,250	50	122,500
Liquified chlorine	\$ 157/ton	300	47,100	600	94,200
Other operating supplies	allowance		40,000		50,000
<u>Maintenance</u>	Included under lead smelter above				
<u>Office & Laboratory</u>					
Supplies	allowance		40,000		60,000
			1,444,780		2,341,920
<u>Contingency, @ 10 %</u>			144,480		234,190
TOTAL LEAD REFINERY			1,589,260		2,576,110
TOTAL LEAD SMELTER WITH REFINERY			6,832,580		11,349,570

CYPRUS ANVIL MINING CORPORATION
SEPARATE ELECTRIC LEAD SMELTER WITH REFINERY

ANNUAL OPERATING COST ESTIMATE (Cont'd)
 In Canadian Dollars
 Assumed power cost 2.33¢ per KWH

Case		I	II		
Refined lead produced (340 op. days/year) from lead concentrate, STPY		<u>50,000</u>	<u>100,000</u>		
Cost item	Unit cost	Quantity	\$/year	Quantity	\$/year
<u>TOTAL LEAD SMELTER WITH REFINERY (carried forward)</u>			6,832,580		11,349,570
<u>SULPHURIC ACID PLANT</u>					
Proportion of operating labour	\$ 6.45/hour	19,600	126,420	19,600	126,430
Proportion of supervision	various	4	84,990	4	84,990
Electric power	2.33 c/KWH	2,908,368	67,760	5,816,736	135,530
Water	Included in power and operating supplies				
Other operating supplies	allowance	-	5,000	-	10,000
Maintenance (labour & supplies)	4.5 % p.a. of direct cost	2,581,000	<u>116,150</u>	3,869,000	<u>174,110</u>
			400,320		531,060
Contingency, @ 10 %			<u>40,030</u>		<u>53,110</u>
TOTAL SULPHURIC ACID PLANT			440,350		584,170
<u>EXCESS ACID NEUTRALIZATION</u>					
Proportion of operating labour	\$ 6.45/hour	12,920	83,330	12,920	83,330
Supervision	various		Included in acid plant		
Electric power	2.33 c/KWH	2,423,260	56,460	4,846,519	112,920
Water	Included in power and operating supplies				
Limestone	\$ 3.50/ton	63,740	223,090	127,481	446,180
Other operating supplies	allowance		5,000		10,000
Maintenance (labour & supplies)	4.5 % p.a. of direct cost	946,000	<u>42,570</u>	1,495,000	<u>67,280</u>
			410,450		719,710
Contingency, @ 10 %			<u>41,050</u>		<u>71,970</u>
TOTAL ACID NEUTRALIZATION			451,500		791,680
<u>TOTAL OPERATING COST OF LEAD SMELTER WITH REFINERY</u>			7,724,430		12,725,420
Cost in \$/short ton lead concentrate			95.79		78.90
Cost in c/lb. of refined lead			7.72		6.36

CYPRUS ANVIL MINING CORPORATION

ELECTROLYTIC ZINC PLANT

HOURLY PAID LABOUR - JOB LIST

Case	I			II		
Slab zinc produced, STPY (365 op. days/year)	<u>70,000</u>			<u>140,000</u>		
	<u>Men/shift</u>	<u>Shifts</u>	<u>Days/week</u>	<u>Men/shift</u>	<u>Shifts</u>	<u>Days/week</u>
<u>OPERATING LABOUR</u>						
<u>Zinc plant</u>						
Concentrate & flux handling	4	1	5	3	2	5
Roasting plant - operator	1	3	7	1	3	7
- helper	2	3	7	3	3	7
Leaching, incl. Jarosite process	3	3	7	4	3	7
Purification	3	3	7	4	3	7
Cell room crew	3	3	7	4	3	7
Stripping crew	16	1	5	28	1	5
Melting & casting crew	5	1	7	6	2	7
Zinc dust production	1	1	5	1	1	5
Cadmium recovery	2	3	7	2	3	7
Labourers	3	1	5	4	1	5
<u>Sulphuric acid plant</u>						
Operator	1	3	7	1	3	7
Acid plant helper	1	3	7	1	3	7
Labourers	1	1	5	1	1	5
<u>Excess acid neutralization</u>						
Operator	1	3	7	1	3	7
Labourers	2	1	5	2	1	5
<u>INDIRECT LABOUR</u>						
Storekeeper	1	1	5	1	1	5
Stores helper	1	1	5	2	1	5
Change house attendant	1	1	7	1	1	7
Power house attendant	1	3	7	1	3	7
Yard gang	4	1	5	6	1	5

Note: Maintenance labour included in total maintenance cost, shown in percent p.a. of direct capital cost.

CYPRUS ANVIL MINING CORPORATION
ELECTRIC LEAD SMELTER WITH REFINERY

HOURLY PAID LABOUR - JOB LIST

Case	I			II		
Refined lead produced, STPY (340 op. days/year)	<u>51,550</u>			<u>103,100</u>		
	<u>Men/shift</u>	<u>Shifts</u>	<u>Days/week</u>	<u>Men/shift</u>	<u>Shifts</u>	<u>Days/week</u>
<u>OPERATING LABOUR</u>						
<u>Lead smelter</u>						
Concentrate & flux handling	2	1	5	2	2	5
Charge crew	1	3	7	2	3	7
Electric furnace operator	1	3	7	1	3	7
Tapping crew	2	3	7	3	3	7
Crane man	1	3	7	1	3	7
Converter crew	2	3	7	4	3	7
Electrode paste handling	1	1	7	1	1	7
Cottrell man	1	3	7	1	3	7
Dust handling	1	3	7	2	3	7
Drossing	1	3	7	2	3	7
Slag disposal	1	3	7	1	3	7
Labourers	2	1	5	3	1	5
<u>Lead refinery</u>						
Decopperizing	1	3	7	2	3	7
Softening (antimony removal)	3	3	7	4	3	7
Desilverizing & vacuum dezincing	2	3	7	3	3	7
Final refining	1	3	7	1	3	7
Lead casting & shipping	4	1	7	3	2	7
Silver crust distillation & cupellation	3	1	5	4	1	5
Copper & antimony dross treatment	2	3	7	3	3	7
Bismuth removal	2	3	7	2	3	7
Labourers	1	1	5	1	1	5
<u>INDIRECT LABOUR</u>						
Store keeper	1	1	5	1	1	5
Boiler attendant	1	3	7	1	3	7
Yard gang	4	1	5	6	1	5

Note: Maintenance labour included in total maintenance cost shown in percent p.a. of direct capital cost.

CYPRUS ANVIL MINING CORPORATION

ELECTROLYTIC ZINC PLANT

HOURLY PAID LABOUR - CALCULATION OF ANNUAL COST
In Canadian Dollars

Case					I			II		
	Slab zinc production, STPY (365 op. days/year)				70,000			140,000		
	<u>Jobs, type and cost</u>				<u>Annual cost</u>			<u>Annual cost</u>		
	<u>Shifts</u>	<u>Days/week</u>	<u>Hrs/job-yr.</u>	<u>\$/hour</u>	<u>Jobs</u>	<u>Hrs/yr.</u>	<u>\$/year</u>	<u>Jobs</u>	<u>Hrs/yr.</u>	<u>\$/year</u>
<u>ZINC PLANT</u>										
Operating	Day	5	2,080	6.45	24	49,920	321,980	33	68,640	442,730
	2	5	4,160	6.45	-	-	-	3	12,480	80,500
	Day	7	2,920	6.45	5	14,600	94,170	-	-	-
	2	7	5,824	6.45	-	-	-	6	34,944	225,390
	3	7	8,760	6.45	14	122,640	791,030	18	157,680	1,017,040
						187,160	1,207,180		273,744	1,765,660
<u>SULPHURIC ACID PLANT</u>										
	Day	5	2,080	6.45	1	2,080	13,420	1	2,080	13,420
	3	7	8,760	6.45	2	17,520	113,000	2	17,520	113,000
						19,600	126,420		19,600	126,420
<u>EXCESS ACID NEUTRALIZATION</u>										
	Day	5	2,080	6.45	2	4,160	26,830	2	4,160	26,830
	3	7	8,760	6.45	2	8,760	56,500	1	8,760	56,500
						12,920	83,330		12,920	83,330
<u>INDIRECT</u>										
	Day	5	2,080	6.45	6	12,480	80,500	9	18,720	120,740
	Day	7	2,920	6.45	1	2,920	18,830	1	2,920	18,830
	3	7	8,760	6.45	1	8,760	56,500	1	8,760	56,500
						24,160	155,830		30,400	196,070
<u>TOTAL</u>						243,840	1,572,760		336,664	2,171,480

Note: For operating cost estimate Acid Plant and Acid Neutralization labour have been charged on the basis of 70 % to Zinc Plant and 30 % to the Lead Smelter in the combined Zinc-Lead Smelting Complex. For separate plants a complete crew will be required in each case.

Hourly rate used is the weighted average for all classifications at Anvil, including fringe benefits at 19.6 %, as given in their letter dated July 27, 1973.

CYPRUS ANVIL MINING CORPORATION
ELECTRIC LEAD SMELTER WITH REFINERY

HOURLY PAID LABOUR - CALCULATION OF ANNUAL COST
In Canadian Dollars

Case					I			II		
Refined lead produced, STPY (340 op. days/year)					51,550			103,100		
<u>Jobs, type and cost</u>					<u>Annual cost</u>			<u>Annual cost</u>		
	<u>Shifts</u>	<u>Days/week</u>	<u>Hrs/job-yr.</u>	<u>\$/hour</u>	<u>Jobs</u>	<u>Hrs/yr.</u>	<u>\$/year</u>	<u>Jobs</u>	<u>Hrs/yr.</u>	<u>\$/year</u>
<u>LEAD SMELTER</u>										
Operating	Day	5	2,080	6.45	4	8,320	53,660	3	6,240	40,250
	2	5	4,160	6.45	-	-	-	2	8,320	53,660
	Day	7	2,920	6.45	1	2,920	18,830	1	2,920	18,830
	3	7	8,760	6.45	11	96,360	621,520	17	148,920	960,530
						107,600	694,010	166,400 1,073,270		
<u>LEAD REFINERY</u>										
Operating (standard)	Day	5	2,080	6.45	4	8,320	53,660	5	10,400	67,030
	Day	7	2,920	6.45	4	11,680	75,340	-	-	-
	2	7	5,824	6.45	-	-	-	3	17,470	112,690
	3	7	8,760	6.45	9	78,840	508,520	13	113,880	734,530
						98,840	637,520	141,750 914,300		
Operating (Bismuth removal)	3	7	8,760	6.45	2	17,520	113,000	2	17,520	113,000
<u>INDIRECT</u>										
	Day	5	2,080	6.45	5	10,400	67,080	7	14,560	93,910
	3	7	8,760	6.45	1	8,760	56,500	1	8,760	56,500
						19,160	123,580	23,320 150,410		
TOTAL						243,120	1,568,110	348,990 2,250,980		

Note: Hourly rate used is the weighted average for all classifications at Anvil, including fringe benefits at 19.6 %, as given in their letter dated July 27, 1973.

For separate lead smelter and refinery a complete crew will be required in addition to the above to man the sulphuric acid and acid neutralization plants (see previous table).

CYPRUS ANVIL MINING CORPORATION

ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SALARIED STAFF

Case	I			II	
Slab zinc production, STPY (365 operating days/year)	70,000			140,000	
Refined lead production, STPY (340 operating days/year)	<u>51,550</u>			<u>103,100</u>	
	<u>Salary</u> <u>\$/year⁽¹⁾</u>	<u>Number of</u> <u>employees</u>	<u>Total</u> <u>\$/year</u>	<u>Number of</u> <u>employees</u>	<u>Total</u> <u>\$/year</u>
<u>GENERAL PLANT FOR COMBINED COMPLEX</u>					
General plant manager	35,000	1	35,000	1	35,000
Assistant plant manager	27,000	1	27,000	1	27,000
Accountant	19,740	1	19,740	1	19,740
Chief metallurgist	19,800	1	19,800	1	19,800
Chief chemist	19,800	1	19,800	1	19,800
Day chemists	12,000	3	36,000	4	48,000
Traffic & purchasing agent	17,760	1	17,760	1	17,760
Warehouse foreman	11,520	1	11,520	1	11,520
Metallurgical accountant	10,800	1	10,800	2	21,600
Accounting clerks	10,800	2	21,600	3	32,400
Clerical staff	9,000	8	72,000	10	90,000
Security guards	9,600	4	38,400	4	38,400
Personnel & industrial relations	18,900	1	18,900	1	18,900
Safety & first aid	13,500	<u>1</u>	<u>13,500</u>	<u>2</u>	<u>27,000</u>
		27	361,820	33	426,920
Fringe benefits @ 27.13 %			<u>98,160</u>		<u>115,820</u>
			459,980		542,740
Incentive plan @ 16.0 %			<u>73,600</u>		<u>86,840</u>
Total General Plant ⁽⁴⁾			533,580		629,580

continued

CYPRUS ANVIL MINING CORPORATION

ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SALARIED STAFF FOR SEPARATE ZINC PLANT AND LEAD SMELTER

Case	I			II	
Slab zinc production, STPY (365 operating days/year)	70,000			140,000	
Refined lead production, STPY (340 operating days/year)	<u>50,000</u>			<u>100,000</u>	
	Salary \$/year ⁽¹⁾	Number of employees	Total \$/year	Number of employees	Total \$/year
<u>GENERAL SUPERVISION FOR SEPARATE PLANTS</u>					
General plant manager	35,000	1	35,000	1	35,000
Accountant	19,740	1	19,740	1	19,740
Chief metallurgist	19,800	1	19,800	1	19,800
Chief chemist	19,800	1	19,800	1	19,800
Day chemists	12,000	2	24,000	3	36,000
Traffic & purchasing agent	17,760	1	17,760	1	17,760
Warehouse foreman	11,520	1	11,520	1	11,520
Metallurgical accountant	10,800	1	10,800	2	21,600
Accounting clerks	10,800	1	10,800	2	21,600
Clerical staff	9,000	5	45,000	7	63,000
Security guards	9,600	4	38,400	4	38,400
Personnel & industrial relations	18,900	1	18,900	1	18,900
Safety and first aid	13,500	<u>1</u>	<u>13,500</u>	<u>2</u>	<u>27,000</u>
		21	285,020	27	350,120
Fringe benefits @ 27.13 %			<u>77,330</u>		<u>94,990</u>
			362,350		445,110
Incentive plan @ 16.0 %			<u>57,980</u>		<u>71,220</u>
Total General Supervision			420,330		516,330

continued

CYPRUS ANVIL MINING CORPORATION

ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SALARIED STAFF

Case

Slab zinc production, STPY (365 operating days/year)	70,000	140,000
Refined lead production, STPY (340 operating days/year)	<u>51,550</u>	<u>103,100</u>

	<u>Salary</u> <u>\$/year⁽¹⁾</u>	<u>Number of</u> <u>employees</u>	<u>Total</u> <u>\$/year</u>	<u>Number of</u> <u>employees</u>	<u>Total</u> <u>\$/year</u>
<u>ZINC PLANT</u>					
Zinc plant superintendent	22,320	1	22,320	1	22,320
Metallurgist	18,000	1	18,000	1	18,000
Assayers	12,000	4	48,000	5	60,000
General foreman	16,800	1	16,800	1	16,800
Shift foremen	15,630	4	62,520	4	62,520
Clerks	9,600	2	19,200	2	19,200
Samplers	10,800	<u>5</u>	<u>54,000</u>	<u>6</u>	<u>64,800</u>
		18	240,840	20	263,640
Fringe benefits @ 27.13 %			<u>65,340</u>		<u>71,530</u>
			306,180		335,170
Incentive plan @ 16.0 %			<u>48,990</u>		<u>53,630</u>
Total Zinc Plant			355,170		388,800

continued

CYPRUS ANVIL MINING CORPORATION

ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SALARIED STAFF

Case	I			II	
Slab zinc production, STPY (365 operating days/year)	70,000			140,000	
Refined lead production, STPY (340 operating days/year)	<u>51,500</u>			<u>103,100</u>	
	Salary \$/year ⁽¹⁾	Number of <u>employees</u>	Total \$/year	Number of <u>employees</u>	Total \$/year
<u>LEAD SMELTER AND REFINERY</u>					
Plant superintendent	22,320	1	22,320	1	22,320
Metallurgist	18,000	1	18,000	1	18,000
Day chemist	12,000	1	12,000	2	24,000
Assayers	12,000	4	48,000	5	60,000
General foreman	16,800	1	16,800	1	16,800
Shift foreman	15,630	4	62,520	4	62,520
Junior Clerk	9,600	2	19,200	2	19,200
Samplers	10,800	<u>5</u>	<u>54,000</u>	<u>6</u>	<u>64,800</u>
		19	252,840	22	287,640
Fringe benefits @ 27.13 %			<u>68,600</u>		<u>78,040</u>
			321,440		365,680
Incentive plan @ 16.0 %			<u>51,430</u>		<u>58,510</u>
Total Lead Smelter and Refinery			372,870		424,190

continued

CYPRUS ANVIL MINING CORPORATION

ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SALARIED STAFF

Case	I			II	
Slab zinc production, STPY (365 operating days/year)			70,000		140,000
Refined lead production, STPY (340 operating days/year)			<u>51,550</u>		<u>103,100</u>
	Salary \$/year ⁽¹⁾	Number of employees	Total \$/year	Number of employees	Total \$/year
<u>SULPHURIC ACID PLANT & NEUTRALIZATION</u>					
Chemical engineer	18,000	1	18,000	1	18,000
Foreman	15,630	1	15,630	1	15,630
Day analysts	12,000	<u>2</u>	<u>24,000</u>	<u>2</u>	<u>24,000</u>
		4	57,630	4	57,630
Fringe benefits @ 27.13 %			<u>15,640</u>		<u>15,640</u>
			73,270		73,270
Incentive plan @ 16.0 %			<u>11,720</u>		<u>11,720</u>
Total Sulphuric Acid Plant & Neutralization ⁽²⁾			84,990		84,990
<u>TOTAL STAFF FOR COMBINED COMPLEX⁽³⁾</u>					
General plant		27	459,980	33	542,740
Zinc plant		18	306,180	20	335,170
Lead smelter and refinery		19	321,440	22	365,680
Sulphuric acid plant and neutralization		<u>4</u>	<u>73,270</u>	<u>4</u>	<u>73,270</u>
		68	1,160,870	79	1,316,860
Incentive plan @ 16.0 %			<u>185,740</u>		<u>210,700</u>
			1,346,610		1,527,560

continued

CYPRUS ANVIL MINING CORPORATION

ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SALARIED STAFF (cont'd)

- Remarks:
- (1) Salaries based on rates supplied by Anvil on May 1, 1974.
 - (2) For operating cost estimate of combined smelter complex staff has been split as follows:
 - (a) 70 % charged to zinc plant
 - (b) 30 % charged to lead smelter
 - (3) Maintenance supervision has been omitted here and is included under annual maintenance allowance.
 - (4) For operating cost estimate of combined smelter complex, general plant staff have been split on a 50/50 basis between the zinc plant and lead smelter.

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SUMMARY OF JOBS AND PAYROLL

Case	I		II	
Slab zinc produced, STPY (365 op. days/year)	70,000		140,000	
Refined lead produced, STPY (340 op./days/year)	51,550		103,100	
	<u>Jobs</u> (1)	<u>Payroll</u> (2)	<u>Jobs</u> (1)	<u>Payroll</u> (2)
<u>STAFF</u>				
General plant	27	27	33	33
Zinc plant	18	18	18	18
Lead smelter and refinery	19	19	22	22
Sulphuric acid plant & neutralization	4	4	4	4
Plant maintenance(3)	<u>7</u>	<u>7</u>	<u>9</u>	<u>9</u>
Total staff	75	75	86	86
<u>HOURLY RATE LABOUR</u>				
Zinc plant (including indirect)	81	102	118	147
Lead smelter (including indirect)	46	61	69	92
Lead refinery (with bismuth removal)	41	56	50	77
Sulphuric acid plant	7	10	7	10
Excess acid neutralization	5	6	5	6
Plant maintenance(3)	<u>83</u>	<u>83</u>	<u>134</u>	<u>134</u>
Total hourly rate labour	263	318	383	466
<u>TOTAL STAFF AND HOURLY RATE LABOUR</u>	338	393	469	552

Remarks: (1) Men/shift x shifts = jobs.

(2) Labour on payroll is based on 260 man-days per year on a five day work week.

(3) Maintenance staff and labour has been calculated from the maintenance cost allowance on the assumption that all maintenance is carried out on a 5 day per week basis.

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SUMMARY OF JOBS AND PAYROLL FOR SEPARATE PLANTS

Case	I		II	
<u>SEPARATE ZINC PLANT</u>				
Slab zinc produced, STPY (365 op.days/yr)	70,000		140,000	
	<u>Jobs</u>	<u>Payroll</u>	<u>Jobs</u>	<u>Payroll</u>
	(1)	(2)	(1)	(2)
<u>STAFF</u>				
General Plant supervision	21	21	27	27
Zinc Plant	18	18	18	18
Sulphuric acid plant & Neutralization	4	4	4	4
Plant maintenance (3)	<u>4</u>	<u>4</u>	<u>6</u>	<u>6</u>
Total staff	47	47	55	55
<u>HOURLY RATE LABOUR</u>				
Zinc plant (including indirect)	81	102	118	147
Sulphuric acid plant	7	10	7	10
Excess acid neutralization	5	6	5	6
Plant maintenance (3)	<u>60</u>	<u>60</u>	<u>92</u>	<u>92</u>
Total hourly rate labour	153	178	222	255
TOTAL FOR ZINC PLANT	200	225	277	310

SEPARATE LEAD SMELTER WITH REFINERY

Refined lead produced, STPY (340 op.days/yr)	50,000		100,000	
	<u>Jobs</u>	<u>Payroll</u>	<u>Jobs</u>	<u>Payroll</u>
	(1)	(2)	(1)	(2)
<u>STAFF</u>				
General plant supervision	21	21	27	27
Lead smelter and refinery	19	19	22	22
Sulphuric acid plant & neutralization	4	4	4	4
Plant maintenance (3)	<u>4</u>	<u>4</u>	<u>6</u>	<u>6</u>
Total staff	48	48	59	59

continued

CYPRUS ANVIL MINING CORPORATION

COMBINED ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY

SUMMARY OF JOBS AND PAYROLL FOR SEPARATE PLANTS (Cont'd)

Case	I		II	
<u>SEPARATE LEAD SMELTER WITH REFINERY</u> (Cont'd)				
Refined lead produced, STPY (340 op.days/yr)	50,000		100,000	
<u>HOURLY RATE LABOUR</u>	<u>Jobs</u>	<u>Payroll</u>	<u>Jobs</u>	<u>Payroll</u>
Lead smelter (including indirect)	46	61	69	92
Lead refinery (with bismuth removal)	41	56	50	77
Sulphuric acid plant	7	10	7	10
Excess acid neutralization	5	6	5	6
Plant maintenance (3)	<u>30</u>	<u>30</u>	<u>50</u>	<u>50</u>
Total hourly rate labour	129	163	181	235
TOTAL FOR LEAD SMELTER & REFINERY	177	211	240	294

Remarks: (1) Men/shift x shifts = jobs.

(2) Labour on payroll is based on 260 man-days per year on a five day work week.

(3) Maintenance staff and labour has been calculated from the maintenance cost allowance on the assumption that all maintenance is carried out on a 5 day per week basis.

COMMENTS ON ESTIMATES

CAPITAL COST ESTIMATES

Before the economics indicate a viable project, a capital cost estimate based on suppliers' quotations and detailed engineering layouts cannot be justified. We have therefore used in-house data from similar projects and adjusted the costs to reflect the February 1974 cost level. The estimates include all necessary auxiliary facilities for a self-contained electrolytic zinc plant and electric lead smelting complex located at Little Salmon in the Yukon. For comparison purposes a separate zinc plant and a separate lead smelter have been estimated using the Little Salmon location as the basis.

The estimated electrolytic zinc plant includes the Jarosite process as well as mechanical handling and stripping of cathodes. These items increase capital cost but this is justified in view of rapidly increasing labour costs providing incentive to reduce manual labour as far as possible. The estimate includes a licence fee for mechanical cathode handling and stripping because it would be advisable to purchase a proven design.

It costs more to build a plant in the Yukon due to greater distance from sources of building materials and equipment. An additional 10 % has therefore been assumed for the Little Salmon location. A contingency of 25 % has been added to all capital cost estimates.

A single absorption sulphuric acid plant is believed sufficient for a northern location, and has been sized to handle the effluent sulphur dioxide from both the zinc plant and the lead smelter for the combined

complex. Sulphuric acid plant costs for the separate plants have been estimated to meet the requirements of the plant to be serviced and are included in the capital cost of the separate plants.

For the combined smelter complex, the capital costs estimated for the lead smelter and refinery are in addition to those listed for the zinc plant and represent the cost of expanding the facilities to accommodate the lead smelter with refinery.

The capital cost estimates for the separate plants considers each plant as a distinct unit in which there is no sharing of site, acid plant, or other facilities.

In each case however mercury removal equipment has been included to provide for the possibility that a market may be developed for sulphuric acid. As long as the excess acid is neutralized this equipment would probably not be necessary.

With the present delivery of steel and major pieces of equipment it is estimated that between three and three and one-half years would be required for engineering, construction and start-up.

TURNKEY AUXILIARY PLANTS

The sulphuric acid plant costs are based on suppliers' quotations for a package plant. Consequently no engineering or construction supervision costs are applicable for these items, since they would be bid on a turnkey basis.

EXCLUSIONS

The following items are excluded from the capital cost estimates

shown for the individual plants:

- (1) Power line to the smelting complex.
- (2) Water supply and service road to the smelter battery limits.
- (3) Site acquisition.
- (4) Interest and escalation during construction.
- (5) Working capital in the form of materials to fill the circuits.
- (6) Start-up costs.
- (7) Inventory of zinc and lead in processing and in storage.

PURCHASE OF KNOWHOW

Allowances have been made to cover the licence fee and purchase of technical knowhow for mechanical handling and stripping of zinc cathodes and the Boliden electric lead smelting process.

OPERATING COST ESTIMATES

The operating cost estimates have been calculated to show the cost of a combined zinc-lead smelter complex and the cost of operating separate plants. In all estimates sulphuric acid and neutralization plants are included.

For the combined smelter complex the acid plant and neutralization facilities service the whole complex, and the costs of labour, supervision, and power for acid neutralization have been split on a 70/30 basis to arrive at separate operating costs for the zinc plant and lead smelter. The cost of acid neutralization is heavily dependent on the price paid for limestone.

In the combined smelter the administrative staff serving the general plant has been distributed on a 50/50 basis to arrive at the

operating cost for each plant. In the case of the separate plants each will have its own administration staff, and general supervision.

Excluded from the operating cost estimates are:

Property taxes

Insurance

Legal and consulting fees

Research and development expenses

Administrative costs other than at the plant site

Product freight, warehousing, and sales costs

Operation of the townsite

LABOUR AND SUPERVISION

The hourly rate used in these estimates is the weighted average of all hourly rate classifications at Anvil and includes 19.6 % fringe benefits. The rates used for staff have been based on the typical salaries given by the Cyprus Anvil Mining Corporation on May 1, 1974 which exclude the 27.13 % fringe benefits. Housing is excluded in both cases. An additional 16.0 % has been added to the staff payroll to cover the incentive program in force at Anvil.

PROCESS ROYALTY

We have applied the formula used by Det Norske Zinkkompani (DNZ) and Electrolytic Zinc Company of Australasia (EZ) for licencing of their jointly owned Jarosite process. Prior to devaluation of the dollar this amounted to \$ 12.00 per short ton of additional zinc recovered. We have increased this to \$ 15.00 per short ton, but recommend that this be negotiated.

CONTINGENCY

A contingency of 10 % has been added to the estimated operating costs to cover uncertainties, in particular regarding process reagents and excess cathode plating requirements. Detailed test work would be necessary to define these requirements.

ECONOMIC FEASIBILITY

The economic feasibility of the smelting complex, as detailed in this section, was developed in conjunction with Cyprus Anvil Mining Corporation.

The Agreement between the Government of Canada and Cyprus Anvil Mining Corporation, dated August 21, 1967, provides that Anvil undertake to conduct a study to determine the feasibility of building a smelter. Anvil is committed to build a smelter if the project will earn, after deducting mineral and income taxes, a rate of return, determined by the Discounted Cash Flow method, of a minimum of 15 % on the total capital, including borrowings from whatever source, invested by Anvil.

On February 22, 1973, a meeting was held with representatives of Indian and Northern Affairs wherein it was agreed that Anvil would immediately undertake a preliminary smelter feasibility study. This preliminary study was to be the subject of a further meeting between Government officials and Anvil in order to determine the best procedure for Anvil to follow in complying with its obligations as called for in the Agreement with the Government dated August 21, 1967.

Jan H. Reimers and Associates Limited of Oakville, Ontario, Consultants acceptable to both the Government and Anvil, were engaged to (1) examine existing smelting techniques and advise as to which process would be most suitable for a smelter in the Yukon and (2) develop a preliminary estimate of the capital and operating costs of such a project.

Ametalco Inc. of New York were engaged to develop an "order of magnitude" marketing program which would contain an estimate of the cost of selling the metals.

Northern Canada Power Commission provided power costs that were appropriate to the cases being examined.

BASIS

For the purpose of assessing the economic feasibility, the following six cases were developed:

<u>Case</u>	<u>Plant</u>	<u>Production - STPY</u>		<u>Percent of Mine production</u>
		<u>Slab zinc</u>	<u>Refined lead</u>	
1	Combined Zinc-Lead Complex	70,000	51,550	50
2	Combined Zinc-Lead Complex	140,000	103,100	100
3	Separate Lead Smelter	-	100,000	100
4	Separate Lead Smelter	-	50,000	50
5	Separate Electrolytic Zinc Plant	140,000	-	100
6	Separate Electrolytic Zinc Plant	70,000	-	50

Two alternatives exist for the operating costs in each of the above cases reflecting the various power rates which are dependent on the kilowatt load. The 10 year amortization of the capital cost of the power facilities coincides with the life of Anvil's orebody, (see table on page 131).

Four levels of metal prices were used for zinc and lead:

- (a) Zinc at 14 ¢/lb and Lead at 12 ¢/lb
- (b) Zinc at 26 ¢/lb and Lead at 22 ¢/lb
- (c) Zinc at 36 ¢/lb and Lead at 32 ¢/lb - the prices for late April 1974
- (d) Zinc at 49 ¢/lb and Lead at 43 ¢/lb - based on escalating the April 1974 price (c) by 10 % for 3½ years

In all cases the following prices were used for

Silver - \$ 4.00/ounce (troy)
 Gold - \$ 150.00/ounce (troy)
 Cadmium - \$ 3.50/lb

Metal prices vary with the market, consequently it was considered advisable to use four price levels in this study. It is noted that recently the price of lead dropped to 24 ¢/lb.

ASSUMPTIONS

The following assumptions have been made in assessing the economics.

1. Escalation

(A) Capital costs

- (i) Complex costs developed by Reimers - 10 % per year for $3\frac{1}{2}$ years or 35 %
- (ii) Townsite costs developed by Anvil - 10 % per year for $3\frac{1}{2}$ years or 35 %
- (iii) Other facilities developed by Anvil - contain no escalation.

(B) Operating costs

- (i) Complex costs developed by Reimers - 10 % per year for $3\frac{1}{2}$ years or 35 %
- (ii) Townsite costs developed by Anvil - 10 % per year for $3\frac{1}{2}$ years or 35 %
- (iii) Property taxes and insurance developed by Anvil - 10 % per year for $3\frac{1}{2}$ years or 35 %

2. Contingency

(A) Capital costs

- (i) Complex costs developed by Reimers contain 25 % plus 10 % Northern Allowance
- (ii) Townsite costs developed by Anvil based on current experience and do not contain a contingency
- (iii) Other facilities are broad estimates only

continued

2. Contingency (cont'd)

(B) Operating costs

- (i) Complex costs developed by Reimers contain 10 %
- (ii) Townsite costs developed by Anvil based on current experience - no contingency
- (iii) Administrative, and Research & Development developed by Anvil based on current experience - no contingency

3. Income tax

(A) Rates - Proposed Federal Budget (a)	50 %
Less: Rebate	<u>15 %</u>
	35 %
Plus: Yukon Tax (b)	<u>15 %</u>
Effective Tax Rate	50 %

(a) Basic elements of the budget brought down earlier this year would be applicable

(b) The tax abatement would be picked up in same manner by the Yukon or Federal Governments.

(B) Earned depletion - maximum of 25 % of taxable income (a)

(C) Assumed 10 % of complex costs represented by buildings

4. Life of smelting complex

The life of the smelter is estimated to be $10\frac{1}{2}$ years based on Anvil's remaining ore reserves.

MARKETING STUDY

Ametalco Inc. of New York were engaged to do an "Order of Magnitude" study. The salient points of their report are:

- (1) Freight and warehousing costs are estimated to be approximately $3\frac{3}{4}$ ¢ per lb. of metal sold
- (2) Selling expenses are estimated to be $\frac{1}{2}$ ¢ per lb. of metal sold

- (3) About three months of metal production would be tied up in inventories and accounts receivable - working capital requirements in this area are estimated to be the value of three months' production.

CAPITAL AND OPERATING COSTS

We were engaged by Cyprus Anvil Mining Corporation to undertake a preliminary study to estimate the capital and operating costs for the six basic cases.

Capital costs

Anvil developed the capital costs of the townsite and other facilities not included in our estimates. The townsite costs, as developed by Anvil, were based on current experience as much as possible. The cost of other facilities, not included in our estimates, were developed by Anvil and have not been escalated. All capital costs, excluding working capital, were escalated 10 % per year for the $3\frac{1}{2}$ years estimated to be required for the construction of the project.

Operating costs

Anvil developed the operating costs of the townsite not included in our estimate. Our estimates do however include a contingency of 10 % and have been escalated by 35 %.

Northern Canada Power Commission provided the unit power costs to be used. The detailed estimates shown previously in this report are only based on two of the possible rates. In order to assess the economics, the power cost was adjusted for each case using both the 40 year and 10 year amortization periods.

Inland transportation costs were developed by Anvil after consultation with White Pass and Yukon Route.

Administration, Research and Development costs were estimated by Anvil.

ECONOMICS

Of the 48 possibilities examined only six showed a return on investment. The discounted cash flow for these six cases, calculated as outlined in the agreement with the Government and at the higher metal prices (i.e. Zinc @ 49 ¢/lb and Lead @ 43 ¢/lb), is tabulated below.

<u>Case</u>	<u>Plant</u>	Power amortized over	Production - STPY		D.C.F. %
			<u>Slab zinc</u>	<u>Refined lead</u>	
2	Combined Zinc-Lead Complex	40 years	140,000	103,100	7.5
2	Combined Zinc-Lead Complex	10 years	140,000	103,100	6.1
5	Separate Electrolytic Zinc Plant	40 years	140,000	-	7.5
5	Separate Electrolytic Zinc Plant	10 years	140,000	-	5.5
6	Separate Electrolytic Zinc Plant	40 years	70,000	-	2.4
1	Combined Zinc-Lead Complex	40 years	70,000	51,550	<2

CONCLUSIONS

The above results lead to the following conclusions:

- (1) A separate lead smelter at any level of production is not economic.
- (2) Based on current metal prices, construction of a smelting complex is not economic.

- (3) Even at high metal prices, the DCF is only half that called for in the Government Agreement with Cyprus Anvil Mining Corporation.
- (4) The DCF from a separate zinc plant is approximately the same as that from a combined lead/zinc complex (both smelting 100 % of the mine's production of the applicable metal). This could be very misleading as it assumes the mine would be able to dispose of its production of lead concentrates under terms and conditions comparable to those currently in existence. In all likelihood, this would not be the case as Anvil's zinc production is used as a lever to market the corresponding lead concentrates.

COST OF CONCENTRATES TO SMELTER

Values of zinc and lead concentrates used in D.C.F. calculations are equivalent to the prices which Cyprus Anvil Mining Corporation can obtain by selling these concentrates to outside smelters on a competitive basis. The values are based on Anvil's current contract with overseas zinc and lead smelters as applied to the contract year 1976, and adjusted for freight differential to the proposed smelter site at Little Salmon, as detailed on pages 128 and 129.

CYPRUS ANVIL MINING CORPORATION
COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL CASH GENERATION - CASE 1

Production: Slab zinc produced 70,000 STPY
 Refined lead produced 51,550 STPY

	<u>40 YEAR POWER AMORTIZATION</u>				<u>10 YEAR POWER AMORTIZATION</u>			
<u>STATISTICS</u>								
Metal prices, zinc c/lb	14 c	26 c	36 c	49 c	14 c	26 c	36 c	49 c
lead c/lb	12 c	22 c	32 c	43 c	12 c	22 c	32 c	43 c
silver \$/oz	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00
gold \$/oz	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00
cadmium \$/lb	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50
Metal produced, zinc STPY	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000
lead, STPY	51,500	51,500	51,500	51,500	51,500	51,500	51,500	51,500
silver, oz/yr	1,589,600	1,589,600	1,589,600	1,589,600	1,589,600	1,589,600	1,589,600	1,589,600
gold, oz/yr	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200
cadmium, STPY	81	81	81	81	81	81	81	81
<u>CASH GENERATION (\$000's)</u>								
Sales, zinc	19,600	36,400	50,400	68,600	19,600	36,400	50,400	68,600
lead	12,360	22,660	32,960	44,290	12,360	22,660	32,960	44,290
silver	6,358	6,358	6,358	6,358	6,358	6,358	6,358	6,358
gold	333	333	333	333	333	333	333	333
cadmium	567	567	567	567	567	567	567	567
	39,218	66,318	90,618	120,148	39,218	66,318	90,618	120,148
Costs								
Concentrate - zinc(*) 144,370 DST	5,375	15,478	23,480	33,884	5,375	15,478	23,480	33,884
- lead(*) 80,640 DST	12,511	18,439	24,226	30,666	12,511	18,439	24,226	30,666
Treatment charge Dorr metal	160	160	160	160	160	160	160	160
Marketing, 4 1/4 c/lb	10,328	10,328	10,328	10,328	10,328	10,328	10,328	10,328
Operating cost	15,409	15,409	15,409	15,409	15,409	15,409	15,409	15,409
Power	6,926	6,926	6,926	6,926	10,936	10,936	10,936	10,936
Townsite	1,958	1,958	1,958	1,958	1,958	1,958	1,958	1,958
Property taxes	1,860	1,860	1,860	1,860	1,860	1,860	1,860	1,860
Administration	850	850	850	850	850	850	850	850
Insurance	284	284	284	284	284	284	284	284
Legal & audit	200	200	200	200	200	200	200	200
Research & development	500	500	500	500	500	500	500	500
Transportation to tidewater	2,795	2,795	2,795	2,795	2,795	2,795	2,795	2,795
Total Annual Operating Cost	59,156	75,187	88,976	105,820	63,166	79,197	92,986	109,830
<u>ANNUAL CASH GENERATION</u>	(19,938)	(8,869)	1,642	14,328	(23,948)	(12,879)	(2,368)	10,318

(*) Value based on 1976 contract year

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

CASH FLOW

CASE 1 using Zinc @ 49 ¢/lb and Lead @ 43 ¢/lb
in 1000's Canadian Dollars

40 YEAR POWER AMORTIZATION

	YEARS																
	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	TOTALS	
Cash Flow Before Taxes	-	-	-	-	14328	14328	14328	14328	14328	14328	14328	14328	14328	14328	7164	150,444	
Income Taxes	-	-	-	-	-	-	-	-	-	868	2074	2934	3548	3991	1624	15,039	
GROSS CASH FLOW	-	-	-	-	14328	14328	14328	14328	14328	13460	12254	11394	10780	10337	5540	135,405	
Investments Considered																	
Depreciable Assets	(17800)	(35600)	(35600)	(35544)	-	-	-	-	-	-	-	-	-	-	*14202	14,202 (124,544)	
Net Working Capital				(7575)	(22725)										27700	(2,600)	
NET CASH FLOW	(17800)	(35600)	(35600)	(43119)	(8397)	14328	14328	14328	14328	13460	12254	11394	10780	10337	47442	22,463	
D.C.F. slightly under 2 %																	
					* Assumes Recovery of Undepreciated Capital Costs												

* Assumes Recovery of Undepreciated Capital Costs

10 YEAR POWER AMORTIZATION

	YEARS															
	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	TOTALS
Cash Flow Before Taxes	-	-	-		10318	10318	10318	10318	10318	10318	10318	10318	10318	10318	5159	108,339
Income Taxes	-	-	-	-												
GROSS CASH FLOW	-	-	-	-												
Investments Considered																
Depreciable Assets	(17800)	(35600)	(35600)	(35544)												(124,544)
Net Working Capital				(7575)	(22725)										27700	(2,600)
NET CASH FLOW	(17800)	(35600)	(35600)	(43119)												(18,805)

Conclusion: At these price levels does not recover
Capital Costs during the life of the ore
body. Assuming no income tax, cash generated
is \$18,805 less than capital costs.

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

ANNUAL CASH GENERATION - CASE 2

Production: Slab zinc produced 140,000 STPY
Refined lead produced 103,100 STPY

40 YEAR POWER AMORTIZATION

10 YEAR POWER AMORTIZATION

STATISTICS

Metal prices, zinc c/lb	14 c	26 c	36 c	49 c	14 c	26 c	36 c	49 c
lead c/lb	12 c	22 c	32 c	43 c	12 c	22 c	32 c	43 c
silver, \$/oz	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00
gold, \$/oz	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00
cadmium \$/lb	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50
Metal produced, zinc STPY	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000
lead STPY	103,100	103,100	103,100	103,100	103,100	103,100	103,100	103,100
silver oz/yr	3,179,300	3,179,300	3,179,300	3,179,300	3,179,300	3,179,300	3,179,300	3,179,300
gold, oz/yr	4,430	4,430	4,430	4,430	4,430	4,430	4,430	4,430
cadmium, STPY	162	162	162	162	162	162	162	162

CASH GENERATION (\$000's)

Sales, zinc	39,200	72,800	100,800	137,200	39,200	72,800	100,800	137,200
lead	24,744	45,364	65,984	88,666	24,744	45,364	65,984	88,666
silver	12,717	12,717	12,717	12,717	12,717	12,717	12,717	12,717
gold	665	665	665	665	665	665	665	665
cadmium	1,134	1,134	1,134	1,134	1,134	1,134	1,134	1,134
	78,460	132,680	181,300	240,382	78,460	132,680	181,300	240,382
Costs								
Concentrate - zinc(*)	9,534	29,740	45,745	66,552	9,534	29,740	45,745	66,552
lead(*)	24,348	36,205	47,779	60,660	24,348	36,205	47,779	60,660
Treatment Charge Dorr metal	320	320	320	320	320	320	320	320
Marketing, 4 1/2 c/lb	20,664	20,664	20,664	20,664	20,664	20,664	20,664	20,664
Operating cost	24,592	24,592	24,592	24,592	24,592	24,592	24,592	24,592
Power	10,858	10,858	10,858	10,858	16,865	16,865	16,865	16,865
Townsite	2,754	2,754	2,754	2,754	2,754	2,754	2,754	2,754
Property taxes	2,881	2,881	2,881	2,881	2,881	2,881	2,881	2,881
Administration	850	850	850	850	850	850	850	850
Insurance	445	445	445	445	445	445	445	445
Legal & audit	200	200	200	200	200	200	200	200
Research & development	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Transportation to tidewater	5,591	5,591	5,591	5,591	5,591	5,591	5,591	5,591
Total Annual Operating Cost	104,237	136,300	163,879	197,567	110,244	142,307	169,886	203,574

ANNUAL CASH GENERATION

(25,777)	(3,620)	17,421	42,815	(31,784)	(9,627)	11,414	36,808
----------	---------	--------	--------	----------	---------	--------	--------

(*) Value based on 1976 contract year

CYPRUS ANVIL MINING CORPORATION

COMBINED ZINC-LEAD SMELTER COMPLEX

CASH FLOW

CASE 2 using Zinc @ 49 c/lb and Lead @ 48 c/lb
in 1000's Canadian Dollars

40 YEAR POWER AMORTIZATION

	YEARS															
	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	TOTALS
Cash Flow Before Taxes	-	-	-	-	42815	42815	42815	42815	42815	42815	42815	42815	42815	42815	15839	443,959
Income Taxes	-	-	-	-	-	2380	6168	8852	10759	12119	13094	13797	17170	19576	6457	110,372
GROSS CASH FLOW	-	-	-	-	42815	40435	36647	33963	32056	30696	29721	29018	25645	23239	9382	333,617
Investments Considered																
Depreciable Assets	(27,470)	(54,940)	(54,940)	(54,941)	-	-	-	-	-	-	-	-	-	-	*17,635	17,635 (192,291)
Net Working Capital				(15,250)	(45,750)										56,900	(4,100)
NET CASH FLOW	(27,470)	(54,940)	(54,940)	(70,191)	(29,350)	40,435	36,647	33,963	32,056	30,696	29,721	29,018	25,645	23,239	8,397	154,861

D.C.F. 7.5 %

* Assumes Recovery of Undepreciated Capital Cost

10 YEAR POWER AMORTIZATION

	YEARS															
	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	TOTALS
Cash Flow Before Taxes	-	-	-	-	36,808	36,808	36,808	36,808	36,808	36,808	36,808	36,808	36,808	36,808	18,404	386,484
Income Taxes	-	-	-	-	-	-	3,278	6,156	8,193	9,647	10,688	11,437	11,980	12,665	7,691	81,735
GROSS CASH FLOW	-	-	-	-	36,808	36,808	33,530	30,652	28,615	27,161	26,120	25,371	24,828	24,143	10,713	304,749
Investments Considered																
Depreciable Assets	(27,470)	(54,940)	(54,940)	(54,941)											*17,865	17,865 (192,291)
Net Working Capital				(15,250)	(45,750)										56,900	(4,100)
NET CASH FLOW	(27,470)	(54,940)	(54,940)	(70,191)	(8,942)	36,808	33,530	30,652	28,615	27,161	26,120	25,371	24,828	24,143	85,478	126,223

D.C.F. 6.1 %

* Assumes Recovery of Undepreciated Capital Cost

CYPRUS ANVIL MINING CORPORATION

SEPARATE LEAD SMELTER WITH REFINERY

ANNUAL CASH GENERATION - CASE 3

Production: Refined lead produced 100,000 STPY

40 YEAR POWER AMORTIZATION

10 YEAR POWER AMORTIZATION

STATISTICS

	12 c	22 c	32 c	43 c	12 c	22 c	32 c	43 c
Metal prices, lead c/lb								
silver \$/oz	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00
gold, \$/oz	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00
cadmium, \$/lb	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50
Metal produced, lead STPY	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
silver oz/yr	2,861,000	2,861,000	2,861,000	2,861,000	2,861,000	2,861,000	2,861,000	2,861,000
gold oz/yr	3,160	3,160	3,160	3,160	3,160	3,160	3,160	3,160

CASH GENERATION (\$000's)

Sales, lead	24,000	44,000	64,000	86,000	24,000	44,000	64,000	86,000
silver	11,444	11,444	11,444	11,444	11,444	11,444	11,444	11,444
gold	<u>474</u>	<u>474</u>	<u>474</u>	<u>474</u>	<u>474</u>	<u>474</u>	<u>474</u>	<u>474</u>
	35,918	55,918	75,918	97,918	35,918	55,918	75,918	97,918
Costs								
Concentrate - lead(*) 161,290 DST	25,024	36,881	48,455	61,335	25,024	36,881	48,455	61,335
Treatment charge Dorr metal	288	288	288	288	288	288	288	288
Marketing, 4 1/4 c/lb	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500
Operating cost	12,249	12,249	12,249	12,249	12,249	12,249	12,249	12,249
Power	3,089	3,089	3,089	3,089	4,774	4,774	4,774	4,774
Townsite	1,471	1,471	1,471	1,471	1,471	1,471	1,471	1,471
Property taxes	1,173	1,173	1,173	1,173	1,173	1,173	1,173	1,173
Administration	850	850	850	850	850	850	850	850
Insurance	175	175	175	175	175	175	175	175
Legal & audit	150	150	150	150	150	150	150	150
Research & development	600	600	600	600	600	600	600	600
Transportation to tidewater	<u>2,300</u>	<u>2,300</u>	<u>2,300</u>	<u>2,300</u>	<u>2,300</u>	<u>2,300</u>	<u>2,300</u>	<u>2,300</u>
Total Annual Operating Cost	55,869	67,726	79,300	92,180	57,554	69,411	80,985	93,865

<u>ANNUAL CASH GENERATION</u>	(19,951)	(11,808)	(3,382)	5,738	(21,636)	(13,493)	(5,067)	4,053
-------------------------------	----------	----------	---------	-------	----------	----------	---------	-------

(*) Value based on 1976 contract year

Note: Cash flow was not calculated as above does not recover capital cost over life of orebody

CYPRUS ANVIL MINING CORPORATION
SEPARATE LEAD SMELTER WITH REFINERY

ANNUAL CASH GENERATION - CASE 4

Production: Refined lead produced 50,000 STPY

40 YEAR POWER AMORTIZATION

10 YEAR POWER AMORTIZATION

STATISTICS

	12 c	22 c	32 c	43 c	12 c	22 c	32 c	43 c
Metal prices, lead c/lb								
silver c/lb	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00
gold \$/oz	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00
cadmium, \$/lb	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50
Metal produced, lead STPY	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
silver oz/yr	1,430,400	1,430,400	1,430,400	1,430,400	1,430,400	1,430,400	1,430,400	1,430,400
gold oz/yr	1,580	1,580	1,580	1,580	1,580	1,580	1,580	1,580

CASH GENERATION (\$000's)

Sales, lead	12,000	22,000	32,000	43,000	12,000	22,000	32,000	43,000
silver	5,722	5,722	5,722	5,722	5,722	5,722	5,722	5,722
gold	237	237	237	237	237	237	237	237
	17,959	27,959	37,959	48,959	17,959	27,959	37,959	48,959
Costs								
Concentrate - lead(*) 80,640 DST	12,511	18,439	24,226	30,666	12,511	18,439	24,226	30,666
Treatment charge Dorr metal	144	144	144	144	144	144	144	144
Marketing, 4 1/4 c/lb	4,250	4,250	4,250	4,250	4,250	4,250	4,250	4,250
Operating cost	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875
Power	1,747	1,747	1,747	1,747	2,694	2,694	2,694	2,694
Townsite	1,053	1,053	1,053	1,053	1,053	1,053	1,053	1,053
Property taxes	779	779	779	779	779	779	779	779
Administration	850	850	850	850	850	850	850	850
Insurance	115	115	115	115	115	115	115	115
Legal & audit	150	150	150	150	150	150	150	150
Research & development	200	200	200	200	200	200	200	200
Transportation to tidewater	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150
Total Annual Operating Cost	30,824	36,752	42,539	48,979	31,771	37,699	43,486	49,926
<u>ANNUAL CASH GENERATION</u>	(12,865)	(8,793)	(4,580)	(20)	(13,812)	(9,740)	(5,527)	(967)

(*) Value based on 1976 contract year

Note: Cash flow was not calculated as above does not recover capital cost over life of orebody

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTROLYTIC ZINC PLANT

ANNUAL CASH GENERATION - CASE 5

Production: Slab zinc produced 140,000 STPY

40 YEAR POWER AMORTIZATION

10 YEAR POWER AMORTIZATION

STATISTICS

	14 c	26 c	36 c	49 c	14 c	26 c	36 c	49 c
Metal prices, zinc c/lb								
silver \$/oz	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00
gold, \$/oz	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00
cadmium, \$/lb	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50
Metal produced, zinc STPY	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000
silver oz/yr	318,300	318,300	318,300	318,300	318,300	318,300	318,300	318,300
gold oz/yr	1,270	1,270	1,270	1,270	1,270	1,270	1,270	1,270
cadmium STPY	162	162	162	162	162	162	162	162

CASH GENERATION (\$000's)

Sales, zinc	39,200	72,800	100,800	137,200	39,200	72,800	100,800	137,200
silver	1,273	1,273	1,273	1,273	1,273	1,273	1,273	1,273
gold	191	191	191	191	191	191	191	191
cadmium	1,134	1,134	1,134	1,134	1,134	1,134	1,134	1,134
	41,798	75,398	103,398	139,798	41,798	75,398	103,398	139,798

Costs

Concentrate - zinc(*) 288,740 DST

Treatment charge Dorr metal

Marketing, 4 1/4 c/lb

Operating cost

Power

Townsite

Property taxes

Administration

Insurance

Legal & audit

Research & development

Transportation to tidewater

Total Annual Operating Cost

Assumes Pb content of Pb/Ag residue pay charges

Assumes Pb content of Pb/Ag residue pay charges

ANNUAL CASH GENERATION

(*) Value based on 1976 contract year

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTROLYTIC ZINC PLANT

CASH FLOW

CASE 5 using Zinc @ 49 c/lb and Lead @ 43 c/lb
in 1000's Canadian Dollars

40 YEAR POWER AMORTIZATION

	YEARS															
	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	TOTALS
Cash Flow Before Taxes	-	-	-	-	28221	28221	28221	28221	28221	28221	28221	28221	28221	28221	14110	296,320
Income Taxes	-	-	-	-	-	1091	3736	5472	6936	7882	8559	9047	10010	12878	6076	71,667
GROSS CASH FLOW	-	-	-	-	28221	27130	24485	22749	21285	20339	19662	19174	18211	15343	8034	224,633
Investments Considered																
Depreciable Assets	(18660)	(37320)	(37320)	(37312)											*11551	11,551 (130,612)
Net Working Capital				(9050)	(27150)										33300	(2,900)
NET CASH FLOW	(18660)	(37320)	(37320)	(46362)	1071	27130	24485	22749	21285	20339	19662	19174	18211	15343	52885	102,672

D.C.F. 7.5 %

* Assumes Recovery of Undepreciated Capital Cost

10 YEAR POWER AMORTIZATION

	YEARS															
	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	TOTALS
Cash Flow Before Taxes	-	-	-	-	22970	22970	22970	22970	22970	22970	22970	22970	22970	22970	11485	241,185
Income Taxes	-	-	-	-	-	-	912	3040	4548	5620	6385	6934	7330	7619	3523	45,911
GROSS CASH FLOW	-	-	-	-	22970	22970	22058	19930	18422	17350	16585	16036	15640	15351	7962	195,274
Investments Considered																
Depreciable Assets	(18660)	(37320)	(37320)	(37312)											*11857	11,857 (130,612)
Net Working Capital				(9050)	(27150)										33300	(2,900)
NET CASH FLOW	(18660)	(37320)	(37320)	(46362)	(4180)	22970	22058	19930	18422	17350	16585	16036	15640	15351	53119	73,619

D.C.F. 5.5 %

* Assumes Recovery of Undepreciated Capital Cost

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTROLYTIC ZINC PLANT

ANNUAL CASH GENERATION - CASE 6

Production: Slab zinc produced 70,000 STPY

40 YEAR POWER AMORTIZATION

10 YEAR POWER AMORTIZATION

STATISTICS

	14 c	26 c	36 c	49 c	14 c	26 c	36 c	49 c
Metal prices, zinc c/lb								
silver \$/oz	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00	\$ 4.00
gold \$/oz	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00	\$ 150.00
cadmium \$/lb	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50	\$ 3.50
Metal produced, zinc STPY	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000
silver oz/yr	159,200	159,200	159,200	159,200	159,200	159,200	159,200	159,200
gold oz/yr	640	640	640	640	640	640	640	640
cadmium STPY	81	81	81	81	81	81	81	81

CASH GENERATION (\$000's)

Sales, zinc	19,600	36,400	50,400	68,600	19,600	36,400	50,400	68,600
silver	636	636	636	636	636	636	636	636
gold	96	96	96	96	96	96	96	96
cadmium	567	567	567	567	567	567	567	567
	20,899	37,699	51,699	69,899	20,899	37,699	51,699	69,899

Costs

Concentrate - zinc(*) 144,370 DST

Treatment charge Dorr metal

Marketing, 4 1/2 c/lb

Operating cost

Power

Townsite

Property taxes

Administration

Insurance

Legal & audit

Research & development

Transportation to tidewater

Total Annual Operating Cost

	5,375	15,478	23,480	33,884		5,375	15,478	23,480	33,884
Assumes Pb content of Pb/Ag residue covers	5,950	5,950	5,950	5,950	Assumes Pb content of Pb/Ag residue covers	5,950	5,950	5,950	5,950
	8,703	8,703	8,703	8,703		8,703	8,703	8,703	8,703
	5,543	5,543	5,543	5,543		8,752	8,752	8,752	8,752
	1,120	1,120	1,120	1,120		1,120	1,120	1,120	1,120
	1,242	1,242	1,242	1,242		1,242	1,242	1,242	1,242
	850	850	850	850		850	850	850	850
	196	196	196	196		196	196	196	196
	150	150	150	150		150	150	150	150
	300	300	300	300		300	300	300	300
	1,610	1,610	1,610	1,610		1,610	1,610	1,610	1,610
	31,039	41,142	49,144	59,548		34,248	44,351	52,353	62,757

	5,375	15,478	23,480	33,884		5,375	15,478	23,480	33,884
Assumes Pb content of Pb/Ag residue covers	5,950	5,950	5,950	5,950	Assumes Pb content of Pb/Ag residue covers	5,950	5,950	5,950	5,950
	8,703	8,703	8,703	8,703		8,703	8,703	8,703	8,703
	5,543	5,543	5,543	5,543		8,752	8,752	8,752	8,752
	1,120	1,120	1,120	1,120		1,120	1,120	1,120	1,120
	1,242	1,242	1,242	1,242		1,242	1,242	1,242	1,242
	850	850	850	850		850	850	850	850
	196	196	196	196		196	196	196	196
	150	150	150	150		150	150	150	150
	300	300	300	300		300	300	300	300
	1,610	1,610	1,610	1,610		1,610	1,610	1,610	1,610
	31,039	41,142	49,144	59,548		34,248	44,351	52,353	62,757

ANNUAL CASH GENERATION

(10,140)	(3,443)	2,555	10,351	(13,349)	(6,652)	(654)	7,142
----------	---------	-------	--------	----------	---------	-------	-------

(*) Value based on 1976 contract year

CYPRUS ANVIL MINING CORPORATION

SEPARATE ELECTROLYTIC ZINC PLANT

CASH FLOW

CASE 6 using Zinc @ 49 c/lb and Lead @ 43 7/1b
in 1000's Canadian Dollars

40 YEAR POWER AMORTIZATION

	YEARS															
	-4	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11	TOTALS
Cash Flow Before Taxes	-	-	-	-	10351	10351	10351	10351	10351	10351	10351	10351	10351	10351	5175	108,685
Income Taxes	-	-	-	-	-	-	-	-	138	1,158	1,881	2,397	2,767	3,033	1,286	12,660
GROSS CASH FLOW	-	-	-	-	10351	10351	10351	10351	10213	9,193	8,470	7,954	7,584	7,318	3,889	96,025
Investments Considered																
Depreciable Assets	(11,990)	(23,970)	(23,970)	(23,977)											*8,985	8,895 (83,907)
Net Working Capital				(4,575)	(13,725)										16,500	(1,800)
NET CASH FLOW	(11,990)	(23,970)	(23,970)	(28,552)	(3,374)	10,351	10,351	10,351	10,213	9,193	8,470	7,954	7,584	7,318	29,374	19,303

D.C.F. 2.4 %

* Assumes Recovery of Undepreciated Capital Cost

10 YEAR POWER AMORTIZATION

	<u>YEARS</u>															
	<u>-4</u>	<u>-3</u>	<u>-2</u>	<u>-1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>TOTALS</u>
Cash Flow Before Taxes	-	-	-	-	7,142	7,142	7,142	7,142	7,142	7,142	7,142	7,142	7,142	7,142	3,571	74,991
Income Taxes	-	-	-	-												
GROSS CASH FLOW	-	-	-	-												
Investments Considered																
Depreciable Assets	(11,990)	(23,970)	(23,970)	(23,977)												(83,907)
Net Working Capital				(4,575)	(13,725)										16,500	(1,800)
NET CASH FLOW	(11,990)	(23,970)	(23,970)	(28,552)												(10,716)

Conclusion:

At these price levels does not recover
Capital Costs during the life of the ore body.
Assuming no income tax, cash generated is \$10,716
less than capital costs.

CYPRUS ANVIL MINING CORPORATION

SMEALTER FEASIBILITY STUDY

VALUE OF ZINC CONCENTRATES - JAPANESE TERMS - 1976 Contract Year

ZINC

Zn 51.58 % - 8.00 % =	<u>14¢/Lb.</u>	<u>26¢/Lb.</u>	<u>36¢/Lb.</u>	<u>49¢/Lb.</u>
43.58 % x 2204.6 = 961 lbs. @	<u>134.54</u>	<u>249.86</u>	<u>345.96</u>	<u>470.89</u>

Treatment Charges:

Base	10.00	53.40	53.40	53.40	53.40
Escalators	4.00 @ 150	6.00	6.00	6.00	6.00
	250		9.58	9.58	9.58
	350		28.60	63.60	109.10
		<u>59.40</u>	<u>97.58</u>	<u>132.58</u>	<u>178.08</u>
Pollution allowance		4.00	4.00	4.00	4.00
Fe Penalty		<u>1.25</u>	<u>1.25</u>	<u>1.25</u>	<u>1.25</u>
		<u>64.65</u>	<u>102.83</u>	<u>137.83</u>	<u>183.33</u>

Other

Transportation to Tidewater - Say \$21/WST	24.37	24.37	24.37	24.37
Skagway Terminal	3.10	3.10	3.10	3.10
Ocean Freight	12.50	12.50	12.50	12.50
Marine Insurance allowance	.37	.37	.37	.37
Other	.70	.70	.70	.70
	<u>41.04</u>	<u>41.04</u>	<u>41.04</u>	<u>41.04</u>
Deduct: Transportation to smelter	<u>7.55</u>	<u>7.55</u>	<u>7.55</u>	<u>7.55</u>
	<u>33.49</u>	<u>33.49</u>	<u>33.49</u>	<u>33.49</u>

Cost to Smelter of Concentrates

Metal		134.54	249.86	345.96	470.89
Less: Treatment charges	64.65		102.83	137.83	183.33
Other	<u>33.49</u>	<u>98.14</u>	<u>33.49</u>	<u>33.49</u>	<u>33.49</u>
		<u>36.40</u>	<u>113.54</u>	<u>174.64</u>	<u>254.07</u>
D.M.T.		<u>33.02</u>	<u>103.00</u>	<u>158.43</u>	<u>230.49</u>

Adjustment of Transportation to Tidewater Costs
if Tonnage is Reduced Below Full Production

	<u>4.21</u>	<u>4.21</u>	<u>4.21</u>	<u>4.21</u>
	<u>37.23</u>	<u>107.21</u>	<u>162.64</u>	<u>234.70</u>

CYPRUS ANVIL MINING CORPORATION

SMEALTER FEASIBILITY STUDY

VALUE OF LEAD CONCENTRATES - JAPANESE TERMS - 1976 Contract Year

<u>LEAD</u>	<u>12c/Lb.</u>	<u>22c/Lb.</u>	<u>32c/Lb.</u>	<u>43c/Lb.</u>
Pb 65.55 % x 95 % = 62.27 % x 2204.6				
= 1373 lbs. @	<u>164.76</u>	<u>302.06</u>	<u>439.36</u>	<u>590.39</u>
Ag 18.1 x 1102.3 = 19.95 - 1.00				
= 18.85 ozs. @ \$4.00	<u>75.40</u>	<u>75.40</u>	<u>75.40</u>	<u>75.40</u>
<u>Treatment Charges:</u>	36.47	36.47	36.47	36.47
Basic £110				
Escalator £ @ 60c	-	55.80	114.00	177.00
	<u>36.47</u>	<u>92.27</u>	<u>150.47</u>	<u>213.47</u>
Pollution Allowance	4.00	4.00	4.00	4.00
	<u>40.00</u>	<u>96.27</u>	<u>154.47</u>	<u>217.47</u>
<u>Other</u>				
Transportation to Tidewater	24.37	24.37	24.37	24.37
Skagway Terminal	3.10	3.10	3.10	3.10
Ocean Freight	12.50	12.50	12.50	12.50
Marine Insurance allowance	.64	.64	.64	.64
Other	.70	.70	.70	.70
	<u>41.31</u>	<u>41.31</u>	<u>41.31</u>	<u>41.31</u>
Less: Transportation to smelter	<u>7.55</u>	<u>7.55</u>	<u>7.55</u>	<u>7.55</u>
	<u>33.76</u>	<u>33.76</u>	<u>33.76</u>	<u>33.76</u>
<u>Cost to Smelter of Concentrates</u>				
Metal	240.16	377.46	514.76	665.79
Less: Treatment Charge	40.00	96.27	154.47	217.47
Other	<u>33.76</u>	<u>33.76</u>	<u>33.76</u>	<u>33.76</u>
	73.76	130.03	188.23	251.23
D.M.T.	<u>166.40</u>	<u>247.43</u>	<u>326.53</u>	<u>414.56</u>
D.S.I.	<u>150.96</u>	<u>224.47</u>	<u>296.23</u>	<u>376.09</u>
Adjustment of Transportation to Tidewater Costs				
if Tonnage Shipped is Reduced Below Full Production	<u>4.19</u>	<u>4.19</u>	<u>4.19</u>	<u>4.19</u>
	<u>155.15</u>	<u>228.66</u>	<u>300.42</u>	<u>380.28</u>

CYPRUS ANVIL MINING CORPORATION

SMEALTER FEASIBILITY STUDY

BREAKDOWN OF PLANT OPERATING COSTS

In 1000's Canadian Dollars

Case:	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
<u>Plants(*)</u>						
Zinc plant	9,646	17,220			17,455	9,824
Less: power	<u>4,604</u>	<u>9,208</u>			<u>9,208</u>	<u>4,604</u>
	5,042	8,012			8,247	5,220
Sulphuric acid plant	512	760			887	620
Less: power	<u>153</u>	<u>307</u>			<u>307</u>	<u>153</u>
	359	453			580	467
Excess acid neutralization	775	1,447			1,521	828
Less: power	<u>56</u>	<u>112</u>			<u>136</u>	<u>68</u>
	719	1,335			1,385	760
Total zinc plant complex	6,120	9,800	N/A	N/A	10,212	6,447
Lead smelter	4,380	7,252	7,604	4,637		
Less: power	<u>1,095</u>	<u>2,108</u>	<u>2,108</u>	<u>1,095</u>		
	3,285	5,144	5,496	3,542		
Lead refinery	1,585	2,567	2,540	1,570		
Less: power	<u>34</u>	<u>65</u>	<u>65</u>	<u>34</u>		
	1,551	2,502	2,475	1,536		
Sulphuric acid plant	200	292	531	414		
Less: power	<u>48</u>	<u>96</u>	<u>96</u>	<u>48</u>		
	152	196	435	366		
Excess acid neutralization	330	622	747	429		
Less: power	<u>24</u>	<u>48</u>	<u>80</u>	<u>40</u>		
	306	574	667	389		
Total Lead Smelter & Refinery	5,294	8,416	9,073	5,833	N/A	N/A
Totals	11,414	18,216	9,073	5,833	10,212	6,447
Escalation @ 35 %	<u>3,995</u>	<u>6,376</u>	<u>3,176</u>	<u>2,042</u>	<u>3,574</u>	<u>2,256</u>
Total complex (exclusive of power)	<u>15,409</u>	<u>24,592</u>	<u>12,249</u>	<u>7,875</u>	<u>13,786</u>	<u>8,703</u>

(*) Figures taken from our Operating Cost Estimates

CYPRUS ANVIL MINING CORPORATION

SMEALTER FEASIBILITY STUDY

POWER RATES

The following rates were estimated by the Northern Canada Power Commission in their telegram dated May 24, 1974 and have been quoted based on an annual load factor of 77.5 % for all cases and current interest rates.

<u>Case</u>	<u>KWH/year</u>	<u>Approx KWH</u>	<u>Cost per KWH</u>	
			<u>Amortization over</u>	<u>40 yrs 10 yrs</u>
1	364,530,110	54,000	1.8	2.8
2	723,833,553	107,000	1.5	2.33
3	142,336,919	21,000	2.2	3.4
4	73,781,824	11,000	2.4	3.7
5	584,889,196	86,000	1.6	2.5
6	292,444,568	43,000	1.9	3.0

CYPRUS ANVIL MINING CORPORATION

SMELTHER FEASIBILITY STUDY

CAPITAL COSTS
in 1000's Canadian Dollars

	(Metal Prices - Zinc @ 14 c/lb., Lead @ 12 c/lb.)						(Metal Prices - Zinc @ 26 c/lb., Lead @ 22 c/lb.)					
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
Production Complex	86,982	137,851	53,032	34,360	95,114	59,383	86,982	137,851	53,032	34,360	95,114	59,383
Escalation on above - 17½ %	15,116	24,124	9,281	6,013	16,645	10,392	15,116	24,124	9,281	6,013	16,645	10,392
Townsite	18,252	24,950	14,086	10,594	15,194	11,176	18,252	24,950	14,086	10,594	15,194	11,176
Escalation on above - 17½ %	3,194	4,366	2,465	1,854	2,659	1,956	3,194	4,366	2,465	1,854	2,659	1,956
Other facilities - common to all cases												
Access Road	200	200	200	200	200	200	200	200	200	200	200	200
Water Supply	300	300	300	300	300	300	300	300	300	300	300	300
Waste Disposal	500	500	500	500	500	500	500	500	500	500	500	500
Working Capital	<u>9,200</u>	<u>18,800</u>	<u>8,200</u>	<u>4,500</u>	<u>10,500</u>	<u>5,300</u>	<u>16,300</u>	<u>32,900</u>	<u>13,400</u>	<u>7,000</u>	<u>19,300</u>	<u>9,700</u>
TOTAL CAPITAL COST:	<u>133,744</u>	<u>211,091</u>	<u>88,064</u>	<u>58,321</u>	<u>141,112</u>	<u>89,207</u>	<u>140,844</u>	<u>225,191</u>	<u>93,264</u>	<u>60,821</u>	<u>149,912</u>	<u>93,607</u>
Cash Generation - with 40 year power amortization	(19,938)	(25,777)	(19,951)	(12,865)	(12,762)	(10,140)	(8,869)	(3,620)	(11,808)	(8,793)	632	(3,443)
Payout - years											237.2	
Cash Generation - with 10 year power amortization	(23,948)	(31,784)	(21,636)	(13,812)	(18,013)	(13,349)	(12,879)	(9,627)	(13,493)	(9,740)	(4,619)	(6,652)
Payout - years												

CYPRUS ANVIL MINING CORPORATION

SMELTER FEASIBILITY STUDY

CAPITAL COSTS
in 1000's Canadian Dollars

	(Metal prices - Zinc @ 36 c/lb., Lead @ 32 c/lb.)						(Metal prices - Zinc @ 49 c/lb., Lead @ 43 c/lb.)					
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
Production Complex	86,982	137,851	53,032	34,360	95,114	59,383	86,982	137,851	53,032	34,360	95,114	59,383
Escalation on above - 17½ %	15,116	24,124	9,281	6,013	16,645	10,392	15,116	24,124	9,281	6,013	16,645	10,392
Townsite	18,252	24,950	14,086	10,594	15,194	11,176	18,252	24,950	14,086	10,594	15,194	11,176
Escalation on above - 17½ %	3,194	4,366	2,465	1,854	2,659	1,956	3,194	4,366	2,465	1,854	2,659	1,956
Other facilities - common to all cases												
Access Road	200	200	200	200	200	200	200	200	200	200	200	200
Water Supply	300	300	300	300	300	300	300	300	300	300	300	300
Waste Disposal	500	500	500	500	500	500	500	500	500	500	500	500
Working Capital	<u>22,700</u>	<u>45,600</u>	<u>18,700</u>	<u>9,700</u>	<u>26,600</u>	<u>13,400</u>	<u>30,300</u>	<u>61,000</u>	<u>24,400</u>	<u>12,400</u>	<u>36,200</u>	<u>18,300</u>
TOTAL CAPITAL COST:	<u>147,244</u>	<u>237,891</u>	<u>98,564</u>	<u>63,521</u>	<u>157,212</u>	<u>97,307</u>	<u>154,844</u>	<u>253,291</u>	<u>104,264</u>	<u>66,221</u>	<u>166,812</u>	<u>102,207</u>
Cash Generation - with 40 year power amortization	1,642	17,421	(3,382)	(4,580)	12,627	2,555	14,328	42,815	5,738	(20)	28,221	10,351
Payout - years	89.7	13.7			12.5	38.1	10.8	5.9	18.2		5.9	9.9
Cash Generation - with 10 year power amortization	(2,368)	11,414	(5,067)	(5,527)	7,376	(654)	10,318	36,808	4,053	(967)	22,970	7,142
Payout - years		20.8			21.3		15.0	6.9	25.7*	*	7.3	14.3
<u>FLOW OF CAPITAL COSTS</u> - <u>YEARS</u>												
capital working capital												
1/7 - 4	-	27,470	-	-	18,660	-	17,800	27,470	11,410	7,690	18,660	11,990
2/7 - 3	-	54,940	-	-	37,320	-	35,600	54,940	22,820	15,380	37,320	23,970
2/7 - 2	-	54,940	-	-	37,320	-	35,600	54,940	22,820	15,380	37,320	23,970
2/7 1/4 - 1	-	66,341	-	-	43,962	-	43,119	70,191	28,914	18,471	46,362	25,552
- 3/4 + 1	-	34,200	-	-	19,950	-	22,725	45,750	18,300	9,300	27,150	13,725
	-	<u>237,891</u>	-	-	<u>157,212</u>	-	<u>154,844</u>	<u>253,291</u>	<u>104,264</u>	<u>66,221</u>	<u>166,812</u>	<u>102,207</u>

* DCF's not attempted as cash generation does not recover capital cost over life of ore body

CYPRUS ANVIL MINING CORPORATION

SMEALTER FEASIBILITY STUDY

BREAKDOWN OF WORKING CAPITAL
in 1000's Canadian dollars

	Metal Prices - Zinc @ 14 c/lb., Lead @ 12 c/lb.						Metal Prices - Zinc @ 26 c/lb., Lead @ 22 c/lb.					
	CASE						CASE					
	1	2	3	4	5	6	1	2	3	4	5	6
Cash on hand - allowance	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Supplies & spare parts - 3 % of complex cost	2,600	4,100	1,600	1,000	2,900	1,800	2,600	4,100	1,600	1,000	2,900	1,800
Metal Inventories - (say 1 mo. production)	3,300	6,500	3,000	1,500	3,500	1,700	5,500	11,100	4,700	2,300	6,300	3,100
Concentrate Inventories - 1 month	1,500	2,800	2,100	1,000	1,000	500	2,800	5,500	3,100	1,500	2,600	1,300
Accounts Receivable - 3 mos per Ametalco report	<u>9,800</u>	<u>19,600</u>	<u>9,000</u>	<u>4,500</u>	<u>10,400</u>	<u>5,200</u>	<u>16,600</u>	<u>33,200</u>	<u>14,000</u>	<u>7,000</u>	<u>18,800</u>	<u>9,400</u>
	<u>18,200</u>	<u>34,000</u>	<u>16,700</u>	<u>9,000</u>	<u>18,800</u>	<u>10,200</u>	<u>28,500</u>	<u>54,900</u>	<u>24,400</u>	<u>12,800</u>	<u>31,600</u>	<u>16,600</u>
Less accounts payable - General (assume 2 x supplies)	5,200	8,200	3,200	2,000	5,800	3,600	5,200	8,200	3,200	2,000	5,800	3,600
- Anvil mine *	<u>3,800</u>	<u>7,000</u>	<u>5,300</u>	<u>2,500</u>	<u>2,500</u>	<u>1,300</u>	<u>7,000</u>	<u>13,800</u>	<u>7,800</u>	<u>3,800</u>	<u>6,500</u>	<u>3,300</u>
	<u>9,000</u>	<u>15,200</u>	<u>8,500</u>	<u>4,500</u>	<u>8,300</u>	<u>4,900</u>	<u>12,200</u>	<u>22,000</u>	<u>11,000</u>	<u>5,800</u>	<u>12,300</u>	<u>6,900</u>
Net Working Capital	<u>9,200</u>	<u>18,800</u>	<u>8,200</u>	<u>4,500</u>	<u>10,500</u>	<u>5,300</u>	<u>16,300</u>	<u>32,900</u>	<u>13,400</u>	<u>7,000</u>	<u>19,300</u>	<u>9,700</u>

* Based on 2½ months accounts receivable, which is current experience.

CYPRUS ANVIL MINING CORPORATION

SMEALTER FEASIBILITY STUDY

BREAKDOWN OF WORKING CAPITAL
in 1000's Canadian dollars

	Metal Prices - Zinc @ 36 c/lb., Lead @ 32 %/lb.						Metal Prices - Zinc @ 49 c/lb., Lead @ 43 c/lb.					
	CASE						CASE					
	1	2	3	4	5	6	1	2	3	4	5	6
Cash	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Supplies & spare parts - 3 % of complex cost	2,600	4,100	1,600	1,000	2,900	1,800	2,600	4,100	1,600	1,000	2,900	1,800
Metal Inventories - 1 mos. production	7,600	15,100	6,300	3,200	8,600	4,300	10,000	20,000	8,200	4,100	11,600	5,800
Concentrate Inventories - 1 month	4,000	7,800	4,000	2,000	3,900	2,000	5,400	10,600	5,100	2,600	5,600	2,800
Accounts Receivable - 3 mos per Ametalco report	<u>22,700</u>	<u>45,300</u>	<u>19,000</u>	<u>9,500</u>	<u>25,800</u>	<u>12,900</u>	<u>30,000</u>	<u>60,000</u>	<u>24,500</u>	<u>12,200</u>	<u>34,900</u>	<u>17,500</u>
	<u>37,900</u>	<u>73,300</u>	<u>31,900</u>	<u>16,700</u>	<u>42,200</u>	<u>22,000</u>	<u>49,000</u>	<u>95,700</u>	<u>40,400</u>	<u>20,900</u>	<u>56,000</u>	<u>28,900</u>
Less Accounts Payable - General (assume 2 x supplies)	5,200	8,200	3,200	2,000	5,800	3,600	5,200	8,200	3,200	2,000	5,800	3,600
- Anvil mine *	<u>10,000</u>	<u>19,500</u>	<u>10,000</u>	<u>5,000</u>	<u>9,800</u>	<u>5,000</u>	<u>13,500</u>	<u>26,500</u>	<u>12,800</u>	<u>6,500</u>	<u>14,000</u>	<u>7,000</u>
	<u>15,200</u>	<u>27,700</u>	<u>13,200</u>	<u>7,000</u>	<u>15,600</u>	<u>8,600</u>	<u>18,700</u>	<u>34,700</u>	<u>16,000</u>	<u>8,500</u>	<u>19,800</u>	<u>10,600</u>
Net Working Capital	<u>22,700</u>	<u>45,600</u>	<u>18,700</u>	<u>9,700</u>	<u>26,600</u>	<u>13,400</u>	<u>30,300</u>	<u>61,000</u>	<u>24,400</u>	<u>12,400</u>	<u>36,200</u>	<u>18,300</u>

* Based on 2½ months accounts receivable, which is current experience

CYPRUS ANVIL MINING CORPORATION

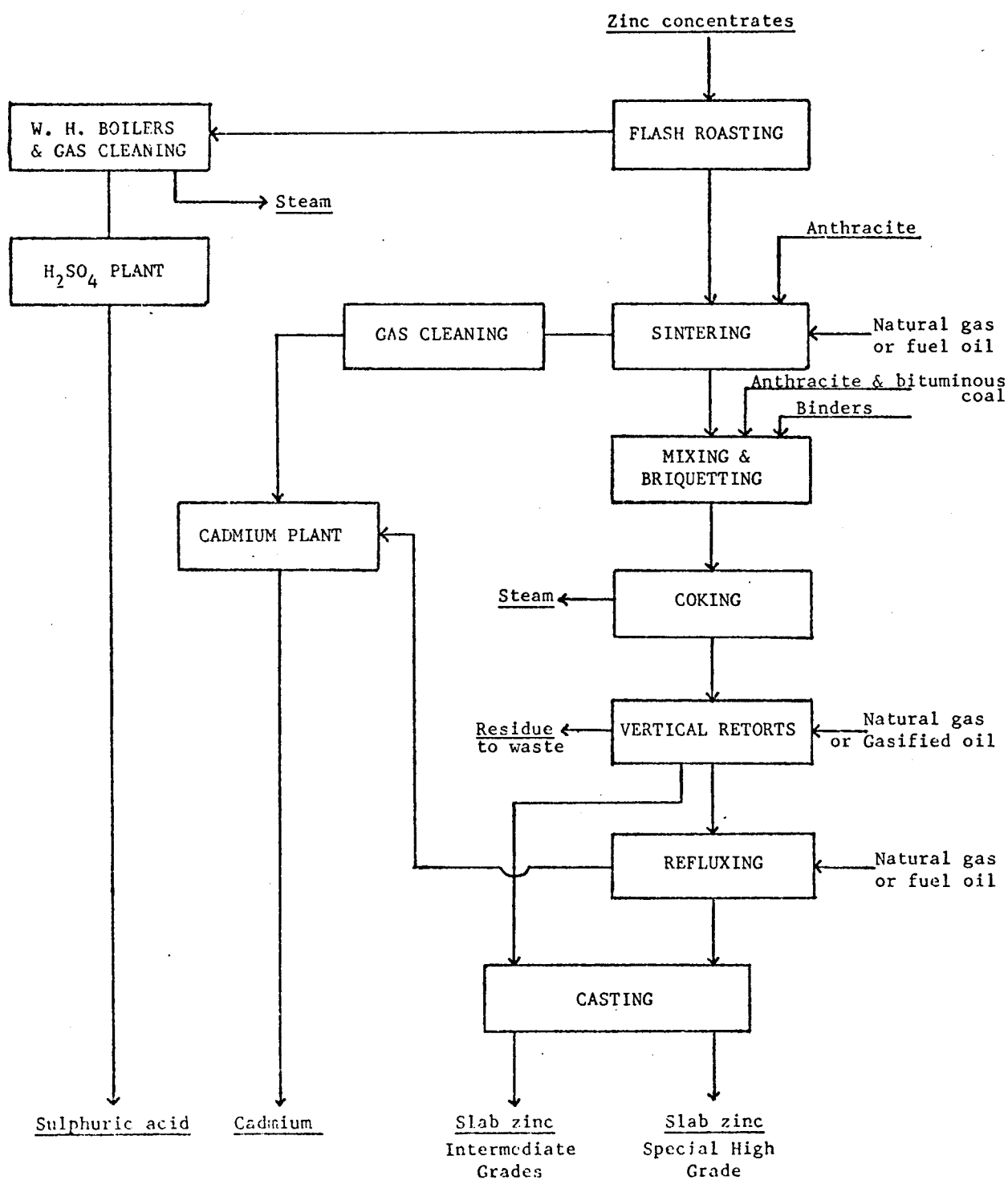
SMEALTER FEASIBILITY STUDY

BREAKDOWN OF TOWNSITE CAPITAL COSTS

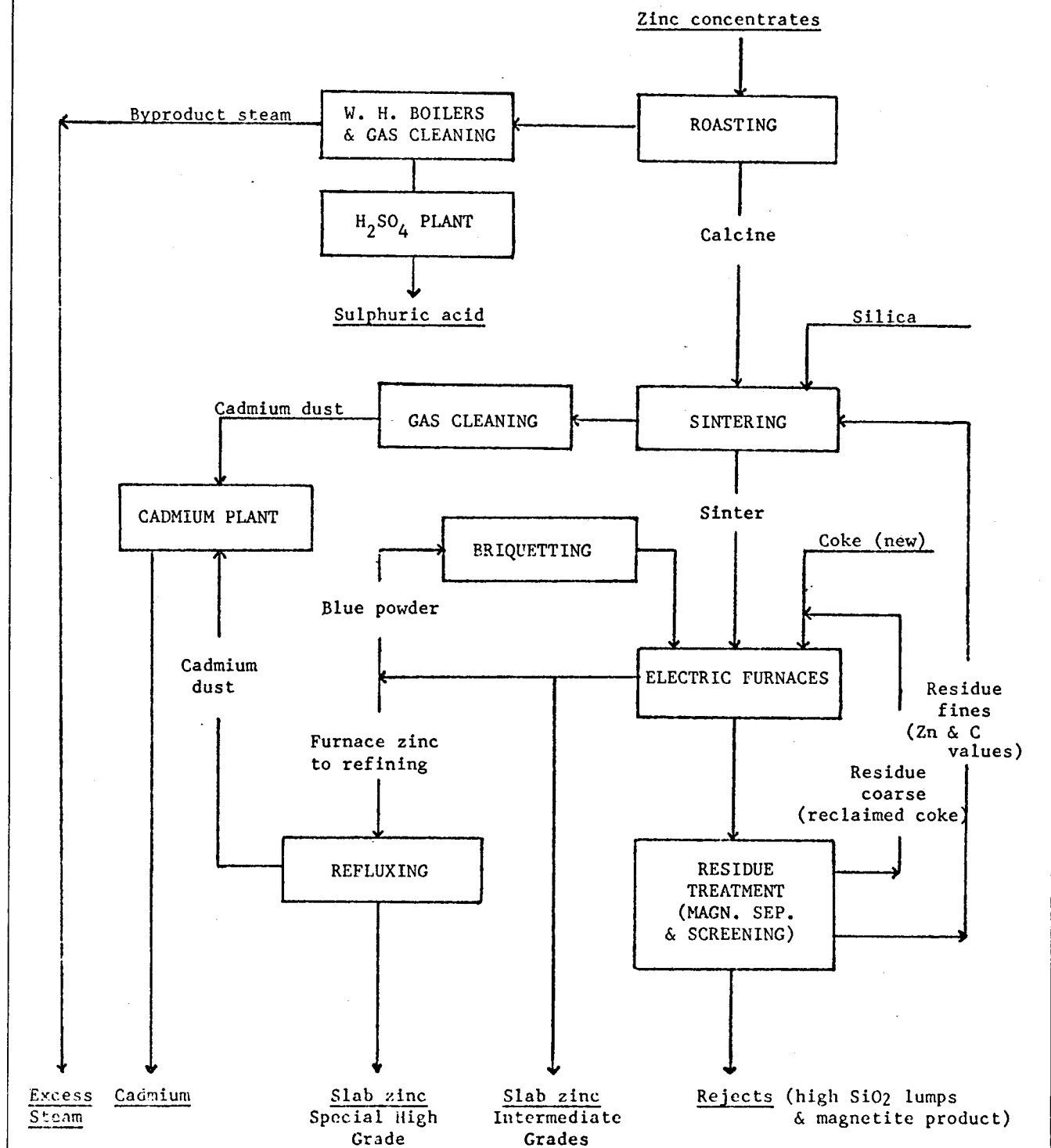
In 1000's Canadian Dollars

Case	1	2	3	4	5	6
Production: Slab zinc STPY	70,000	140,000	-	-	140,000	70,000
Refined lead STPY	<u>51,550</u>	<u>103,100</u>	<u>100,000</u>	<u>50,000</u>	<u>-</u>	<u>-</u>
<u>ACCOMMODATION</u>						
Employee housing, @ 40,000/emp.	13,680	19,200	10,240	7,360	11,160	7,840
Single employee quarters @ 10,000/emp.	850	1,200	640	460	690	490
Cafeteria	<u>350</u>	<u>350</u>	<u>350</u>	<u>350</u>	<u>350</u>	<u>350</u>
	14,880	20,750	11,230	8,170	12,200	8,680
<u>LAND AND STANDARD SERVICES</u>						
Water pump house & storage	200	200	200	200	200	200
Sewage treatment	60	60	60	60	60	60
Land clearing, roads, etc.	2,112	2,940	1,596	1,164	1,734	1,236
<u>AUXILIARY SERVICES</u>						
Recreation centre	<u>1,000</u>	<u>1,000</u>	<u>1,000</u>	<u>1,000</u>	<u>1,000</u>	<u>1,000</u>
TOTAL TOWNSITE COST	<u>18,252</u>	<u>24,950</u>	<u>14,086</u>	<u>10,594</u>	<u>15,194</u>	<u>11,176</u>

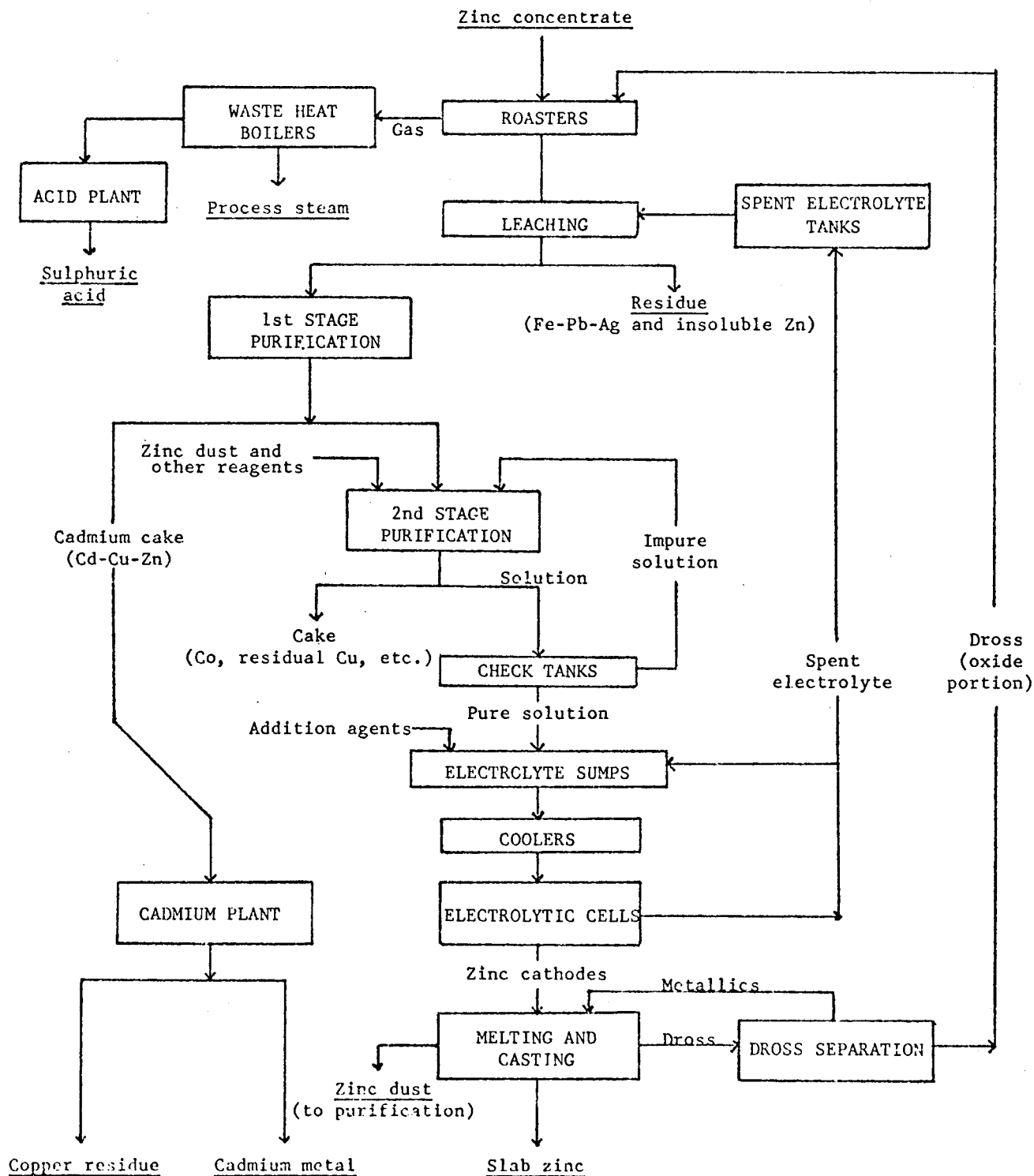
NEW JERSEY ZINC CO. VERTICAL RETORT PROCESS



ST. JOE ELECTROTHERMIC ZINC PROCESS



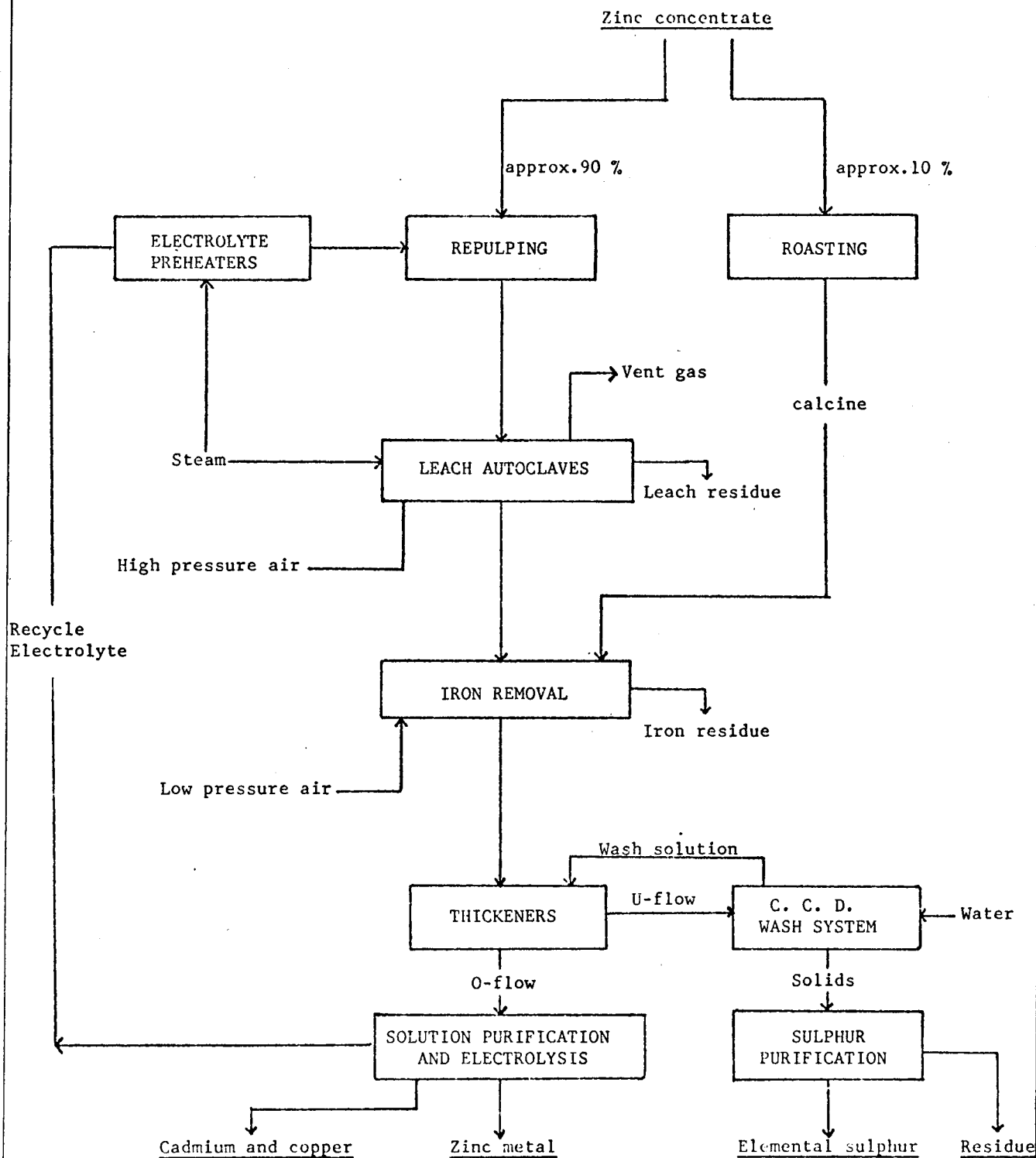
ELECTROLYTIC ZINC PROCESS - CONVENTIONAL
(with byproduct sulphuric acid recovery)



Note: Purification process varies according to impurities present in concentrates.

PRESSURE LEACH - ELECTROLYTIC ZINC PROCESS

(with elemental sulphur recovery)

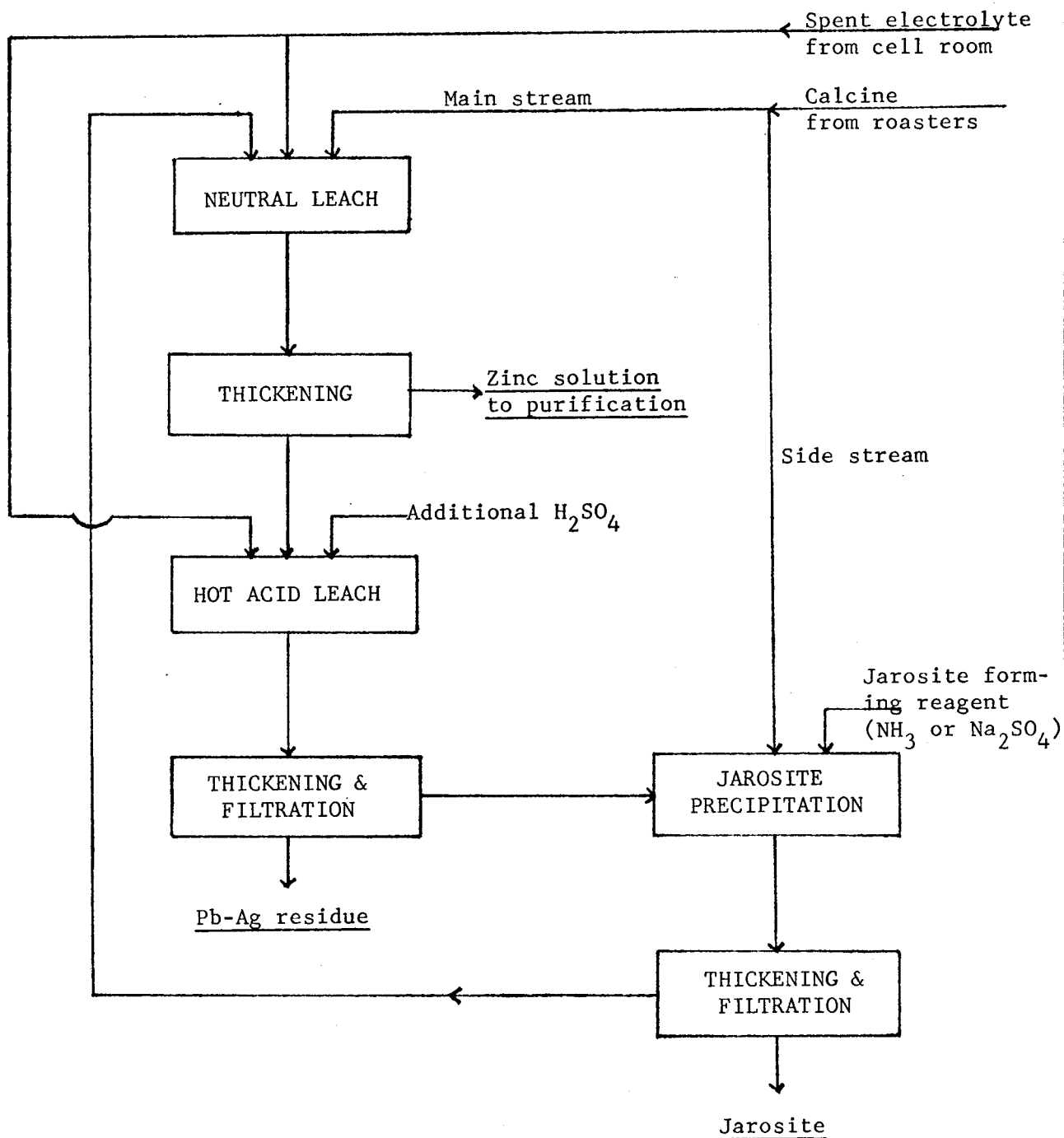


Note: Other versions of this process are possible

ELECTROLYTIC ZINC PROCESS IMPROVEMENTS

JAROSITE PROCESS INTEGRATED WITH TWO-STAGE CALCINE LEACHING

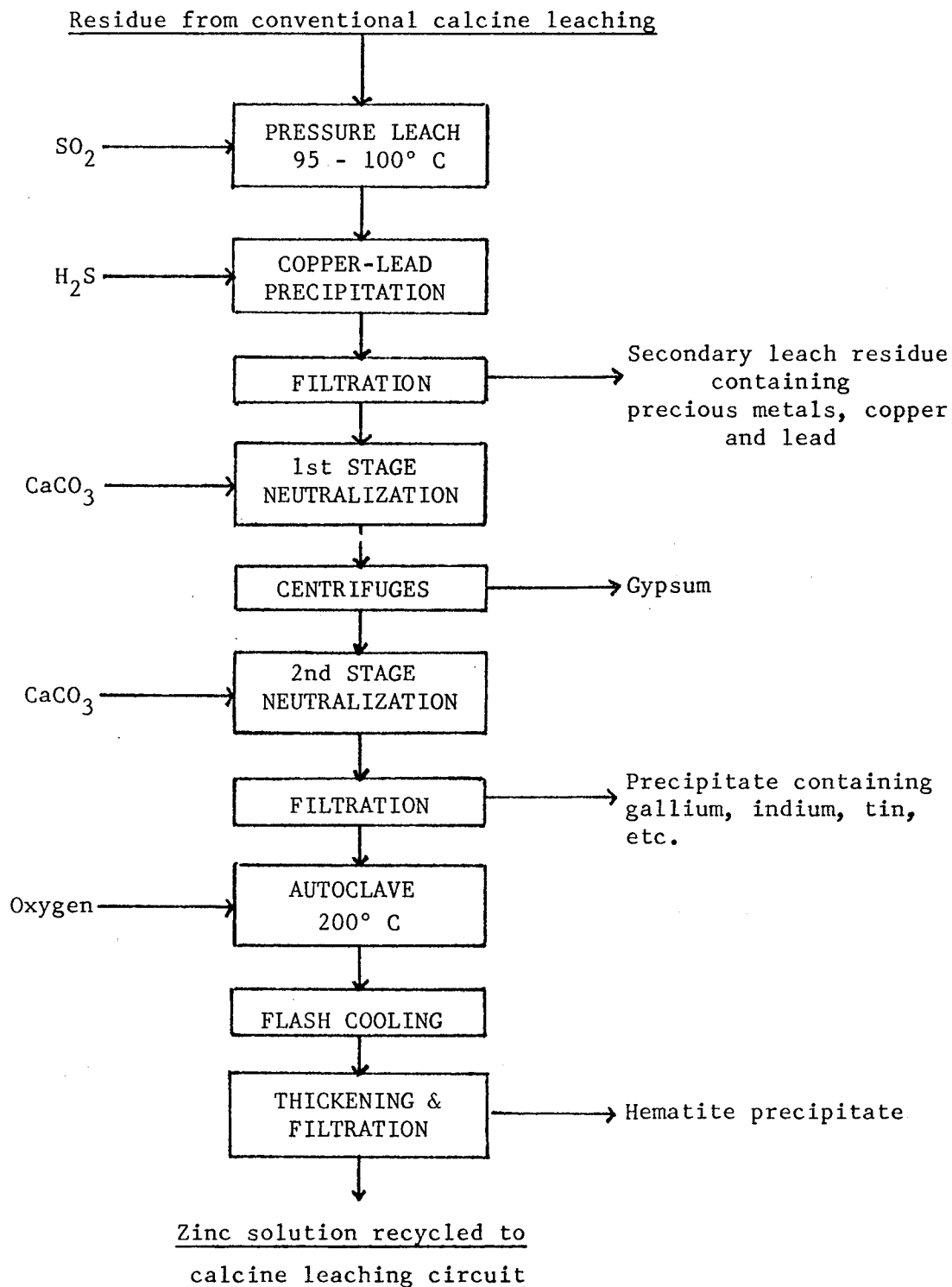
(according to Det Norske Zinkkompani A/S, Odda, Norway)



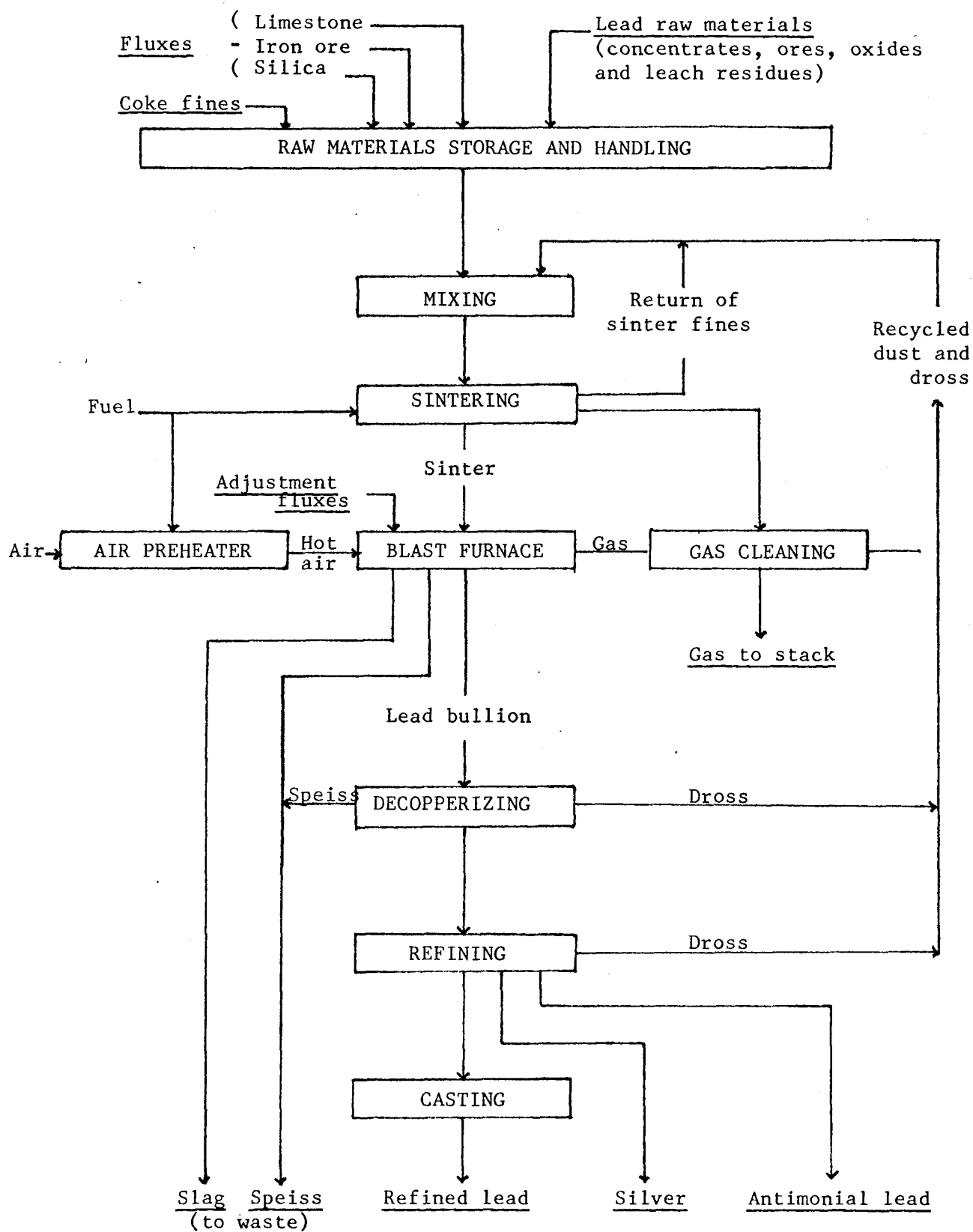
ELECTROLYTIC ZINC PROCESS IMPROVEMENTS

AKITA ZINC CO. - SHERRITT GORDON RESIDUE TREATMENT PROCESS

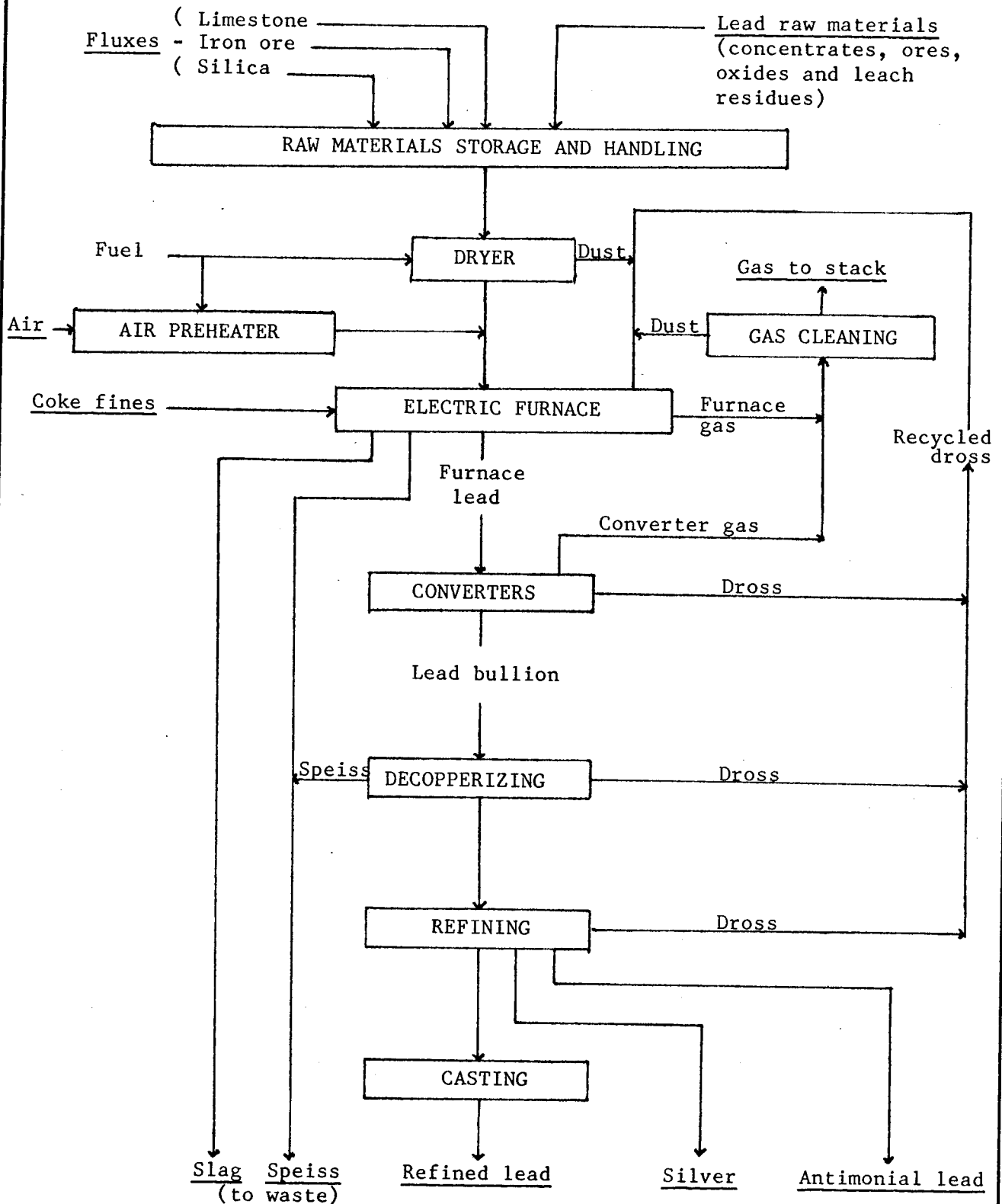
(According to Akita Zinc Co. Ltd., Iijima near Akita City, Japan)



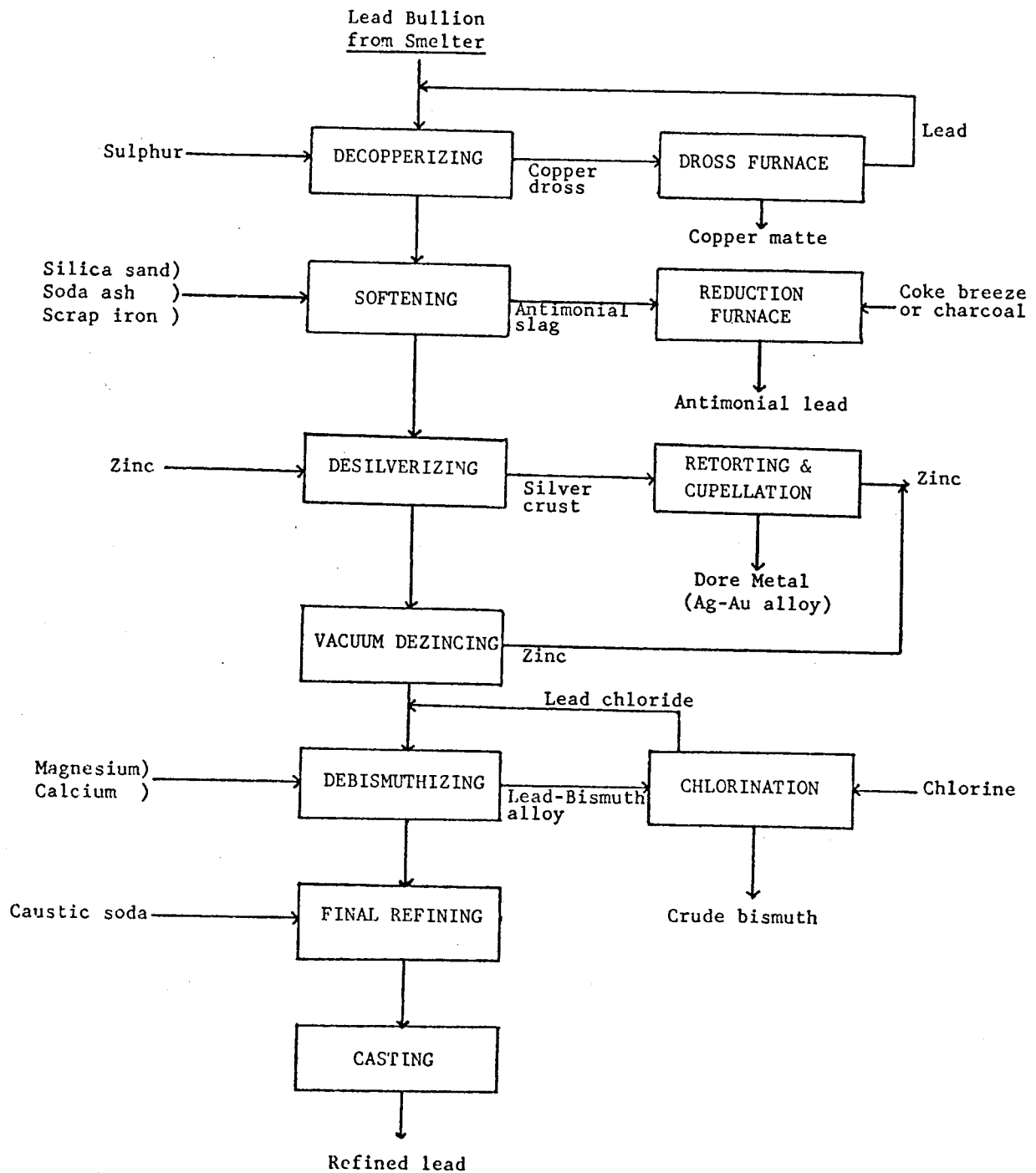
BLAST FURNACE LEAD SMELTING - GENERAL FLOWSHEET



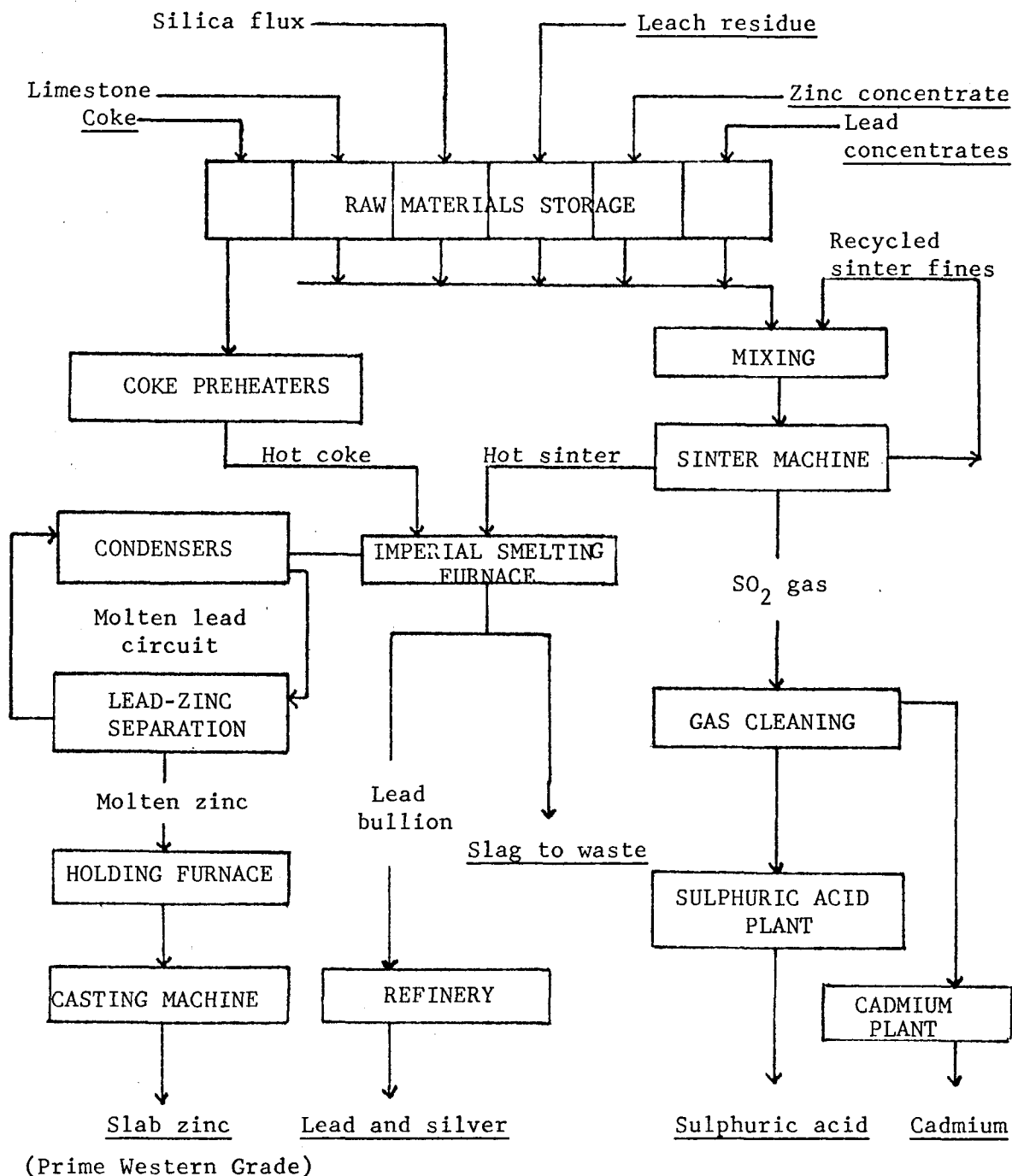
ELECTRIC LEAD SMELTING - GENERAL FLOWSHEET



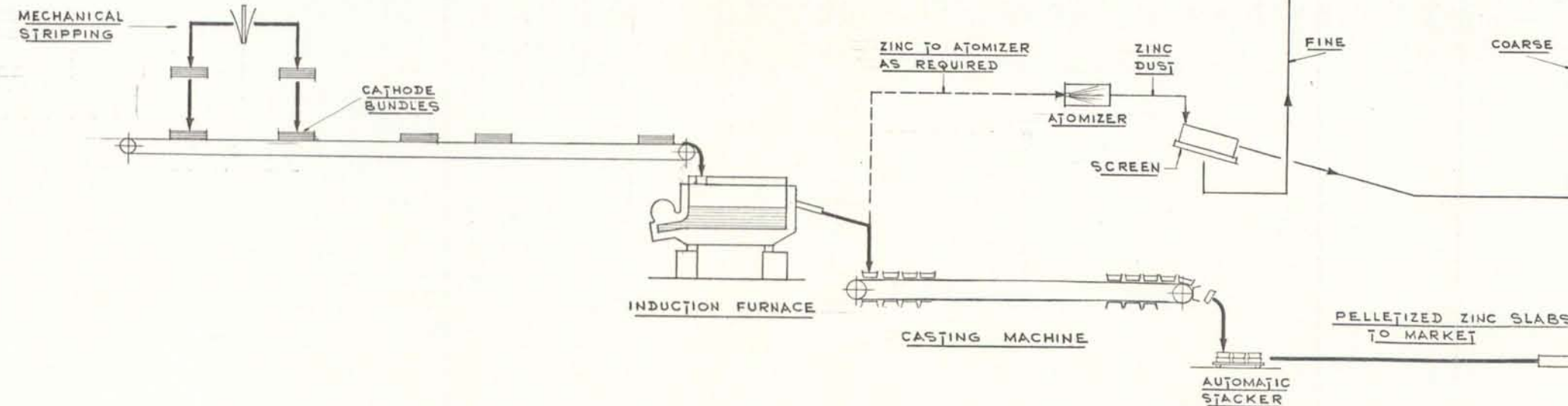
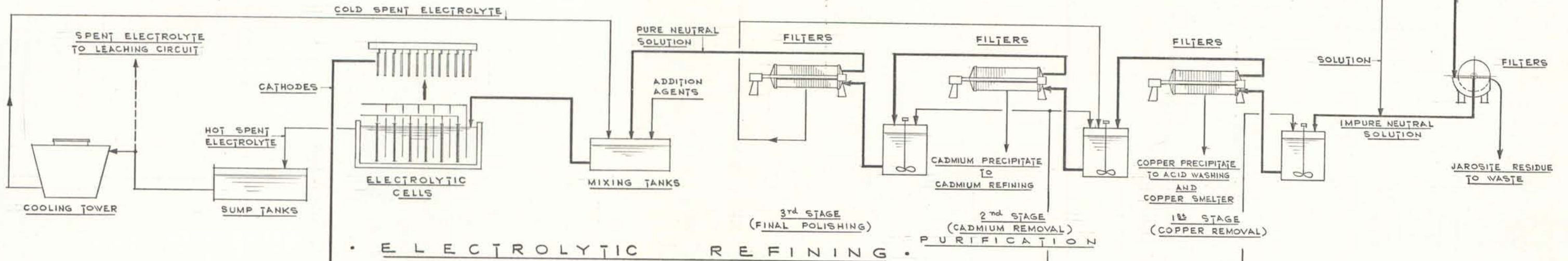
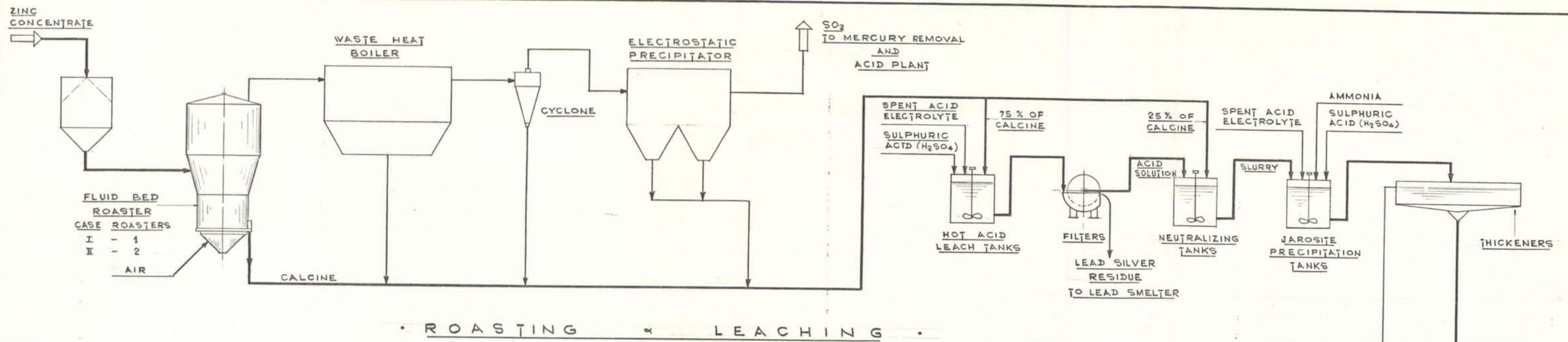
LEAD REFINING (WITH DEBISMUTHIZING) - GENERAL FLOWSHEET



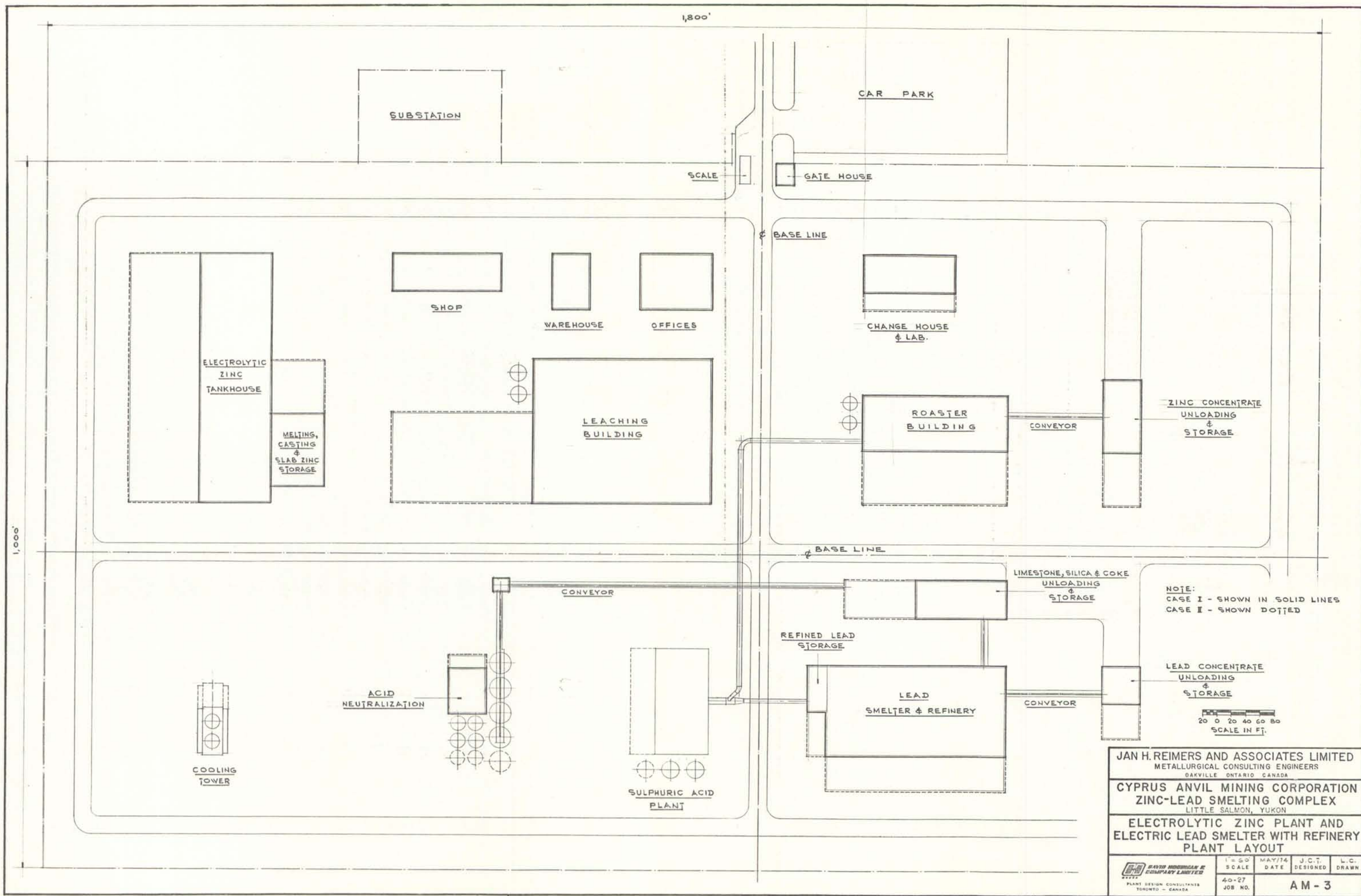
IMPERIAL SMELTING PROCESS



Note: A proportion of the Prime Western zinc from lead-zinc separation can be further processed to Special High Grade zinc in a refluxing plant, or VDZ zinc recovered from the condenser lead circuit in a vacuum dezincing unit.



PLANT OPERATING TIME: 365 DAYS PER YEAR				
PLANT CAPACITY:				
SHORT TONS PER YEAR SLAB ZINC			CASE I	CASE II
			70,000	140,000
JAN H. REIMERS AND ASSOCIATES LIMITED				
METALLURGICAL CONSULTING ENGINEERS				
OAKVILLE, ONTARIO, CANADA				
CYPRUS ANVIL MINING CORPORATION				
ZINC-LEAD SMELTING COMPLEX				
LITTLE SALMON, YUKON				
ELECTROLYTIC ZINC PLANT				
PROCESS FLOWSHEET				
 DAVID NEWMAN & COMPANY LIMITED PLANT DESIGN CONSULTANTS TORONTO - CANADA	NONE	MAY/74	J.C.T.	D.W.
	SCALE	DATE	DESIGNED	DRAWN
40-27				
JOB NO.				
				AM-1



NOTE:
CASE I - SHOWN IN SOLID LINES
CASE II - SHOWN DOTTED

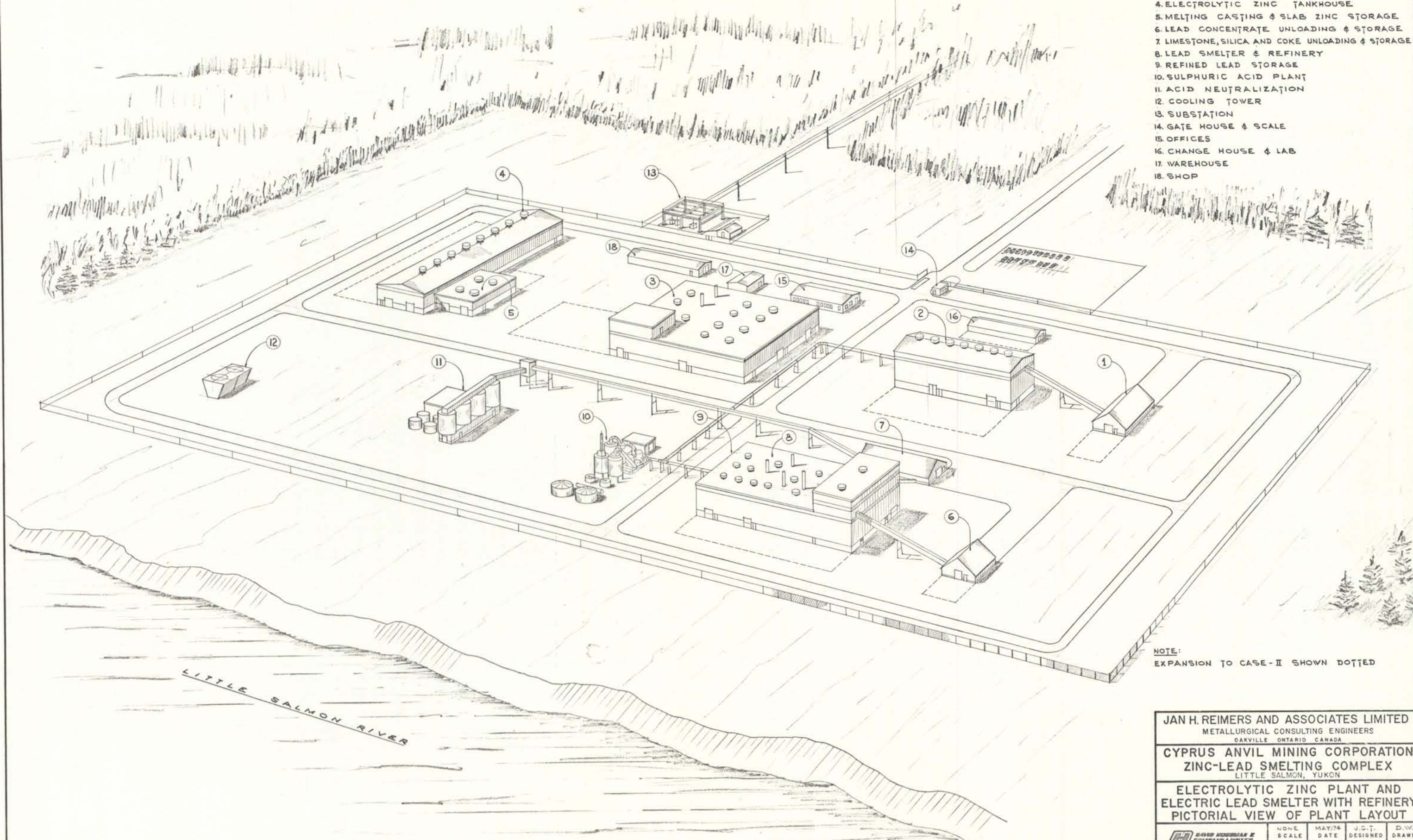
LEAD CONCENTRATE
UNLOADING
&
STORAGE

20 0 20 40 60 80
SCALE IN FT.

JAN H. REIMERS AND ASSOCIATES LIMITED METALLURGICAL CONSULTING ENGINEERS OAKVILLE, ONTARIO, CANADA			
CYPRUS ANVIL MINING CORPORATION ZINC-LEAD SMELTING COMPLEX LITTLE SALMON, YUKON			
ELECTROLYTIC ZINC PLANT AND ELECTRIC LEAD SMELTER WITH REFINERY PLANT LAYOUT			
 PLANT DESIGN CONSULTANTS TORONTO - CANADA	1" = 50' SCALE	MAY/74 DATE	J.C.T. DESIGNED
	40-27 JOB NO.	L.C. DRAWN	
AM - 3			

LEGEND

1. ZINC CONCENTRATE UNLOADING & STORAGE
2. ROASTER BLDG.
3. LEACHING BLDG.
4. ELECTROLYTIC ZINC TANKHOUSE
5. MELTING CASTING & SLAB ZINC STORAGE
6. LEAD CONCENTRATE UNLOADING & STORAGE
7. LIMESTONE, SILICA AND COKE UNLOADING & STORAGE
8. LEAD SMELTER & REFINERY
9. REFINED LEAD STORAGE
10. SULPHURIC ACID PLANT
11. ACID NEUTRALIZATION
12. COOLING TOWER
13. SUBSTATION
14. GATE HOUSE & SCALE
15. OFFICES
16. CHANGE HOUSE & LAB
17. WAREHOUSE
18. SHOP



NOTE:
EXPANSION TO CASE-II SHOWN DOTTED

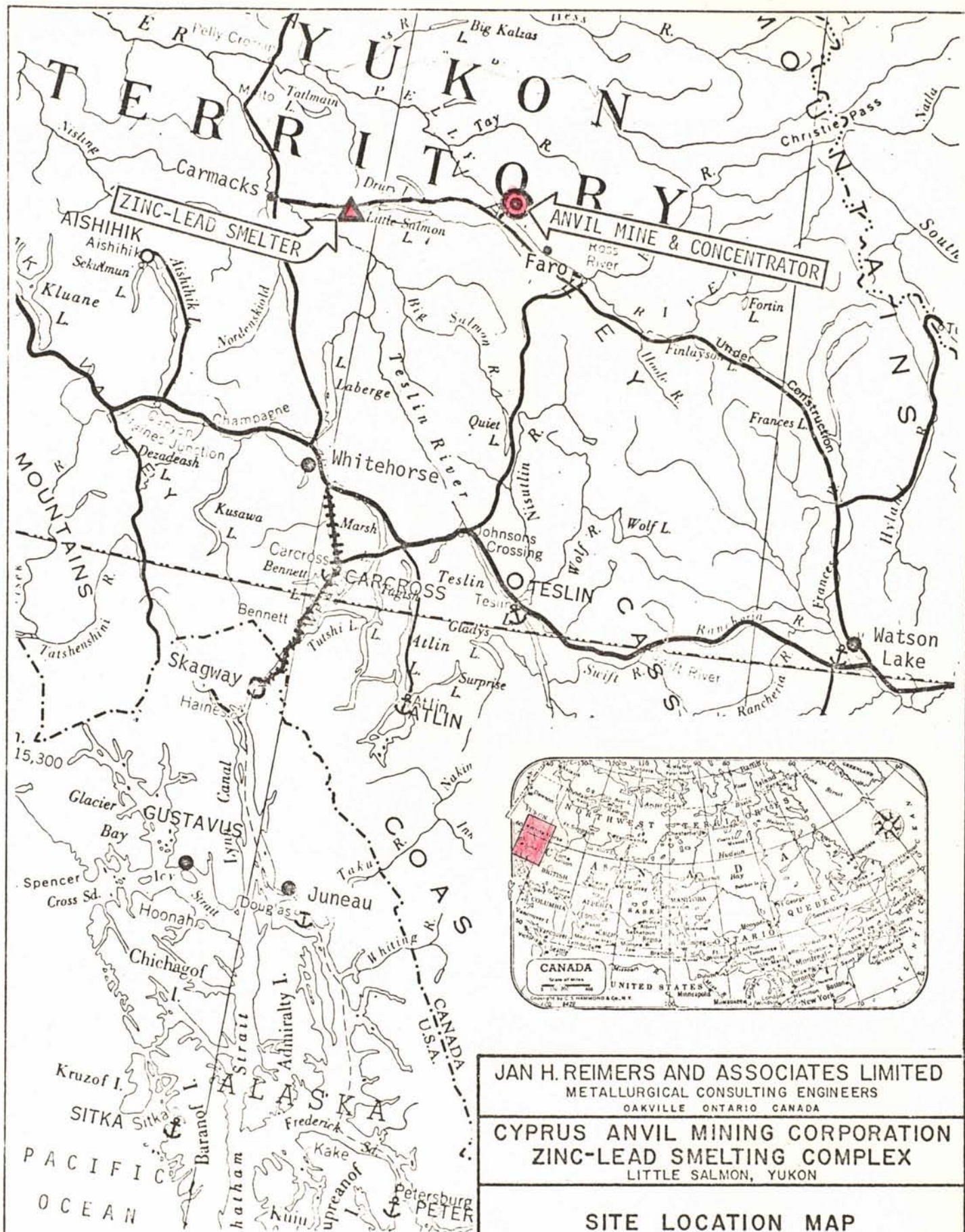
JAN H. REIMERS AND ASSOCIATES LIMITED
METALLURGICAL CONSULTING ENGINEERS
OAKVILLE, ONTARIO, CANADA

CYPRUS ANVIL MINING CORPORATION
ZINC-LEAD SMELTING COMPLEX
LITTLE SALMON, YUKON

ELECTROLYTIC ZINC PLANT AND
ELECTRIC LEAD SMELTER WITH REFINERY
PICTORIAL VIEW OF PLANT LAYOUT

DAVID HODGKIN & COMPANY LIMITED
PLANT DESIGN CONSULTANTS
TORONTO - CANADA

SCALE	DATE	DESIGNED	D.V.
NONE <td>MAY/74 <td>J.C.T. <td>D.V. </td></td></td>	MAY/74 <td>J.C.T. <td>D.V. </td></td>	J.C.T. <td>D.V. </td>	D.V.
40-27 <td>JOB NO. <td colspan="2">AM - 4</td> </td>	JOB NO. <td colspan="2">AM - 4</td>	AM - 4	



JAN H. REIMERS AND ASSOCIATES LIMITED
 METALLURGICAL CONSULTING ENGINEERS
 OAKVILLE ONTARIO CANADA

CYPRUS ANVIL MINING CORPORATION
ZINC-LEAD SMELTING COMPLEX
 LITTLE SALMON, YUKON

SITE LOCATION MAP



DAVID HUSSMAN & COMPANY LIMITED

PLANT DESIGN CONSULTANTS
 TORONTO - CANADA

NONE SCALE	MAY/74 DATE	— DESIGNED	L.C. DRAWN
40-27 JOB NO.	AM-5		