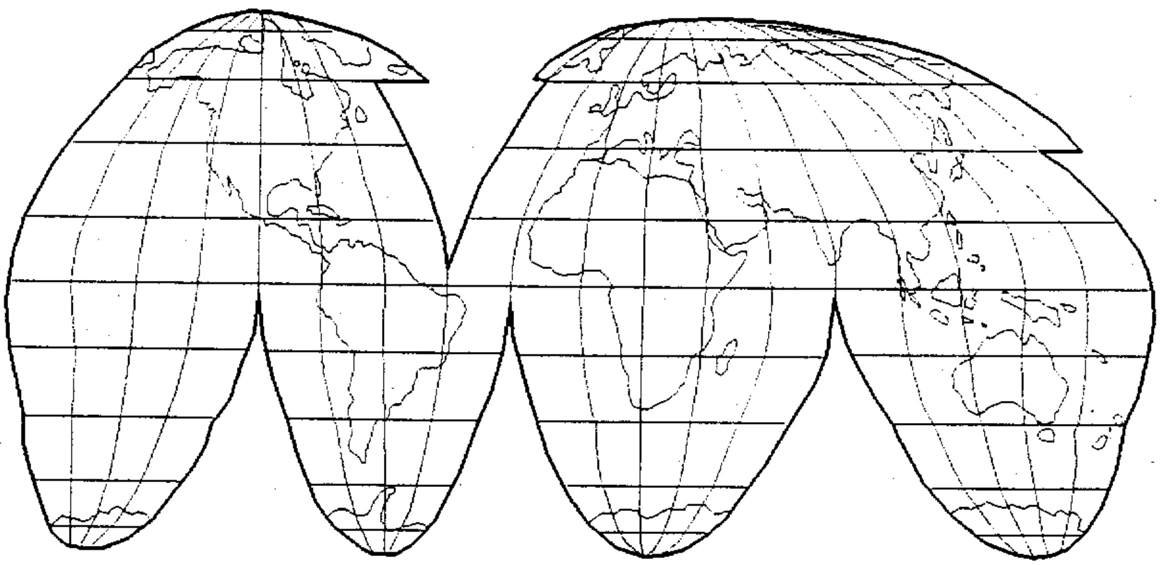
# A Study into the Feasibility

# *of*

# *Small Scale Custom/*

# *Portable Milling in Yukon*



April, 1987

# A STUDY INTO THE FEASIBILITY
# of
# SMALL SCALE CUSTOM/PORTABLE MILLING
# in
# YUKON

## EXECUTIVE SUMMARY

### 1. Project Description

This Project is presented in response to a request by Economic Development: Mines and Small Business, Energy and Mines Branch, Government of Yukon. Funding for this project has come from the Canada-Yukon Economic Development Agreement, Economic Development and Planning Sub-Agreement.

Governments of Canada and Yukon wish to assist in the expansion and diversification of the mining industry. This study has been commissioned as a contribution toward this goal. The study concerns itself with the viability of a custom ore treatment plant as an aid to the small scale operator, owners of smaller vein deposits and/or those who require a less capital intensive vehicle for immediate cash flow from which to finance enhanced exploration and property development.

The plant studied encompasses the treatment of most lode ore types occuring in the Yukon and addresses its most suitable and economic construction/location, ranging from permanent siting to a fully mobile unit capable of siting at individual ore reserve sources.

Such a plant, or range of plants, is conceptually designed and the capital and operating costs are combined with other requirements normal for a total mine ore treatment complex in order to arrive at the commercial viability and expected rate of return on investment for such a venture.

### 2. Yukon Background

There are some 26,200 people distributed throughout the Yukon's 482,515 square kilometres, some 70 percent residing in the capital city of Whitehorse. The territory is serviced by 4688 kilometres of highway, of which one-third is paved or has a thin asphalt surface. Of these highways, two connect to the main Canadian highway system and two to the Alaska road and port systems.

The Yukon has typical sub-arctic weather conditions with the five summer months averaging 12°C temperatures and thus permitting five to six months per year of milling operation requiring minimal cladding and insulation.

There are 844 kilometres of hydro power grid in the Yukon, 499 kilometres transmitted on 140 kV lines and 345 kilometres on 34.5 kV lines. Most physical plant assets are owned by The Yukon Development Corporation with distribution services through Yukon Electric Company Limited.

3. Regional Ore Occurrences

This study covers the lode deposits of gold, silver, lead, zinc and tungsten, and their occurrence and treatment. The types of process flow sheets presented relate to the following ores.

| | |
|---|---|
| Gold | a) in sulphide free (or very low sulphide) ore<br>b) with limited silver and some of galena, sphalerite, chalcopyrite, and pyrite or pyrrhotite<br>c) in complex high sulphide ores with some or all of silver, galena, sphalerite, chalcopyrite, pyrite, pyrrhotite, arsenopyrite and other contaminants (e.g. antimony) |
| Silver | principally lead (galena) and silver in veins, often massive galena |
| Lead-Zinc | high grade sulphide ore but low in other sulphides |
| Tungsten | scheelite or other heavy mineral ore such as cassiterite |

4. Project Components

Prior to discussing details of custom milling, order-of-magnitude values have been given for a typical 125 TPD mining project, thus emphasizing the capital and operating cost influence of custom milling within the project structure.

| Activity | Capital Cost % | Operating Cost % |
|---|---|---|
| Mining | 32 | 36 |
| Milling & Tailings | 45 | 24 |
| Infrastructure | 23 | 40 |
| TOTAL | 100 | 100 |

The major cost differences between custom and owner operated milling operations revolve around these items:

- Environmental Controls
- Tailings Disposal
- Crude Ore Haulage
- Personnel Accommodations
- Plant Depreciation

5. Processing Plant Components

All components relating to a process plant are discussed individually, with comments on applicability of equipment types together with the magnitude of site services required. A summary of such factors include the following:

- Crushing
- Grinding
- Gravity
- Flotation
- Cyanidation
- Stockpiling
- Assaying
- Electrical
- Power
- Water
- Tailings
- Manpower
- Accommodations
- Environment

Diagrams are presented to illustrate typical applications of the various equipment components.

6. Process Metallurgy and Plant Design

The study attempts to emphasize the complexities of regional mineralogy and metallurgy and the need for extensive testing prior to commitment to a plant system. The metallurgical testing procedures and process options for typical Yukon ores are therefore detailed.

Detailed plant design criteria are discussed for each segment of flowsheet options with diagrams being presented to illustrate equipment configurations for typical mobile modules, together with a discussion of applicable environmental control features.

7. Marketing

The study discusses options for marketing of products, presents typical smelter contract details and illustrates the typical Net Smelter Return to be expected with example calculations. These calculations emphasize the impact of freight, penalties and various deductions normal to such contracts and the necessity for complete understanding of the scope of final payment prior to embarking on a mining venture.

8. Capital and Operating Costs

Equipment capital costs, weights and horsepower requirements are detailed for various size ranges of milling plants. These items are subdivided into crushing, grinding and various process-type components. Examples of a variety of plant sizes and processes are presented for both mobile and permanent type typical milling plants. Operating costs are shown for such plants.

9. Financial Analysis

A financial analysis of estimated toll charges is summarized for various types of plant installations utilizing information derived in previous sections of the report. The analysis applies to a range of Returns on Investment from 15% to 30%. An abbreviated example follows for a 25% R.O.I.

TOLL CHARGE ESTIMATE ($ Per Short Ton Dry)

| | TYPE | | | |
|---|---|---|---|---|
| | Portable | Permanent | Permanent | Permanent |
| Capacity (TPD) | 100 | 100 | 300 | 300 |
| Flow Sheet | Single Flot.Conc. | Single Flot.Conc. | Single Flot.Conc. | Cyanidation |
| Capital ($x10$^6$) | 0.59 | 1.54 | 2.12 | 3.22 |
| Annual Tons | 15,000 | 36,500 | 109,500 | 109,500 |
| Capital Cost ($/T) | 14.50 | 15.73 | 7.21 | 10.93 |
| Operating Cost ($/T) | 23.77 | 23.71 | 18.62 | 24.51 |
| Working Cap. ($/T) | 0.95 | 0.97 | 0.60 | 0.41 |
| Cost Per Ton ($) | 39.22 | 40.47 | 26.43 | 35.85 |

# A STUDY INTO THE FEASIBILITY of SMALL SCALE CUSTOM/PORTABLE MILLING in YUKON


EXECUTIVE SUMMARY

LIST OF FIGURES

SECTION I INTRODUCTION

1.1 Project Description 1-1
1.2 Yukon Mining Background 1-2
1.2.1 Population Centres 1-2
1.2.2 Climate 1-2
1.2.3 Highway Networks 1-3
1.2.4 Power 1-4
1.2.5 Regional Ore Occurrences and Types 1-5
1.2.6 Acts, Regulations and Processes 1-6

SECTION II PROJECT COMPONENTS

2.1 Relative Costs 2-1
2.2 Capital Costs 2-1
2.3 Operating Costs 2-2
2.4 Process Plant Location 2-3
2.4.1 General 2-3
2.4.2 Mine Owner's Perspective 2-3
2.4.3 Process Owner's Perspective 2-4
2.4.4 Conclusions 2-6

SECTION III PROCESS PLANT COMPONENTS

3.1 Plant Location 3-1
3.1.1 Regional Plant 3-1
3.1.2 Mobile Plant 3-1
3.2 Processing Equipment 3-1
3.2.1 General 3-1
3.2.2 Crushing 3-2
3.2.3 Grinding 3-3
3.2.4 Gravity Equipment 3-4
3.2.5 Flotation 3-4
3.2.6 Cyanidation 3-4
3.2.7 Electrical 3-5
3.2.8 New vs Reconditioned 3-6
3.3 Site Services 3-6
3.3.1 Power 3-6
3.3.2 Water 3-7
3.3.3 Tailings Disposal 3-7
3.3.4 Assaying 3-7
3.3.5 Manpower 3-8
3.3.6 Housing and Transport 3-9
3.3.7 Stockpiling 3-9

SECTION IV PROCESS METALLURGY

4.1 Metallurgical Evaluation 4-1
4.2 Gold/Silver Deposits 4-2
4.3 Lead/Zinc/Copper Deposits 4-4
4.4 Tungsten Ores 4-5
4.5 Regional Mineralogy/Metallurgy 4-5

SECTION V PLANT DESIGN DETAILS

5.1 Stationary Plants 5-1
5.2 Mobile Plants and Modules 5-1
5.2.1 Design Criteria 5-1
5.2.2 Crushing 5-2
5.2.3 Grinding 5-2
5.2.4 Recovery Circuits 5-3
- Gravity
- Flotation
- Cyanidation
5.2.5 Dewatering 5-4
5.2.6 Power 5-4
5.2.7 Assaying 5-5
5.2.8 Personnel Housing 5-5
5.3 Environmental 5-5
5.3.1 Acid Generation Potential 5-5
5.3.2 Dissolved Metals 5-6
5.3.3 Cyanide 5-6
5.3.3 Air Emission 5-7

SECTION VI MARKETING

6.1 General 6-1
6.2 Sale of Ores 6-1
6.3 Purchase of Ores 6-2
6.4 Sale of Concentrates and Bullion 6-3
6.5 Smelter Locations 6-3
6.6 Toll Leaching of Flotation Concentrates 6-3
6.7 Transportation 6-4

SECTION VII CASE STUDIES

7.1 Gold Ore 7-1
7.2 Silver Ore 7-3

SECTION VIII CAPITAL AND OPERATING COSTS

8.1 Capital Costs 8-2
8.1.1 Equipment Cost Details 8-2
8.1.2 Module Costs 8-5
8.1.3 Typical Modular Plant 8-6
8.1.4 All Weather Considerations 8-7
8.1.5 Typical All-Weather Plants 8-8
8.1.6 Comparison Summary 8-11
8.2 Operating Costs 8-12

SECTION IX FINANCIAL ANALYSIS

SECTION X SUMMARY


| | | |
|---|---|---|
| 10.1 | Summary | 10-1 |
| 10.2 | Ore Types | 10-1 |
| 10.3 | Custom Mill Size | 10-1 |
| 10.4 | Trends in Gold | 10-2 |
| 10.5 | Trends in Silver | 10-2 |
| 10.6 | Incentives | 10-2 |

ACKNOWLEDGEMENTS

REFERENCES

## LIST OF FIGURES


1.1 Yukon Highway Network & Population Centres
1.2 Yukon Electric Power Facilities
1.3 Yukon Mineral Occurrence
3.1 Crushing Plan Flowsheet Options
3.2 Single Stage Ball Mill Grinding Circuit
3.3 Spiral Concentrator
3.4 Mineral Jig
3.5 Denver Flotation Mechanism
3.6 Flotation Flowsheet, Concentrate Dewatering
3.7 Merrill Crowe Cyanidation
3.8 Carbon-In-Pulp Cyanidation
3.9 Assay Laboratory
4.1 Lab Testing - Gold/Silver
4.2 Lab Testing - Gold/Silver/Base Metal
4.3 Lab Testing - Tungsten
5.1 Crushing Plant - Plan View
5.2 Crushing Plant - Elevation View
5.3 Grinding Module
5.4 Flotation / Dewatering
5.5 Cyanidation - Leaching
5.6 Cyanidation - Precipitation

# A STUDY INTO THE FEASIBILITY
# of
# SMALL SCALE CUSTOM/PORTABLE MILLING
# in
# YUKON

## SECTION I

## INTRODUCTION

### 1.1 Project Description

This Project is presented in response to a request by Economic Development: Mines and Small Business, Energy and Mines Branch, Government of Yukon. Funding for this project has come from the Canada-Yukon Economic Development Agreement, Economic Development and Planning Sub-Agreement.

Governments of Canada and Yukon wish to assist in the expansion and diversification of the mining industry. This study has been commissioned as a contribution toward this goal. The study concerns itself with the viability of a custom ore treatment plant as an aid to the small scale operator, owners of smaller vein deposits and/or those who require a less capital intensive vehicle for immediate cash flow from which to finance enhanced exploration and property development.

The plant studied encompasses the treatment of most lode ore types occuring in the Yukon and addresses its most suitable and economic construction/location, ranging from permanent siting to a fully mobile unit capable of siting at individual ore reserve sources.

Such a plant, or range of plants, is conceptually designed and the capital costs, operating costs, inventory levels, replacement parts, operating schedules, manpower requirements and other pertinent economic factors are combined with other requirements normal for a total mine ore treatment complex in order to arrive at the commercial viability and expected rate of return on investment for such a venture.

The study is organized and presented so as to be a clear and concise reference to that portion of a total mining ore treatment complex to be served by such a plant, and therefore the overall benefits to be derived from its use, as well as a reference as to the economics of the venture itself.

The study includes applicable references to those geological regions exhibiting traditionally high frequencies of mineralization related to the scope of the study, but is not specific to individual mining properties.

The method of organizing the work is to describe the total capital and operating effort required, within a Yukon context, to establish and operate an ore concentrator complex and that portion of effort which can be supplied by a custom plant.

Such an analysis, when combined with specific ore treatment options, enables conclusions as to economic size and siting/mobility of a custom milling facility.

All aspects of the recommended plant(s) are defined in specific cost, labour, environmental and regulatory terms and a financial analysis is presented to describe the economic viability of such a project.

## 1.2 Yukon Mining Background

### 1.2.1 Population Centres

The Yukon Territory has experienced a fluctuating pattern of growth rate throughout the century. While natural increase, military presence and tourism have been and remain important factors, the mining industry constitutes a continuing and major factor in migration trends.

The listing of communities below serves as an example of the population centres in Yukon's 482,515 square kilometres. The figures are taken from September, 1986 Yukon Health Care estimates.

| Centre | Population |
|---|---|
| Old Crow | 267 |
| Dawson | 1,553 |
| Mayo-Elsa-Keno | 957 |
| Carmacks | 408 |
| Ross River | 393 |
| Haines Junction | 531 |
| Whitehorse | 18,385 |
| Watson Lake | 1,595 |
| Carcross-Tagish | 433 |
| Faro | 966 |
| Teslin | 411 |
| Other | 267 |
| Total Yukon | 26,166 |

### 1.2.2 Climate

The mineralized areas of Yukon are generally in the sub-arctic, hence temperatures and precipitation have a wide summer-winter variation punctuated by the freeze-up and break-up periods. While perhaps a gross simplification, a general summary is illustrated below. More area specific examples may be seen in Table 1.2.

WINTER - NOVEMBER TO MARCH (5 months)

| | |
|---|---|
| Typical Temperature | -19°C |
| Typical Snowfall | 22 cm/month (as water equivalent) |

SUMMER - MAY TO SEPETEMBER (5 months)

| | |
|---|---|
| Typical Temperature | +12°C |
| Typical Rainfall | 36 mm/month |

TRANSITION - APRIL AND OCTOBER (2 months)

| | |
|---|---|
| Typical Temperature | - 3°C |
| Typical Rainfall | 12 mm/month |
| Typical Snowfall | 12 cm/month |

One may conclude from the foregoing that a reasonable expectation for moderately comfortable milling operations involving only moderate winterization is confined to a six (6) month period each year.

### 1.2.3 Highway Networks

There are eleven highways in the Yukon, varying in length from 35 to 615 kilometres and totaling 4,688 kilometres in length. This road network effectively grids the southern and mineral-intense portion of the territory. The road network is shown on FIG. 1.1 and road surface designations are illustrated in Table No. 1.

Main access routes connecting the Yukon to other continental or overseas transportation arteries are:

No. 1 - Alaska Highway

- North to Fairbanks and the Alaska road network
- South to Fort St. John-Dawson Creek and the Canada road network

No. 2 - Klondike Highway

- South through Carcross to the port of Skagway, Alaska

No. 3 - Haines Highway

- South from Haines Junction to the port of Haines, Alaska

No. 4 - Robert Campbell Highway

- South from Watson Lake, through British Columbia to port of Stewart, B.C.

There are no restrictions on Yukon roads during the freeze-up period. During break-up, which normally lasts about six weeks, the general rule is to haul only legal axle loads, with the Yukon government using a testing truck to monitor its highways. Other than during break-up, it is normally possible to obtain overweight permits for specific applications.

1.2.4 Power

The Yukon Development Corporation, a territorial crown corporation, has recently acquired from Northern Canada Power Commission all of its power producing assets in the Yukon. Power is distributed by the Yukon Electric Company Limited. Sites for power generation and distribution are shown on FIG. 1.2.

As can be seen, the principal generating stations are the hydro plants at Whitehorse and Aishihik, which also have a diesel generating plant for peaking and emergency backup. A power grid from this station extends through 140 KV lines north and east to Faro and Ross River, and west to Haines Junction. Step-down transformers off this grid would cost approximately $85,000.

Power Supply and Costs

Although this subject is dealt with in specific terms in the main body of the study, it is felt that some expression of general analysis is suitable at this point.

Micro-Hydro Sites - While these are necessarily site specific, it can be fairly stated that development of small hydro sites, even for flow water conditions in summer months, are capital intensive and require extensive longevity to be economic. A figure of $3,500/kW is felt to be an appropriate capital cost for such a system.

Diesel-Electric Plants - Such plants are moderate in capital cost, are quite mobile and have the advantage of attractive salvage value. Their disadvantage lies in the high operating cost, mostly diesel fuel.

Yukon Power Grids - The main 140 KV transmission grid offers moderately priced power throughout its route, with line loss increasing the unit price incrementally with distance from source. On a semi-permanent or temporary basis, an industrial user would expect to contribute to a $50,000 transformer charge plus transmission costs of $30,000 per kilometre to the plant site. While Yukon Electrical offers power in other parts of the territory, this power is mostly diesel generated and may not be suitable for large additional demands except on a long term contract basis.

Power Cost

A broad analysis of the scope of power costs for plants considered in this study are:

Capital Cost

| | Micro-Hydro | Diesel-Electric | Substation |
|---|---|---|---|
| 100 kW | $ 350,000 | $ 80,000 | $30,000 |
| 200 kW | 700,000 | 100,000 | 30,000 |
| 400 kW | 1,400,000 | 120,000 | 30,000 |

Operating Cost per kWhr

| | Micro-Hydro | Diesel-Electric | Power Grid |
|---|---|---|---|
| $ per kWhr | 0.01 - 0.03 | 0.20 - 0.25 | 0.10 - 0.20 |

The foregoing serves to illustrate the need for careful consideration of all available alternatives for powering custom/ mobile plants..

### 1.2.5 Regional Ore Occurrences and Types

This study covers the lode deposits of gold, silver, lead, zinc and tungsten and their occurrence and treatment. Occurrences of these minerals have been plotted in FIG. 1.3 and can be seen to lie primarily between the southern limit of the Whitehorse Trough and the northern boundary of the Selwyn Basin extending to the border of the Northwest Territories.

North of the Tintina Fault lead-zinc ores predominate, associated to some degree with silver. Gold ores are sporadic, occuring both in association with the Whitehorse Trough and sporadically throughout the Selwyn Basin. Tungsten occurs sporadically throughout the mineralized zone.

The Yukon is divided into four Mining Districts. A sampling of Quartz Claims staked in each district is tabulated below, each full claim being 1500 ft. x 1500 ft.

| | 1986 | 1984 | 1982 | 1980 |
|---|---|---|---|---|
| Whitehorse | 2,494 | 3,056 | 981 | 3,290 |
| Dawson | 559 | 2,834 | 538 | 2,081 |
| Mayo | 310 | 298 | 408 | 1,956 |
| Watson | 2,644 | 1,977 | 1,852 | 3,555 |
| Total | 6,007 | 8,165 | 3,779 | 10,882 |

The types of process flow sheets presented relate to the following ores.

Gold
- a) in sulphide free (or very low sulphide) ore
- b) with limited silver and some of galena, sphalerite, chalcopyrite, and pyrite or pyrrhotite
- c) in complex high sulphide ores with some or all of silver, galena, sphalerite, chalcopyrite, pyrite, pyrrhotite, arsenopyrite and other contaminants (e.g. antimony)

Silver — principally lead (galena) and silver in veins, often massive galena

Lead-Zinc — high grade sulphide ore but low in other sulphides

| | |
|---|---|
| Tungsten | scheelite or other heavy mineral ore such as cassiterite |

Parameters used in developing typical flow sheets have been derived from discussions with representatives of the following mines and properties.

| | | |
|---|---|---|
| Gold Ores | - | Mount Skukum Mine<br>Skukum Creek<br>Venus<br>Tinta Hill |
| Silver Ores | - | Keno Area Deposits<br>Springmount<br>Plata-Inca<br>CMC/Midnight<br>Swift River/Rancheria area |
| Lead-Zinc-Silver Ores | - | Mount Hundre<br>Eagle |
| Tungsten Ores | - | Dublin Gulch<br>Cab (Risby) |

### 1.2.6 Acts, Regulations and Processes

The following is a short list, there being other Acts, Regulations and Guidelines to be considered.

A. Acts, Regulations and Guidelines

1. Yukon Quartz Mining Act - governs mining rights, royalties, work performance and licence requirements for bedrock minerals

2. Territorial Lands Act and Regulations - deals with surface leases and land use permits

3. Northern Inland Waters Act and Regulations - concerns water and licences, terms and conditions

4. Fisheries Act - deals with water use impact on aquatic habitat

5. Territorial Quarrying Regulations - regulation by permit for quarrying of sand, gravel, stone, topsoil

6. Metal Mining Liquid Effluent Regulations - relate to Fisheries Act and to conditions of water use

B. Procedures

All necessary licences and permits must be in place prior to commencement of operations. Tenure for a 21 year lease of a mineral claim may be obtained on application to the District Mining Recorder.

Related Procedures

Environmental Assessment Review Procedure (DIAND)
Land Use Permit - for operations of land (DIAND)
Water Licences - for use of water (YTWB)
Timber Permits - for cutting and removal of trees (DIAND)
Quarrying Permits - for removal of granular materials (DIAND)

Committees

Federal Territorial Land Use Advisory Committee (DIAND)
Territorial Water Boards
Regional Environmental Review Committee (DIAND)

Related Committees

Yukon Benefits Committee (DIAND)

Guidelines

Land Use Guidelines, Mineral Exploration (DIAND)
Land Use Guidelines, Access Roads and Trails (DIAND)
Environmental Guidelines for Pits and Quarries (DIAND)

Related Guidelines

Environmental Screening Guidelines (DIAND)
Guidelines for Preparing Initial Environmental Evaluations (DIAND)
Guidelines for Preparation of an Environmental Impact Statement (DIAND)
Development Assessment Guidelines (YTG)
Socio-Cultural Assessment Guidelines (YTG)

FIG. 1.1

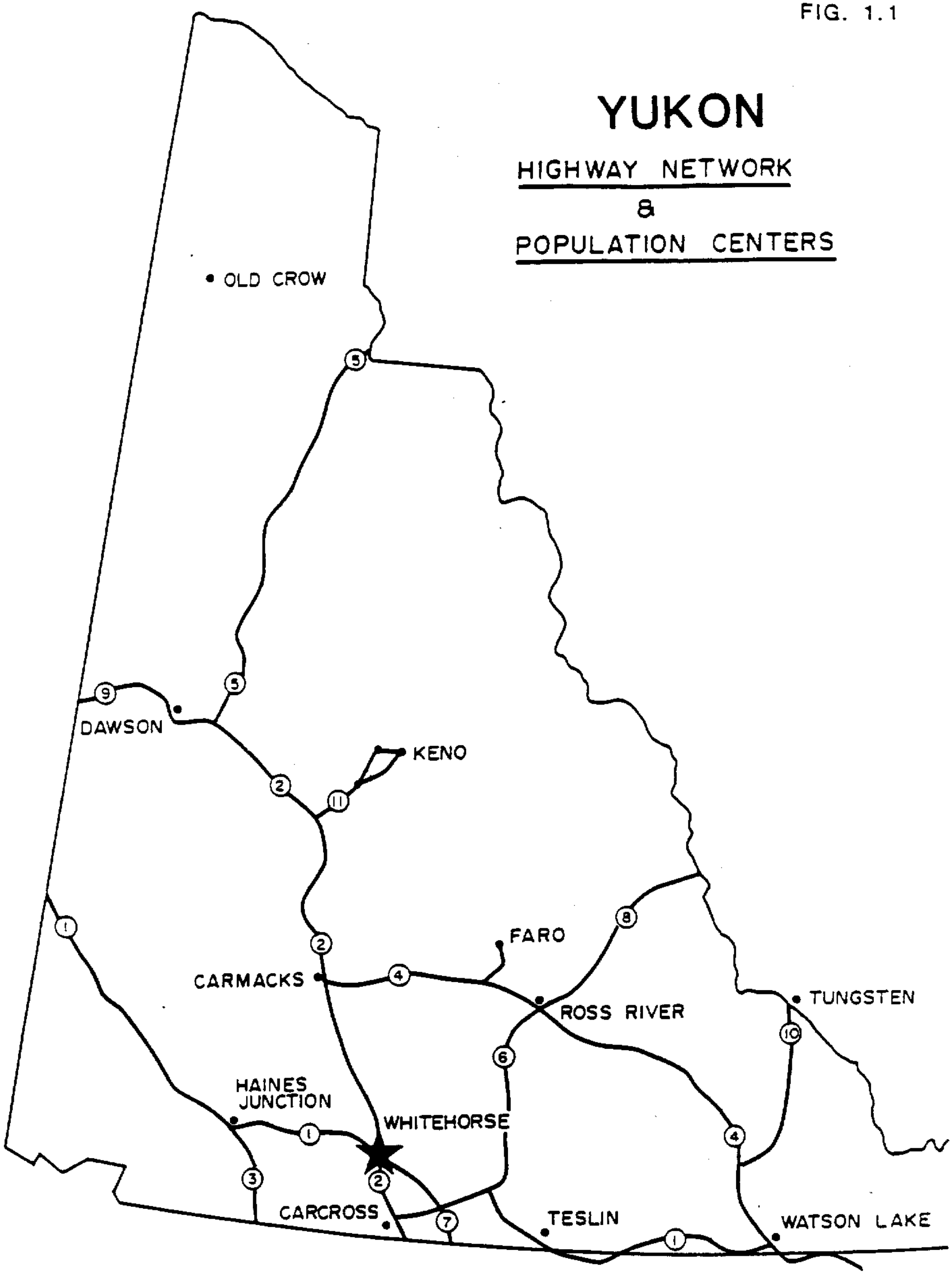

YUKON
HIGHWAY NETWORK
&
POPULATION CENTERS
OLD CROW
5
5
9
DAWSON
KENO
2
11
1
2
FARO
8
CARMACKS
4
ROSS RIVER
TUNGSTEN
10
6
HAINES
JUNCTION
WHITEHORSE
1
4
3
2
CARCROSS
7
TESLIN
1
WATSON LAKE

FIG. 1.2

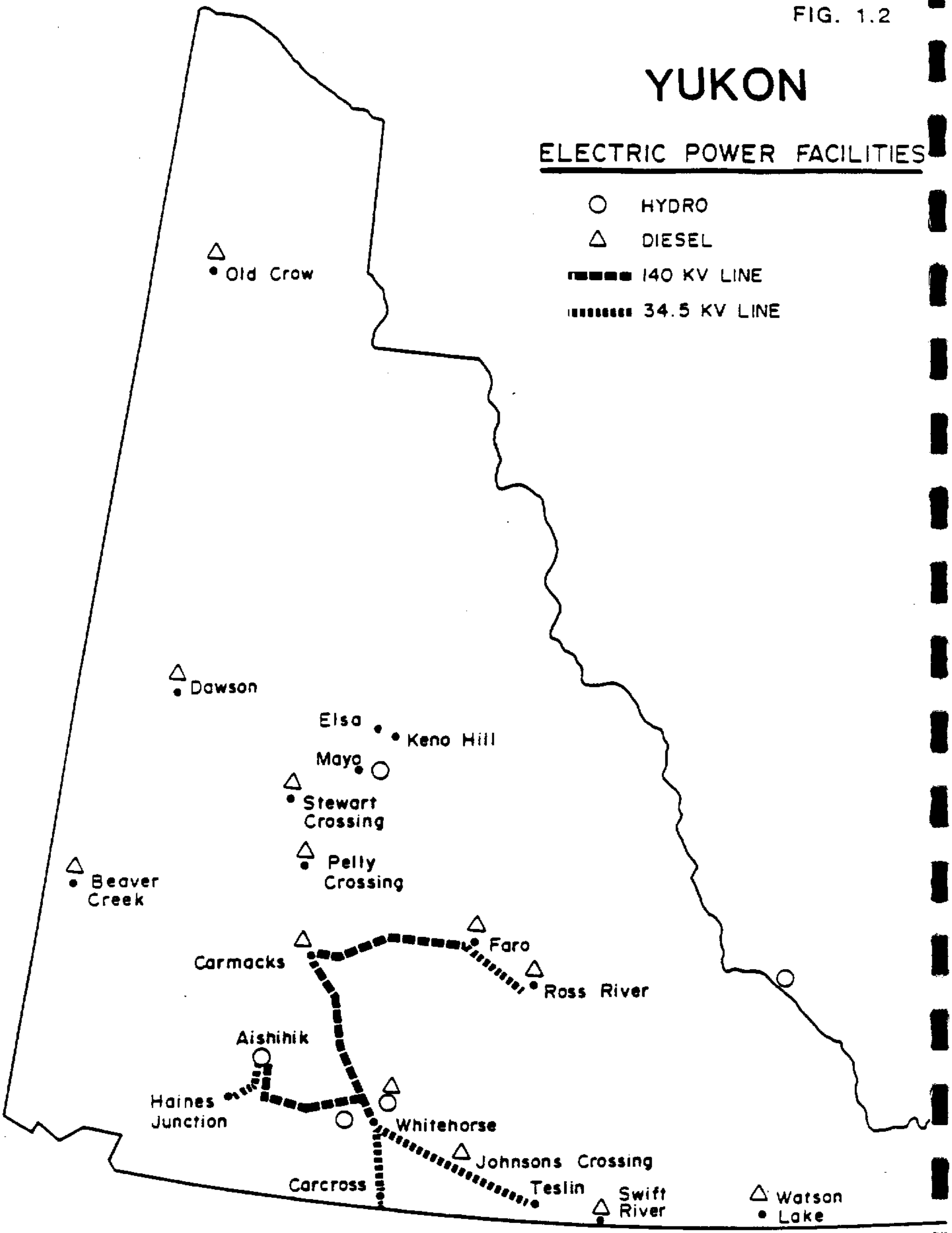

YUKON
ELECTRIC POWER FACILITIES
HYDRO
DIESEL
140 KV LINE
34.5 KV LINE
Old Crow
Dawson
Elsa
Keno Hill
Mayo
Stewart
Crossing
Pelly
Crossing
Beaver
Creek
Carmacks
Faro
Ross River
Aishihik
Haines
Junction
Whitehorse
Johnsons Crossing
Carcross
Teslin
Swift
River
Watson
Lake

FIG. 1.3

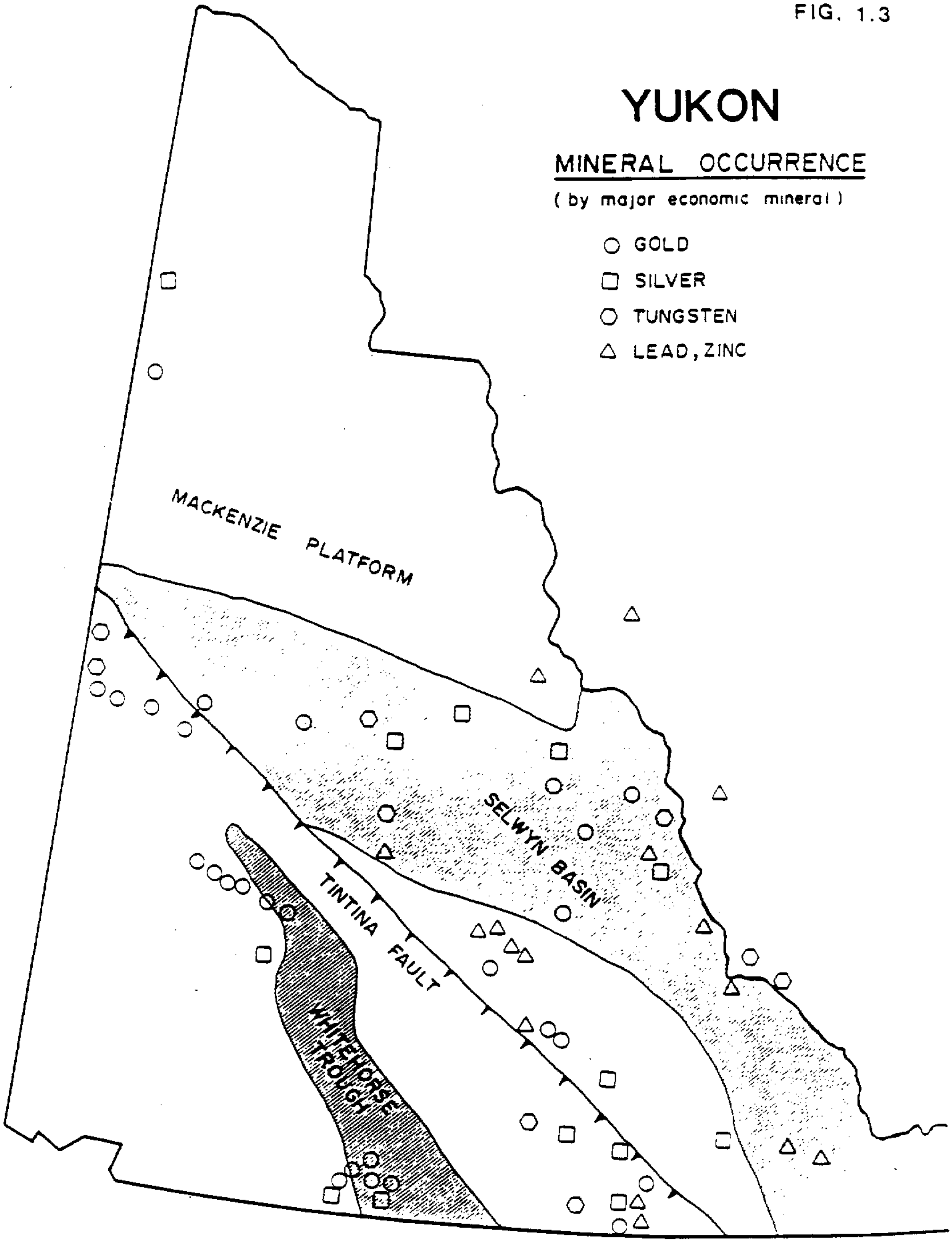

YUKON
MINERAL OCCURRENCE
( by major economic mineral )
GOLD
SILVER
TUNGSTEN
LEAD, ZINC
MACKENZIE PLATFORM
SELWYN BASIN
TINTINA FAULT
WHITEHORSE TROUGH

Table 1.1

YUKON HIGHWAYS BY ROAD SURFACES
As at October 1985

| | Kilometres | Road Surface |
|---|---|---|
| # 1 Alaska Highway | | |
| km 1008.2 - 1013.8 | 5.6 km | BST |
| km 1013.8 - 1024.9 | 11.1 km | Pavement |
| km 1024.9 - 1208.0 | 183.1 km | BST |
| km 1208.0 - 1238.0 | 30.0 km | CACL |
| km 1238.0 - 1392.4 | 154.5 km | BST |
| km 1392.4 - 1507.4 | 115.0 km | Pavement |
| km 1507.4 - 1968.7 | 461.3 km | BST |
| TOTAL | 960.8 km | |
| #1A Whitehorse Access Roads | | |
| South Access Road | 3.8 km | Pavement |
| Two Mile Hill | 1.4 km | Pavement |
| TOTAL | 5.2 km | |
| #2 Klondike Highway | | |
| km 24 - 159 | 135.0 km | BST |
| km 192 - 248 | 56.0 km | Pavement |
| km 248 - 281 | 33.0 km | BST |
| km 281 - 297 | 16.0 km | Pavement |
| km 297 - 346 | 49.0 km | BST |
| km 346 - 360.2 | 14.2 km | Pavement |
| km 360.2 - 388 | 27.8 km | CACL |
| km 388 - 470 | 82.0 km | BST |
| km 470 - 663 | 193.0 km | CACL |
| km 663 - 715 | 52.0 km | BST |
| km 715 - 719.3 | 4.3 km | Pavement |
| TOTAL | 662.3 km | |
| #3 Haines Road | | |
| km 70 - 88.5 | 18.5 km | Pavement |
| km 92 - 153 | 61.0 km | Gravel |
| km 153 - 170 | 17.0 km | CACL |
| km 170 - 256 | 86.0 km | BST |
| TOTAL | 182.5 km | |
| #4 Campbell Highway | | |
| km 0 - 13.1 | 13.1 km | Pavement |
| km 13.1 - 429 | 415.9 km | Gravel |
| km 429 - 522.1 | 93.1 km | CACL |
| km 522.1 - 538 | 15.9 km | BST |
| km 538 - 600 | 62.0 km | CACL |
| TOTAL | 600.0 km | |
| #5 Dempster Highway km 0 - 468 | 468.0 km | Gravel |
| #6 Canol Road km 0 -462.7 | 462.7 km | Gravel |
| #7 Atlin Road km 0 - 42.4 | 42.4 km | Gravel |
| #8 Tagish Road km 0 - 52.8 | 52.8 km | Gravel |
| #9 Top of the World Highway km 0 - 105 | 105.0 km | Gravel |
| #10 Nahanni Range Road km 0 - 134 | 134.0 km | Gravel |
| #1 Silver Trail | | |
| km 0 - 96.0 | 96.9 km | CACL |
| km 96.9 - 110 | 13.1 km | Gravel |
| TOTAL | 110.0 km | |
| #37 Cassiar Road km 0 - 4.5 | 4.5 km | BST |

Codes: BST - Thin asphalt surface
CACL - Calcium chloride dust control

[illegible]

1951 - 1980

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OLD CROW** 67°35'N 139°50'W 253 m | | | | | | | | | | | | | |
| Daily Maximum Temperature | -28.4 | -25.4 | -18.6 | -5.6 | 6.7 | 17.1 | 20.5 | 16.5 | 7.7 | -5.1 | -19.[illegible] | -24.[illegible] | [illegible] |
| Daily Minimum Temperature | -38.0 | -35.2 | -29.8 | -18.6 | -4.3 | 4.9 | [illegible] | 4.7 | -2.2 | -12.6 | [illegible] | [illegible] | [illegible] |
| Daily Temperature | -33.[illegible] | -30.3 | -24.2 | -12.1 | 1.2 | 11.0 | 14.2 | 10.6 | 2.8 | -8.8 | -22.5 | -29.[illegible] | [illegible] |
| Rainfall | [illegible] | 0.0 | 0.6 | 0.4 | 3.9 | 34.8 | 18.7 | 34.5 | 9.5 | 1.2 | 2.0 | 2.4 | [illegible] |
| Snowfall | [illegible] | 6.2 | 5.9 | 6.3 | 15.7 | 1.2 | 0.0 | 0.2 | 11.5 | 20.0 | 18.8 | 12.0 | [illegible] |
| Total Precipitation | [illegible] | 7.0 | 12.0 | 7.1 | 10.4 | 36.0 | 18.7 | 34.9 | 25.2 | 24.0 | 17.2 | 14.8 | [illegible] |
| **DAWSON** 64°3'N 139°26W 320 m | | | | | | | | | | | | | |
| Daily Maximum Temperature | -27.1 | -18.8 | -7.4 | 5.4 | 14.4 | 20.8 | 22.4 | 19.4 | 11.9 | -0.5 | -12.3 | -22.1 | 0.4 |
| Daily Minimum Temperature | -34.2 | -28.2 | -22.2 | -8.7 | 0.7 | 6.6 | 8.9 | 6.5 | 1.0 | -7.5 | -20.[illegible] | -29.3 | [illegible] |
| Daily Temperature | -30.7 | -23.5 | -14.8 | -1.6 | 7.6 | 13.7 | 15.6 | 13.0 | 6.5 | -4.0 | -16.7 | -25.7 | -6.[illegible] |
| Rainfall | - | 0.0 | 0.1 | 2.3 | 19.0 | 38.8 | 47.2 | 43.5 | 25.4 | 6.0 | 0.4 | - | 182.[illegible] |
| Snowfall | 16.5 | 17.0 | 10.8 | 7.8 | 2.1 | T | 0.0 | 0.4 | 3.2 | 24.2 | 24.5 | 28.6 | 137.[illegible] |
| Total Precipitation | 16.5 | 15.7 | 10.1 | 9.7 | 21.1 | 38.8 | 47.2 | 44.0 | 28.2 | 28.7 | 21.5 | 24.6 | 306.[illegible] |
| **MAYO A** 63°37'N 135°52'W 504 m | | | | | | | | | | | | | |
| Daily Maximum Temperature | -23.7 | -13.5 | -4.1 | 5.9 | 14.2 | 20.4 | 22.2 | 19.4 | 12.3 | 2.0 | -10.5 | -19.[illegible] | 2.[illegible] |
| Daily Minimum Temperature | -34.2 | -26.2 | -19.2 | -6.8 | 0.9 | 6.3 | 8.2 | 5.7 | 0.7 | -6.6 | -19.9 | -29.3 | [illegible] |
| Daily Temperature | -29.0 | -19.9 | -11.7 | -0.4 | 7.5 | 13.4 | 15.2 | 12.6 | 6.5 | -2.3 | -15.2 | -24.2 | -4.0 |
| Rainfall | T | 0.0 | 0.4 | 1.4 | 17.4 | 35.3 | 51.7 | 41.4 | 27.8 | 8.8 | 0.9 | T | 195.[illegible] |
| Snowfall | 18.7 | 17.9 | 10.8 | 7.5 | 2.1 | 0.0 | 0.0 | 0.1 | 2.7 | 20.7 | 25.5 | 24.5 | 130.9 |
| Total Precipitation | 17.5 | 16.4 | 10.3 | 8.6 | 19.5 | 35.3 | 51.7 | 41.5 | 30.3 | 28.3 | [illegible] | 22.5 | 306.3 |
| **CARMACKS** 62°6'N 136°18'W 523 m | | | | | | | | | | | | | |
| Daily Maximum Temperature | -23.4 | -13.0 | -3.1 | 6.8 | 14.4 | 20.1 | 21.7 | 19.6 | 13.2 | 3.0 | -9.7 | -19.1 | 2.5 |
| Daily Minimum Temperature | -33.[illegible] | -25.9 | -20.1 | -7.0 | -0.3 | 4.9 | 7.3 | 5.1 | 0.2 | -6.8 | -17.8 | -28.8 | -10.2 |
| Daily Temperature | -28.2 | -19.4 | -11.8 | -0.1 | 7.1 | 12.5 | 14.5 | 12.4 | 6.7 | -2.0 | -13.8 | -24.0 | -3.8 |
| Rainfall | 0.0 | 0.0 | 0.2 | 0.7 | 12.9 | 37.5 | 42.3 | 34.6 | 23.3 | 5.5 | 0.7 | 0.0 | 157.7 |
| Snowfall | 17.6 | 10.7 | 9.4 | 7.1 | 1.8 | 0.0 | 0.0 | 0.0 | 1.3 | 12.8 | 17.1 | 17.2 | 95.0 |
| Total Precipitation | 18.4 | 12.5 | 10.6 | 7.2 | 15.5 | 37.4 | 42.3 | 34.1 | 25.1 | 17.7 | 16.6 | 14.9 | 254.3 |
| **ROSS RIVER** 61°59'N 132°27'W 698 m | | | | | | | | | | | | | |
| Daily Maximum Temperature | -22.6 | -11.5 | -2.7 | 6.0 | 13.4 | 19.8 | 21.8 | 19.1 | 13.1 | 3.1 | -11.0 | -19.8 | 2.[illegible] |
| Daily Minimum Temperature | -36.[illegible] | -28.7 | -22.2 | -8.8 | -2.1 | 2.8 | 5.3 | 2.3 | -2.6 | -9.6 | -22.2 | -32.5 | -13.[illegible] |
| Daily Temperature | -29.6 | -20.6 | -13.5 | -2.2 | 5.4 | 11.0 | 12.8 | 10.5 | 5.1 | -3.4 | -17.9 | -26.6 | -5.7 |
| Rainfall | 0.1 | 0.2 | 0.2 | 6.5 | 13.0 | 31.7 | 41.5 | 31.4 | 22.3 | 4.0 | 0.8 | 0.4 | 152.[illegible] |
| Snowfall | 19.0 | 15.5 | 12.8 | 6.5 | 0.4 | 0.1 | 0.0 | 0.9 | 0.7 | 11.9 | 21.2 | 17.9 | [illegible] |
| Total Precipitation | 19.4 | 15.7 | 14.5 | 12.3 | 14.5 | 31.9 | 41.5 | 32.4 | 22.9 | 15.8 | 23.3 | 13.3 | 253.5 |
| **HAINES JUNCTION** 60°45'N 137°35'W 599 m | | | | | | | | | | | | | |
| Daily Maximum Temperature | -17.0 | -8.0 | -1.9 | 5.9 | 12.6 | 18.1 | 19.9 | 18.5 | 13.1 | 4.5 | -6.5 | -14.7 | 3.7 |
| Daily Minimum Temperature | -26.6 | -23.1 | -18.1 | -7.1 | -1.9 | 2.5 | 5.0 | 3.0 | -0.9 | -7.1 | -17.8 | -26.2 | -10.0 |
| Daily Temperature | -22.9 | -15.6 | -10.0 | -0.6 | 5.4 | 10.3 | 12.5 | 10.8 | 6.2 | -1.3 | -12.2 | -20.5 | -3.2 |
| Rainfall | 0.6 | 0.6 | 0.3 | 1.2 | 11.6 | 29.1 | 36.3 | 28.8 | 28.9 | 13.4 | 4.0 | 2.9 | 157.6 |
| Snowfall | 22.5 | 16.4 | 10.1 | 6.9 | 3.4 | 0.0 | 0.0 | 0.1 | 0.5 | 19.7 | 31.1 | 30.0 | 140.7 |
| Total Precipitation | 21.9 | 15.9 | 9.5 | 7.6 | 14.9 | 29.1 | 36.3 | 28.9 | 29.4 | 33.1 | 34.1 | 31.8 | 292.5 |
| **WHITEHORSE A** 60°43'N 135°4'W 703 m | | | | | | | | | | | | | |
| Daily Maximum Temperature | -16.4 | -8.3 | -2.3 | 5.6 | 12.7 | 18.4 | 20.3 | 18.4 | 12.4 | 4.4 | -5.3 | -12.5 | 4.0 |
| Daily Minimum Temperature | -25.0 | -18.1 | -14.0 | -5.1 | 0.6 | 5.5 | 7.9 | 6.5 | 2.6 | -3.1 | -12.3 | -20.7 | -6.2 |
| Daily Temperature | -20.7 | -13.2 | -8.2 | 0.3 | 6.7 | 12.0 | 14.1 | 12.5 | 7.5 | 0.6 | -8.9 | -16.6 | -1.2 |
| Rainfall | T | T | T | 0.8 | 10.1 | 29.8 | 33.9 | 37.0 | 25.9 | 6.7 | 1.1 | 0.2 | 145.5 |
| Snowfall | 21.3 | 15.2 | 16.4 | 10.5 | 2.9 | 0.9 | 0.0 | 0.8 | 4.5 | 16.1 | 23.8 | 24.2 | 136.6 |
| Total Precipitation | 17.7 | 13.3 | 13.5 | 9.5 | 12.9 | 30.7 | 33.9 | 37.9 | 30.3 | 21.5 | 19.8 | 20.2 | 261.2 |
| **WATSON LAKE** 60°7'N 128°49'W 689 m | | | | | | | | | | | | | |
| Daily Maximum Temperature | -21.3 | -12.0 | -3.3 | 6.0 | 13.3 | 18.9 | 21.0 | 19.3 | 12.9 | 4.4 | -9.1 | -19.5 | 2.6 |
| Daily Minimum Temperature | -32.0 | -25.3 | -19.2 | -7.1 | 0.5 | 6.4 | 8.8 | 7.0 | 2.3 | -4.6 | -18.5 | -28.3 | -9.2 |
| Daily Temperature | -26.7 | -18.7 | -11.3 | -0.6 | 6.9 | 12.7 | 14.9 | 13.1 | 7.6 | -0.1 | -13.8 | -23.5 | -3.3 |
| Rainfall | 0.3 | 0.1 | 0.6 | 2.9 | 24.1 | 51.6 | 58.2 | 42.0 | 40.3 | 16.3 | 2.2 | 0.3 | 238.9 |
| Snowfall | 40.4 | 32.2 | 28.0 | 13.8 | 5.5 | T | 0.0 | 0.0 | 3.4 | 21.6 | 37.3 | 46.6 | 228.8 |
| Total Precipitation | 33.1 | 25.3 | 23.2 | 15.1 | 29.4 | 51.6 | 58.2 | 42.0 | 43.7 | 35.0 | 31.8 | 36.8 | 425.2 |
| **TUNGSTEN** 61°57'N 128°15'W 1143 m | | | | | | | | | | | | | |
| Daily Maximum Temperature | -19.5 | -13.5 | -8.3 | -0.1 | 7.2 | 15.1 | 16.6 | 15.1 | 7.8 | -0.1 | -10.2 | -15.6 | -0.5 |
| Daily Minimum Temperature | -29.3 | -24.4 | -19.7 | -11.9 | -3.1 | 2.9 | 5.3 | 3.7 | -1.2 | -8.5 | -19.4 | -25.5 | -10.9 |
| Daily Temperature | -24.4 | -19.0 | -14.0 | -6.0 | 2.1 | 9.0 | 10.9 | 9.5 | 3.3 | -4.4 | -14.8 | -20.5 | -5.7 |
| Rainfall | 0.0 | 0.0 | 0.2 | 11.6 | 19.2 | 68.4 | 90.9 | 72.3 | 55.7 | 15.1 | 0.2 | 0.0 | 332.6 |
| Snowfall | 30.7 | 44.0 | 30.7 | 24.2 | 7.3 | 0.5 | 0.0 | 0.3 | 13.7 | 59.2 | 60.5 | 45.6 | 316.7 |
| Total Precipitation | 32.4 | 42.1 | 32.2 | 27.6 | 25.9 | 69.3 | 90.8 | 72.6 | 69.1 | 73.5 | 62.5 | 40.7 | 644.7 |

## SECTION II

## PROJECT COMPONENTS

### 2.1 Relative Costs

Prior to approaching the details of custom milling, it is well to place order-of-magnitude importance to all aspects of a typical mining complex. In this way the capital and operating influence of custom milling can be viewed as a specific entity within the project structure.

Table 2.1 and Table 2.2 illustrate the relative importance of various segments of such a project in terms of capital and operating cost percentages. The figures represent a hypothetical 125 TPD underground mining complex, and while it is realized that underground mines are highly site specific, the tables serve to point out certain features regarding custom milling.

a) Where a custom mill is located in the mining site, the mine owner is assumed to supply all infrastructure. In this case, the mill owner would have responsibility for 35 percent of the capital cost and 23 percent of the operating cost.

b) Where a custom mill is located on a remote site the ratio changes to the mill owner having responsibility for 59 percent of the capital cost and 34 percent of the operating cost. With this scenario, the capital costs of mill water, tailing ponds, environmental and personnel accomodations are the responsibility of the mill owner, but are non-recurring and hence spread among multiple users.

The examples referenced represent distinct methods of association between the mine and the mill. From these examples it is possible to extrapolate varying scenarios, the most common being a custom mill sited on a specific property but available for third party custom milling. In this event, certain items of infrastructure, both capital and operating, are common to all mill users and are subject to separate and distinct pricing arrangements.

### 2.2 Capital Costs

It is not the intention of this study to present feasible costs for all size ranges and site specifics relating to a mining project. It may be helpful, however, to consider in resumé the pertinent factors comprising the cost elements of such projects and thereby serve as a reminder as to the features that are common to both the mining and the milling portions of such projects.

Table 2.1

MINE COMPLEX

TYPICAL CAPITAL COST

(% of Total)

(Underground Mining)

| ITEM | ON-SITE MILL MINE | ON-SITE MILL MILL | REMOTE MILL MINE | REMOTE MILL MILL |
|---|---|---|---|---|
| **Mining** | | | | |
| Operation, Maintenance | 30 | - | 30 | - |
| Crude Ore Haulage | - | - | - | - |
| Environment and Regulation | 2 | - | 2 | - |
| Sub total | 32 | - | 32 | - |
| **Milling** | | | | |
| Stockpiles | 1 | - | - | 1 |
| Mill | - | 33 | - | 33 |
| Tailings | 5 | - | - | 5 |
| Water Regime | 2 | - | - | 2 |
| Products | - | 2 | - | 2 |
| Marketing | - | - | - | - |
| Environment and Regulation | 3 | - | - | 3 |
| Sub total | 11 | 35 | - | 46 |
| **Infrastructure** | | | | |
| Power | 5 | - | 2 | 4 |
| Assay | 2 | - | - | 2 |
| Services Distribution | - | 2 | 1 | 1 |
| Personnel and Accommodation | 10 | - | 9 | 3 |
| Fire and Safety | 2 | - | - | 2 |
| Offices | 2 | - | 1 | 1 |
| Sub total | 21 | 2 | 13 | 13 |
| TOTAL | 63 | 37 | 45 | 59 |
| or | 100% | | 104% | |

Note: Remote Mill costs are expressed as relative to an On-Site Mill. Numbers may not add due to rounding of values.

# MINE COMPLEX

## TYPICAL OPERATING COST

## (% of Total)

## (Underground Mining)

| ITEM | ON-SITE MILL MINE | ON-SITE MILL MILL | REMOTE MILL MINE | REMOTE MILL MILL |
|---|---|---|---|---|
| **Mining** | | | | |
| Operation, Maintenance | 36 | - | 36 | - |
| Crude Ore Haulage | - | - | 10 | - |
| Sub total | 36 | - | 46 | - |
| **Milling** | | | | |
| Operations | - | 23 | - | 23 |
| Marketing | incl. | incl. | incl. | incl. |
| Sub total | - | 23 | - | 23 |
| **Infrastructure** | | | | |
| Operations | 8 | - | 6 | 3 |
| Personnel and Accommodation | 23 | - | 17 | 8 |
| Corporate | 9 | - | 9 | - |
| Sub total | 40 | - | 32 | 11 |
| TOTAL | 77 | 23 | 78 | 34 |
| or | 100% | | 112% | |

Note: Remote Mill costs are expressed as relative to an On-Site Mill.

| FACTORS IN PROJECT COSTS | MINING | MILLING | INFRASTRUCTURE |
|---|---|---|---|
| Accesses | X | X | X |
| Environmental and Regulatory | X | X | X |
| Equipment and Maintenance | X | X | X |
| Power and Distribution | X | X | X |
| Water and Distribution | X | X | X |
| Personnel | X | X | X |
| Fire Prevention | X | X | X |
| Health and Safety | X | X | X |
| Mine Development | X | | |
| Crude Ore Delivery | X | | |
| Waste Disposal | X | | |
| Product Storage | | X | |
| Tailings Disposal | | X | |
| Drainage and Sewerage | | | X |
| Offices and Warehousing | | | X |
| Accommodations | | | X |

## 2.3 Operating Costs

While the accounting procedures for cost control are normally quite detailed and are expressed in unit costs per tonne of material handled, the general headings are simple. The following check list summarizes such costs under headings which represent centres of responsibility. Note that all such costs are subdivided into Labour and Supplies.

### 2.3.1 Mining

- Mining
- Mine Maintenance
- Engineering, Survey, Sampling

### 2.3.2 Milling

- Milling
- Mill Maintenance
- Tailings Disposal
- Product Handling
- Sampling, Assay

### 2.3.3 Surface and Administration

- Roads and Yards
- Power and Distribution
- Water and Distribution
- Warehousing
- Offices
- Management
- Administration and Accounting
- Fire
- Health and Safety
- Accommodations
- Fire

## 2.4 Process Plant Location

### 2.4.1 General

Having considered the part the process plant plays in the mining project as a whole, the location of such a plant should be considered both from the point of view of the Process Plant Owner and of the Mine Owner.

The foregoing summaries attempt to distinguish between the process plant and the associated infrastructure or "offsites" and may be described in text form as:

a) A process plant and offsites erected on a mine property will cost the project the same capital and operating dollars regardless of ownership (discounting profit, mobilization and demobilization).

b) Should the process plant be a toll facility on a dedicated site, the plant would account for 37% of the project capital cost and 23% of project operating costs.

c) Should the process plant be a toll facility on a dedicated site with the process owner being responsible for offsites as well as the plant, his capital cost would rise to 59% of the project, and operating costs to 34%.

   In such a scenario, the process plant would be depreciated over its useful life, while the offsites would be depreciated only over the site life. This would be the same case regardless of whether the toll was per single or multiple customer use.

d) Should the process plant and offsites be in a remote site, the process owner would be responsible for all process plant and offsites, both being depreciated over the useful life of the plant. To the mine owner, this scenario is the same as (c) above with the exception of added crude ore haulage costs.

### 2.4.2 Mine Owner's Perspective

It is assumed that the mine owner will always process his own ore in his own facilities, built to his own metallurgical specifications, provided his ore reserves warrant the expense. Lacking sufficient ore reserves, it will be to his advantage to ship to a toll process plant thereby paying for plant depreciation on a per ton basis for the ore he does produce from time to time.

The ideal location for such a toll plant would, of course, be on his own property. To entice a process plant to his location, he accepts two basic alternatives.

a) A Dedicated Plant: a plant for his own use. This alternative implies:

- has a site suitable for offsites and plant
- accepts a "mobile" itinerant plant
- accepts the capital cost of offsites
- contracts to a steady supply of ore at plant capacities

b) <u>A Non-Dedicated Plant</u>: a plant for his use, and others. This alternative implies:
- has a site suitable for offsites and plant
- has a location suitable for delivery by other customers
- does not expend the capital cost of offsites
- contracts to a major portion of a steady supply of ore at plant capacities
- has sufficient ore reserves to warrant toll operator investment in offsites on this site

Should the mine owner not be able to attract a plant to his own property, his alternative is to ship to a remote process plant. Indeed, he may choose to do so in any event rather than accept the cost of offsites on his property.

Assuming a 125 TPD process plant operating 150 days per year where the owner wishes to retrieve offsite capital costs of $720,000 over 5 years at 15% interest rates, the toll charge for such a capital investment would be $25.95 per ton. At a cost of $0.25 per ton mile for crude ore haulage, the mine owner would be in an advantageous position if the haul distance to the remote plant were under 100 miles. Such calculations must necessarily consider the costs of loading and dumping, with a variable distance treated as "overhaul" mileage.

In addition to the economics of process plant location, the mine owner with insufficient ore reserves for his own plant must consider his obligations for ore delivery, i.e. mining rate.

Underground mining rates are almost totally dependent on the number and size of exposed ore faces. To develop a system of access, mining, mining equipment, ventilation, etc., for tonnage rates in excess of 50 to 125 TPD based on short term reserves is considered unlikely. For mining rates above 125 TPD, development costs for continuous mining are considered non-economic on life expectations shorter than a toll processor owner would wish to write off his costs.

Open pit mining rates are not as sensitive to such development costs and accelerated production rates over short term ore reserves would be quite normal.

### 2.4.3 <u>Process Owner's Perspective</u>

The process plant owner has as his prime concern the availability of customers. The following options must be considered by such an investor.

a) Single Client
On-Site Plant
Short Duration Contract
Move Plant to New Location

Under this scenario, the short duration of contract is predicated on limited outlined reserves. While the period may extend, there will be no contractual assurance. The mine owner will supply all required offsites. The plant will be fully mobile and be limited, because of this, to under 125 TPD.

b) Prime Client
On-Site Plant .
Medium Duration Contract
Toll Processing to Others
Move Plant to New Location

Under this scenario, the duration of the contract is predicated on limited outlined ore reserves. While the period may extend, there will be no contractual assurance. The location is suitable for ore delivery by other customers and is within economic crude ore haulage range. The process owner will supply the plant and offsites both during and after depletion of prime client reserves. The plant will be mobile, under 125 TPD, and probably will be moved in the future to a new site.

c) Prime Client
On-Site Plant
Long Duration Contract
Over-Sized Plant
Toll Processing to Others
Plant Stationary for Extended Period

The duration of, the contract is predicated on long term ore reserves combined with a small mining rate. The development of offsites is advantageous and the location is well suited for delivery by other clients. The process owner must assure the prime client of minimum working stockpiles for his ore.

d) Multiple Clients
Remote Plant
Region Assures Long Duration
Plant Sized on Market Study
Total Toll Processing
Plant May Move if Markets Change

This alternative is essentially the same as (c) above except the long term prime client is replaced with multiple clients, all of whom must face a crude ore haulage cost. The plant would be ideally placed with respect not only to client proximity, but to offsites such as power and tailings disposal. The advantage of this alternative lies in facing the solution of environmental problems only once.

### 2.4.4 Conclusions

1. Offsites: The Process Owner is most likely to invest in the capital and operating expense of both the plant and offsites unless the plant is mobile and for single client use at any given time.

2. Size: The process plant is most likely to be mobile and therefore under 125 TPD unless there is a single long term contract user or multiple contract users assured in a given region.

3. Location: Unless the process plant is sited at a long term contract location, the plant will be at a remote location and most likely within 100 miles of prospective users.

## SECTION III

## PROCESSING PLANT COMPONENTS

### 3.1 Plant Location

The two proposed plant construction techniques, i.e. mobile and permanent, will require the same equipment types and process flowsheets.

#### 3.1.1 Regional Plant

The regional plant will be permanently sited in a location which can be reached by truck haulage. It may be the operating mill for an existing mining operation which has surplus capacity available for toll processing of similar ores, or a plant whose sole purpose for existence is as a custom milling operation.

This plant will be characterized by its all-weather construction, which will enable it to be operated throughout the year.

#### 3.1.2 Mobile Plant

The mobile plant, as indicated in Section 2.4, may be either fully mobile, for operation as an itinerant concentrator, or permanently located at a central site to which ores can be hauled. In either case, the plant will be constucted on skids and directly on truck trailers for ease in transporting from the fabrication site to the mill site. The plant can be relocated within days and be operating at a new site, providing the mobilization and demobilization expenses can be justified.

The principal feature of this plant type is the absence of a building enclosure and the use of ground stockpiles as opposed to bins which would be used in the permanent plant option.

This plant is much less expensive to construct than the all-weather option, but cannot be operated during the winter.

### 3.2 Processing Equipment

#### 3.2.1 General

All of the proposed ore types will need to be crushed and ground prior to separation into saleable products.

Typically the crushing plant which will process a gold ore will accommodate a lead/zinc ore equally well.

The proposed single stage wet ball mill grinding circuit can be expected to process all of the ore types. Because of variations in ore hardness (work index) and grind requirements, the circuit which will economically process one ore will not necessarily handle another ore equally well.

The recovery, i.e. concentration circuit, requirements for the various ore types will necessitate some combination of gravity, flotation, and cyanidation to produce the required saleable products.

The design of any concentrator flowsheet is somewhat of a mecano set exercise in which the various available unit operations are assembled in a sequence which will satisfy the mineralogical requirements of deposit to the economical production of saleable products, be they bullion, gravity or flotation concentrates.

The modular mill concept is merely an extension of this fundamental approach such that the various required circuits are assembled in a building block exercise to accommodate the needs of the ore.

### 3.2.2 Crushing

Several optional crushing plant configurations have been considered, as follows: (See FIG. 3.1)

- Single stage jaw crushing.
- Two stage jaw crushing.
- Single stage jaw crushing followed by a cone crusher in either open or closed circuit with a vibrating screen

The use of 2 (possibly 3) stage closed circuited crushing is pretty well universally practiced in large capacity crushing plants where the economies of closed circuiting can be readilly justified. This plant configuration represents the ultimate no risk plant design.

For the operator of a small plant, in which the capacities of the individual crushing components vastly exceeds the feed rate requirement of the grinding circuit, other less costly options should be considered.

A narrow vein, high sulphide ore which in the normal course of mining will result in fine fragmentation, may lend itself to the use of a single 10" X 16" jaw crusher to produce a -17 mm (3/4") ball mill feed. Although this is an unusually coarse mill feed, with highly friable lead zinc deposits it can be quite suitable. This crushing plant configuration, although simple to operate requires a good knowledge of the mineralogy of the deposit before it can be chosen with confidence, but can be quite effective where its use is indicated.

A 2 stage jaw crushing plant was at one time more popular than it is today, and for a small scale operation does have considerable merit. A jaw crusher compared to a cone crusher is (1) less expensive (2) less complicated (3) can be readily inspected in service and (4) can be maintained with less skill.

The most popular crushing plant flowsheet for small tonnage operations will contain a jaw crusher followed by a cone crusher in closed circuit with a vibrating screen. This configuration will perform very well on all ore types except those which contain clay. This latter condition needs to be assessed early in the mine development, since the presence of clay will necessitate the inclusion of a washing circuit within the crushing system. Failure to recognize this characteristic will lead to considerable delays in ore handling and will probably affect the plant performance adversely.

It is not possible to economically design an ore handling system which will never have to accomodate oversize rock. The best that can ever be done is to minimize the inconvenience without incurring excessive mining costs.

It is far better to install a somewhat oversized primary jaw crusher than to save only a few thousand dollars by purchasing a marginally sized unit, and then spend more than all of the savings in materials handling costs.

### 3.2.3 Grinding

The preferred grinding circuit for the proposed modular mill will consist of a single ball mill in closed circuit with a cyclone classifier. (See FIG. 3.2)

Other types of grinding devises, such as rod and autogenous (or semi-autogenous) mills are not applicable in small installations. The former will rarely produce a sufficiently fine product for economical separation, and the latter requires a relatively expensive testing program with a considerable uncertainty as to assured success.

This is not to say that a grinding mill which formerly served as a rod mill cannot be operated as a ball mill. Normally, all that is required is to replace the grinding rods with balls, and at some time install end liners with a lifter instead of the smooth end liner which is required in rod mill service.

If a grinding mill is available with a companion spiral or rake classifier, and if it is in very good condition, it could be retained. Otherwise, a hydrocyclone (cyclone) is the preferred choice because of low capital and operating costs.

If a good quality grinding mill is available with a serviceable set of metal (typically cast Ni-hard) liners, they should be retained. Replacement liners, however, should probably be of rubber manufacture, since a small operation rarely has the necessary equipment to safely handle the much heavier cast metal liners. Rubber liners usually will perform well from an operating cost viewpoint, and are the typical preferred choice for a small operation.

### 3.2.4 Gravity Equipment

A gravity concentration circuit is frequently used in gold circuits and is the preferred primary concentration stage ahead of either flotation or cyanidation when free gold is encountered.

Gravity circuits are easily operated, but must be kept secure, since the opportunity to steal this valuable commodity must be minimized.

The preferred gravity concentration equipment for the small mill consists of a mineral jig followed by a shaking table for cleanup.

At one time, the use of jigs followed by amalgamation was popular. This practice has fallen into disfavour since the inevitable mercury losses can potentially contaminate the site runoff water in perpetuity.

Larger plants are, with increasing frequency, using spiral concentrators in series with a shaking table. It is the author's opinion that the additional complexity of the required flowsheet cannot be justified in a small plant.

The most popular jig is the mechanically driven Denver duplex jig, which is both inexpensive and easily operated. (See FIG. 3.4)

### 3.2.5 Flotation

Many gold, silver, and tungsten and all copper, lead, zinc mills will employ flotation concentration.

Most flotation circuits will contain at least one stage of cleaner flotation to upgrade the rougher (primary) concentrate and to discard contaminants which inevitably will float in the rougher circuit.

In the small plant, the most popular flotation machine is the Denver type, which is available in two forms: Sub-A, and D.R. The Sub-A machine utilizes a pumping type of impeller which is capable of advancing concentrates through cleaning stages. This machine requires more attention to operate than the open flow D.R. type, but either will perform well. (See FIG. 3.5) There are several other machine types, but these are less common.

### 3.2.6 Cyanidation

Most gold milling operations employ cyanidation to recover gold/silver into a highly marketable bullion. These plant require a much higher level of detailing both in the laboratory testing and in the plant design than is typically encountered in single sulphide flotation and gravity circuits.

Initial laboratory testing, as detailed in Section 4.1, is required to determine the processing options for the gold/silver ore in question. Generally, if a marketable flotation concentrate can be produced from a deposit, this should be done, at least initially, to establish both the viablilty of the mine operation and the operator's credibility with the regulatory agencies.

If the laboratory testing indicates that cyanidation is a must, the potential operator should carefully assess the inevitable higher capital and operating costs associated with cyanidation circuits, and the additional regulatory constraints.

Two types of cyanidation circuits are commonly employed today: Merrill Crowe (MC), and Carbon. The MC, or zinc precipitation circuit has been in use for over 50 years, and is well understood. Within the last 10 years, the use of activated carbon has been developed commercially, and most of the plants which are now being constructed are of this type. Both flowsheet configurations have suitable applications, but generally the carbon is preferred because of lower capital and operating costs, and potentially marginally higher recoveries.

Typical cyanidation circuit flowsheets are attached as Figures 3.7 and 3.8. These drawings indicates the relative complexity of cyanidation circuits and the considerable attention which must be paid to water management to avoid circuit imbalance.

It is the authors' opinion that cyanidation circuits should not be included at the small scale of operation which is envisaged in this report, unless a skilled hydrometallurgist is retained to test and design the processing flowsheet.

The owner must be aware that the regulatory requirements for the permitting of a cyanidation concentrator are much more severe than that of a flotation plant.

### 3.2.7 Electrical

Generally, the most economical construction method for the electrical distribution system is to shop-build the completed package in either a trailer or a cargo container for delivery to site intact. Only a limited number of field runs are then required on-site.

If power is to be supplied by diesel electric units, both the generators and distribution system can be located in the same enclosure.

Caution must be exercised in the too hasty purchase of older electrical switchgear which may not meet the current Canadian Electrical Code.

### 3.2.8 New vs Reconditioned Equipment

The equipment cost component of a conventional stationary milling plant represents only 20 - 25% of the completed plant. In the modular plant, which does not include a building, the equipment proportion will inevitably be somewhat larger.

It is frequently a good investment to install reconditioned equipment which typically can be purchased for 40 - 60% of new equipment prices, and usually much improved delivery.

It is usually excessively risky to purchase used equipment on an as-is-where-is basis and not expect to have to spend additional money to overhaul it. A project which cannot afford the cost of reconditioned equipment is one which is underfinanced, and will probably fail since the owner will have an unclear understanding of the complexity of the business venture.

There are several reputable businesses in Canada which rebuild mining and milling equipment, and are prepared to warranty their work. Unless the owner or his agent has specific knowledge of the equipment, he should rely upon the capabilities of the reconditioned equipment suppliers.

## 3.3 Site Services

### 3.3.1 Power

The options for the supply of power to the site include:
- distributed hydro electric
- dedicated micro-hydro plant
- dedicated diesel electric generators

These are discussed in detail in Section 1.2.4.

From the perspective of minimizing the capital outlay, option (1) is the most attractive providing the plant can be located adjacent to an acceptable connection site on the hydro grid.

A plant which anticipates longer life should consider the much higher capital cost option of a dedicated micro hydro plant, because of substantially reduced operating costs.

The use of a dedicated diesel electric plant is attractive from the perspective of initial outlay, since suitable units can frequently be leased. Caution should be exercised in the selection of older, and therefore less energy efficient engines. The annual cost of supplying fuel to a diesel generator is several times that of the capital cost of the unit, so that fuel economy must be considered at the time of initial commitment.

Diesel electric generators are generally most economically purchased already installed in insulated vans which are completely electrified, including the distribution system.

Since only approximately 35% of the energy available from fuel is converted to power and the balance to heat, the use of the generator cooling system for plant and process thermal requirements should be detailed at the time of purchase of the diesel generator. Most commonly, only the jacket heat is used, but an additional equal heat source exists in the stack losses. Where it is appropriate to dry concentrates, the use of this "waste" heat should always be considered.

### 3.3.2 Water

The process water requirements for flotation and cyanidation concentrators are as shown below. Water requirements are based upon a production rate of 100 tonnes per day, and can be prorated to any other desired plant capacity.

| Circuit | Water requirements cu m/day | USGM | Remarks |
|---|---|---|---|
| Flotation | 150 | 27 | no recycle |
| | 30 | 6 | max recycle |
| Cyanidation (MC) | 20 | 4 | 10 % bleed |
| Cyanidation (C) | 150 | 27 | no recycle |
| | 30 | 6 | max recycle |

Note: (MC) Merrill Crowe (C) Carbon

### 3.3.3 Tailing Disposal

The design and construction of tailing disposal earthwork requires the attention of a Geotechnical Engineering specialist.

The siting of the milling plant should, if possible, be made to facilitate the construction and operation of the tailing disposal system.

The early retention of a Geotechnical Engineering consultant is prudent, since it may avoid making a commitment on the location of a plantsite which has no available material for the construction of a tailing facility.

The permitting for the milling operation will in any case be conditional upon the design and construction of the tailing facility being assigned to a Registered Professional Engineer who specializes in dam construction.

### 3.3.4 Assaying

The circumstance must be considered as exceptionally rare to non-existant where an ore deposit is sufficiently consistant in straightforward metallurgy, and the entire staff so experienced, that the milling operation can be controlled visually without the need for on-site assaying.

Normally the mine cut-off grade needs to be established through assays and the plant operation requires daily assays to know that the operation is proceeding as planned. Therefore, unless exceptional conditions exist, an on-site assaying facility is required.

All assay offices will contain an essentially identical sample preparation (bucking) facility which will contain a minimum of:

- sample drying oven.
- approximate 4" X 6" jaw crusher.
- sample splitter.
- pulverizer, preferably of the shatterbox type, as opposed to the older and largely obsolete rotary type.

The type of assaying facilities will depend upon the elements which need to be analysed to control the operation. Note that sometimes an easily analysed element can be used for process control rather than the principle element which may be more difficult to analyse.

The typical base metal concentrator can still be controlled using classical wet titration techniques which will provide adequate accuracy and minimal capital outlay.

More commonly today, an atomic adsorption spectrophotometer (A.A.) is used for essentially all base metal and silver analyses. Gold can be run on an A.A. unit, although most minesite assay ofices will have an assay furnace to provide the higher accuracy for bullion or other high grade materials.

The typical layout of an assay laboratory with optional fire assaying or A.A., is shown FIG. 3.9.

### 3.3.5 Manpower

A small scale gravity/flotation concentrator can be operated by a single operator on shift, with an additional operator on day shift for crushing and to assist in the concentrator. An additional trainee should ideally be available for miscellaneous assistance and for replacement emergencies.

Mechanical and electrical maintenance requirements will be modest, and typically will require the attention of one mechanic and one part time electrician. One assayer will be required.

The Mill Superintendent is expected to have the required knowledge, experience and skills necessary to direct his staff. Back-up skills, particularly in the field of metallurgy, may come from a Consultant Metallurgist in combination with remote testing research as required. It may be necessary to go outside the Yukon for this key position.

All other staff will likely be available within the Yukon labour pool, although a few weeks of on-site training may be required for specific process circuits. Special training allowances will be required for cyanidation circuits and reagent mixing. The assayer will be under direct shift supervision of the Mill Superintendent, and this position can likely be filled in the Yukon.

### 3.3.6 Housing and Transportation

Details of the housing and transportation requirements are beyond the scope of this report, but the best mill siting is one which requires the provision of neither of these services.

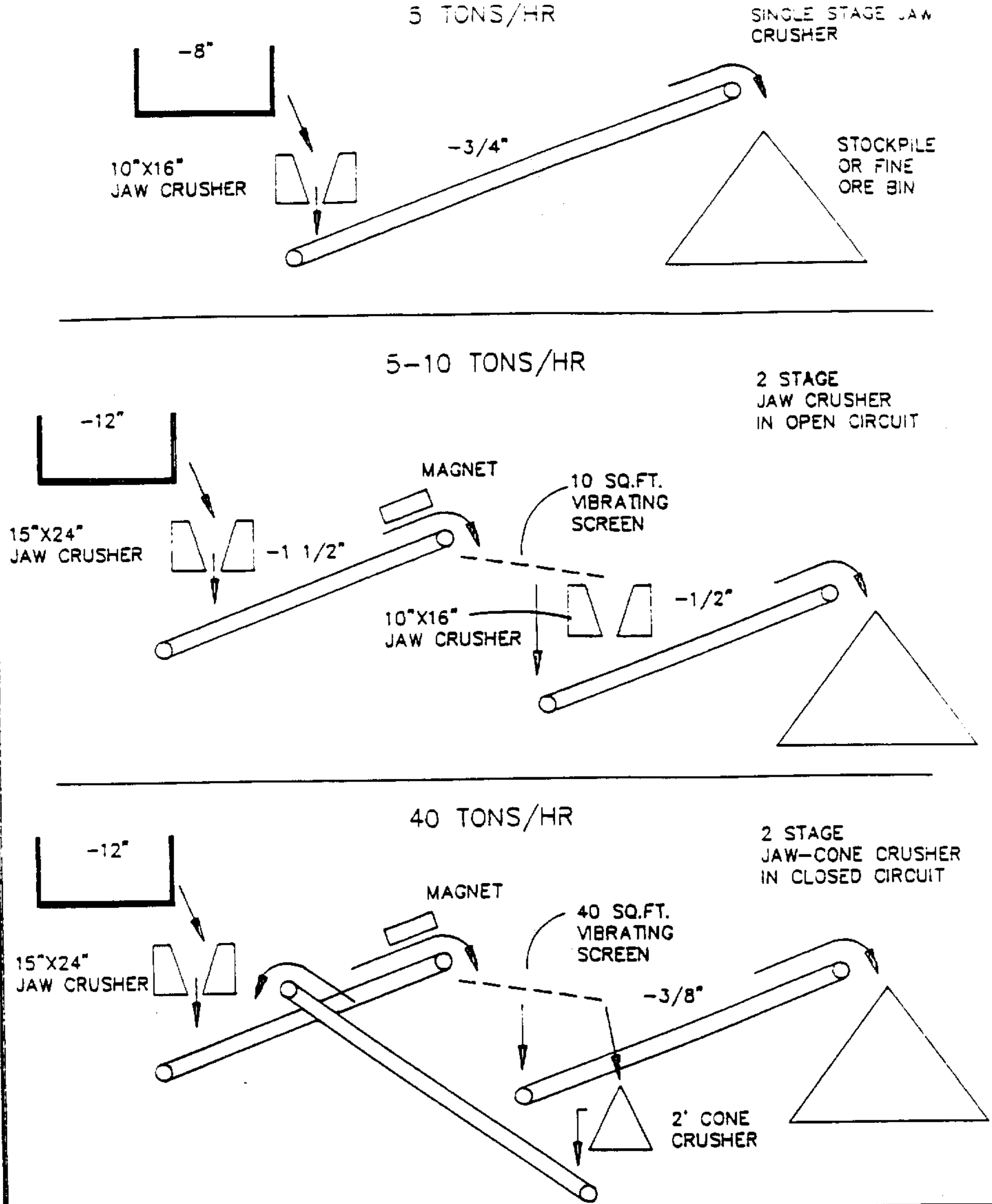
### 3.3.7 Stockpiling

The operation of a toll processing plant will require a provision for stockpiling ore at the mill site. The location must be sufficiently large to prevent the mingling of ores from various sources.

There should be no need to provide a concrete or asphalt base for the pile, although the use of a sand interface at the bottom will enable the pile to be thoroughly cleaned at the end of a production run.

Piles can be covered with tarpaulins, but these are frequently damaged on removal if there is any snow cover. During summer, there is no need to cover a stockpile since dusting occurs mostly during periods of dumping or excavating.

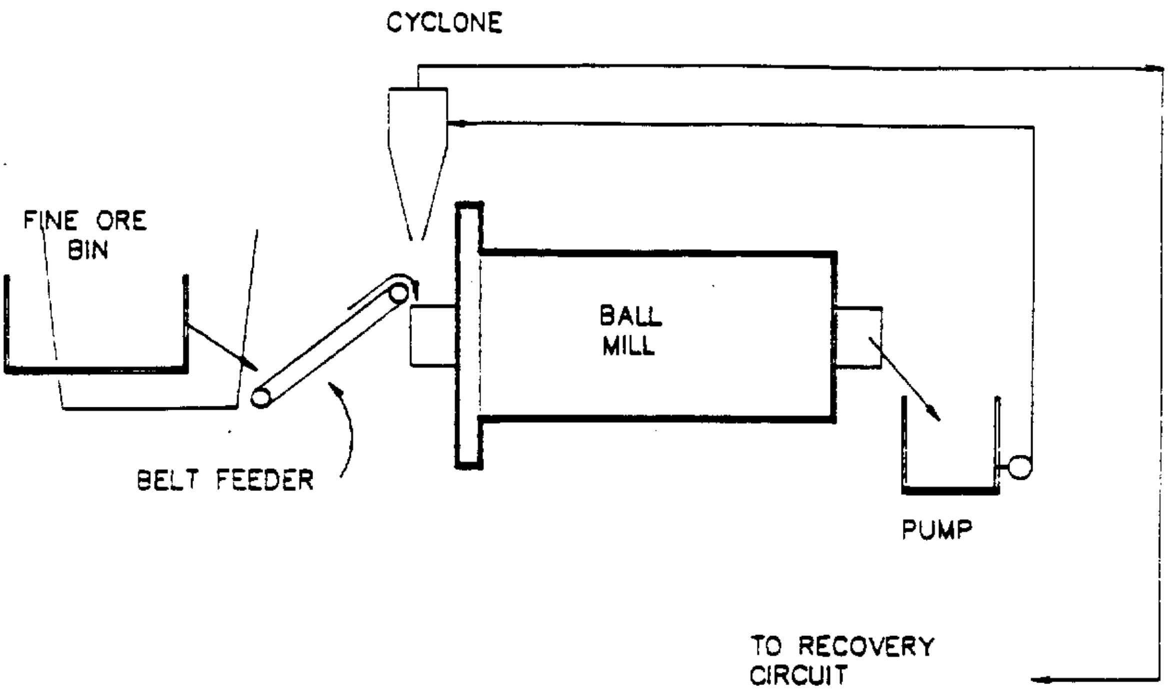
There is little likelihood that a structural roof can be justified over this type of stockpile.




YUKON
CUSTOM/PORTABLE MILLING STUDY

CRUSHING PLANT FLOWSHEET OPTIONS

UMA ENGINEERING LTD. G.W. HAWTHORN
APRIL 1987 FIG. 3.1



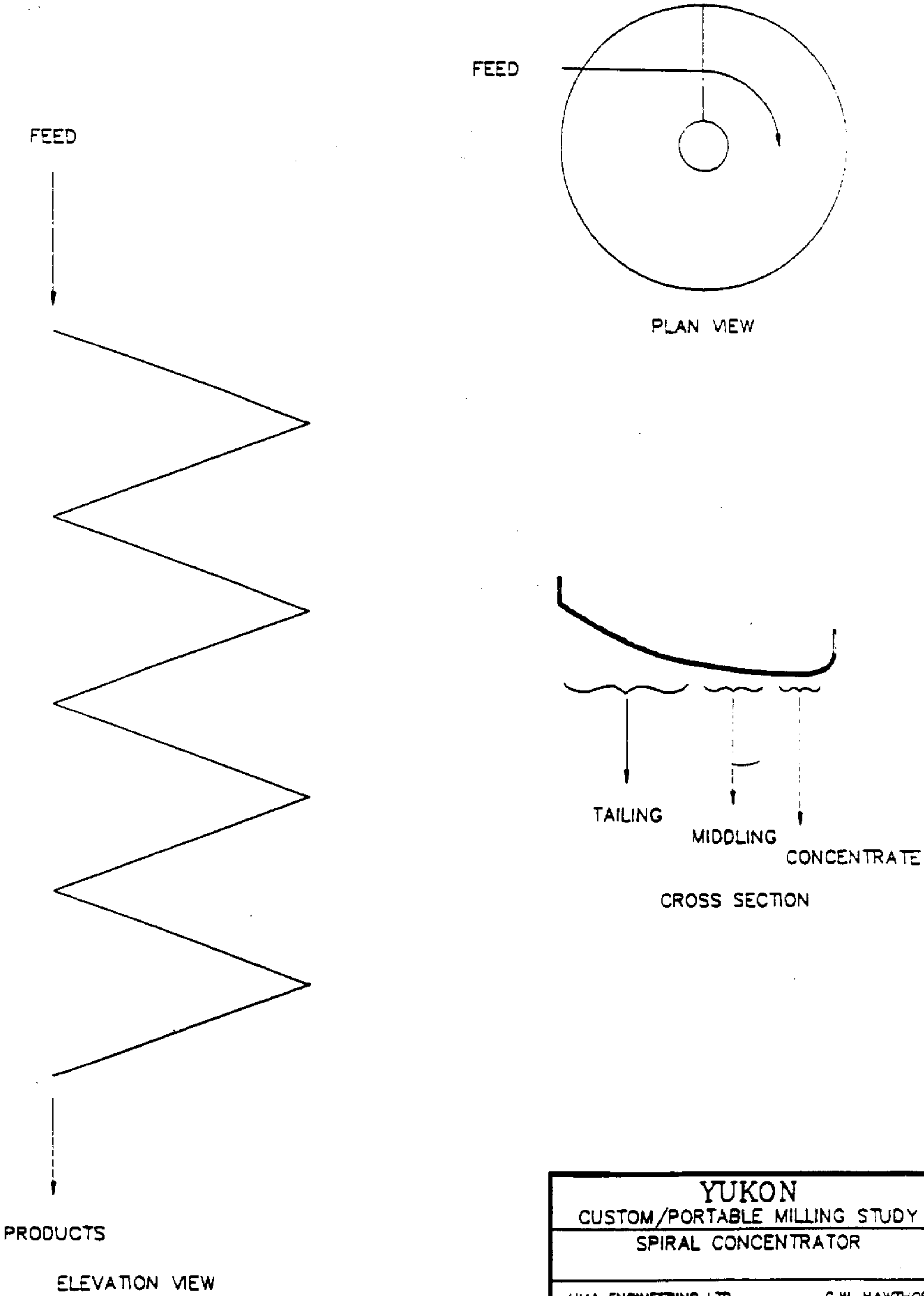

NOTE:

A MINERAL JIG MAY BE INSTALLED ON EITHER THE BALL MILL DISCHARGE, OR CYCLONE UNDERFLOW, IF GRAVITY RECOVERABLE GOLD OR SILVER IS PRESENT

YUKON
CUSTOM/PORTABLE MILLING STUDY

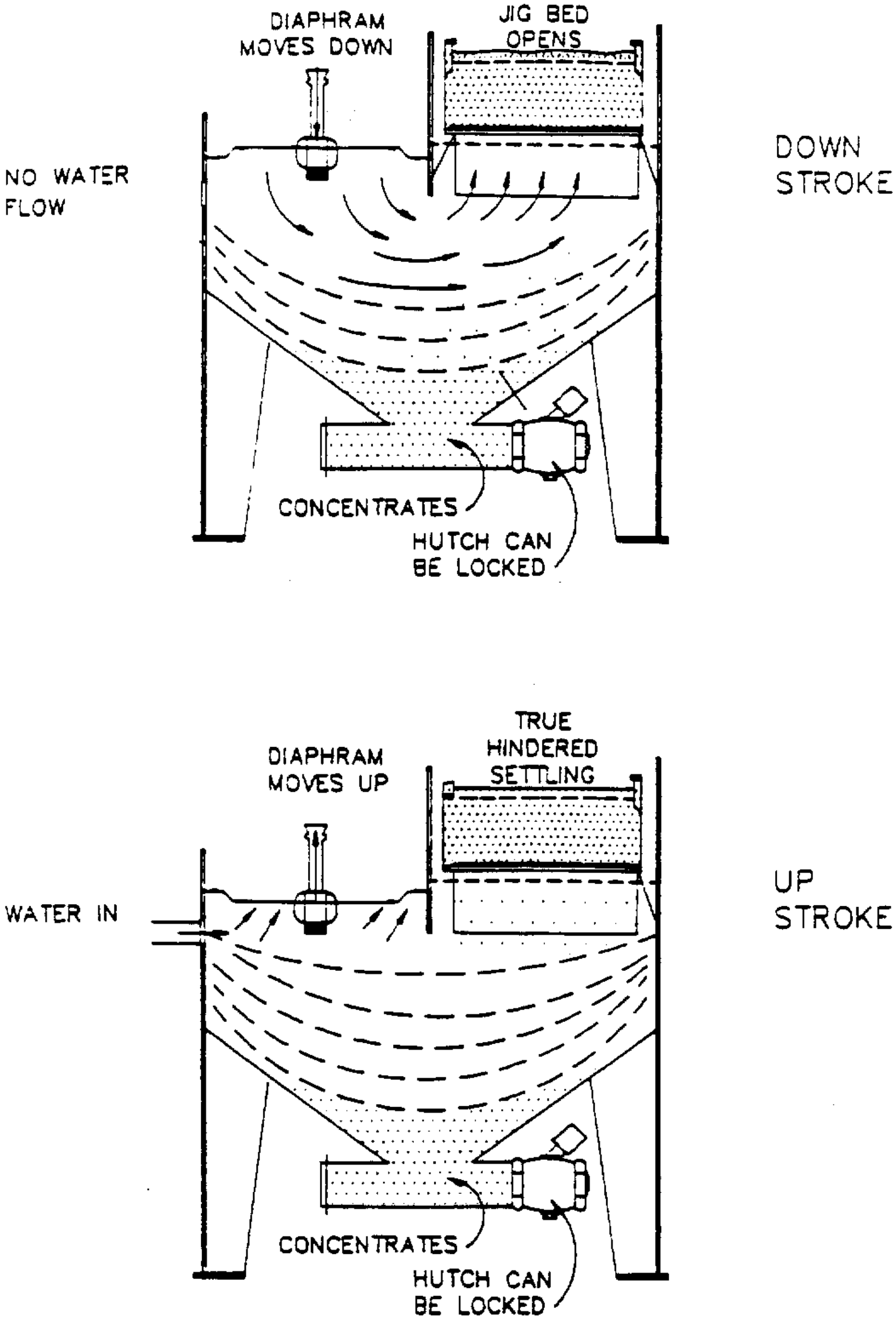
SINGLE STAGE BALL MILL
GRINDING CIRCUIT

UMA ENGINEERING LTD. G.W. HAWTHORN
APRIL 1987 FIG. 3.2



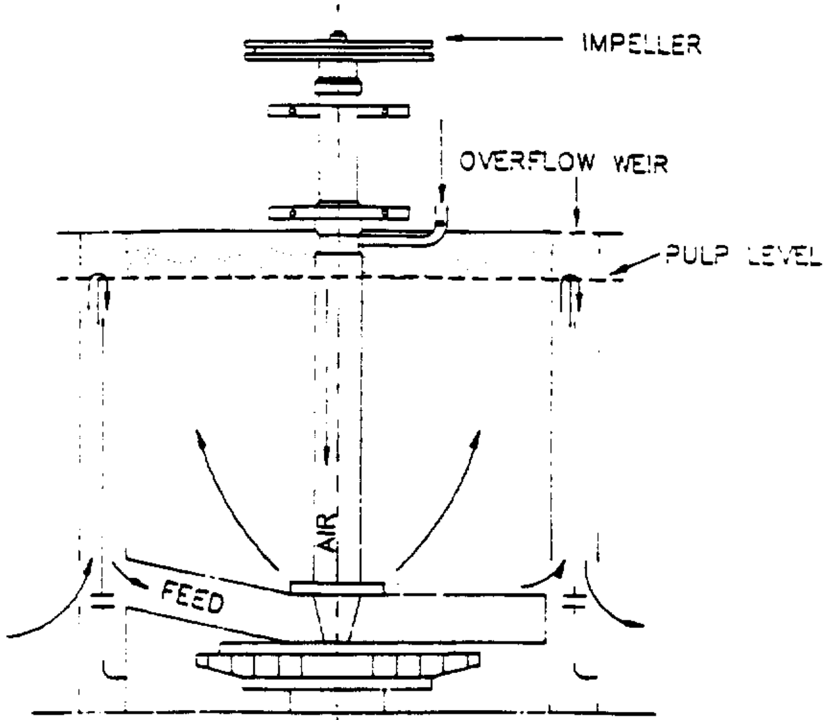

YUKON
CUSTOM/PORTABLE MILLING STUDY
SPIRAL CONCENTRATOR

UMA ENGINEERING LTD. G.W. HAWTHORN
APRIL 1987 FIG. 3.3

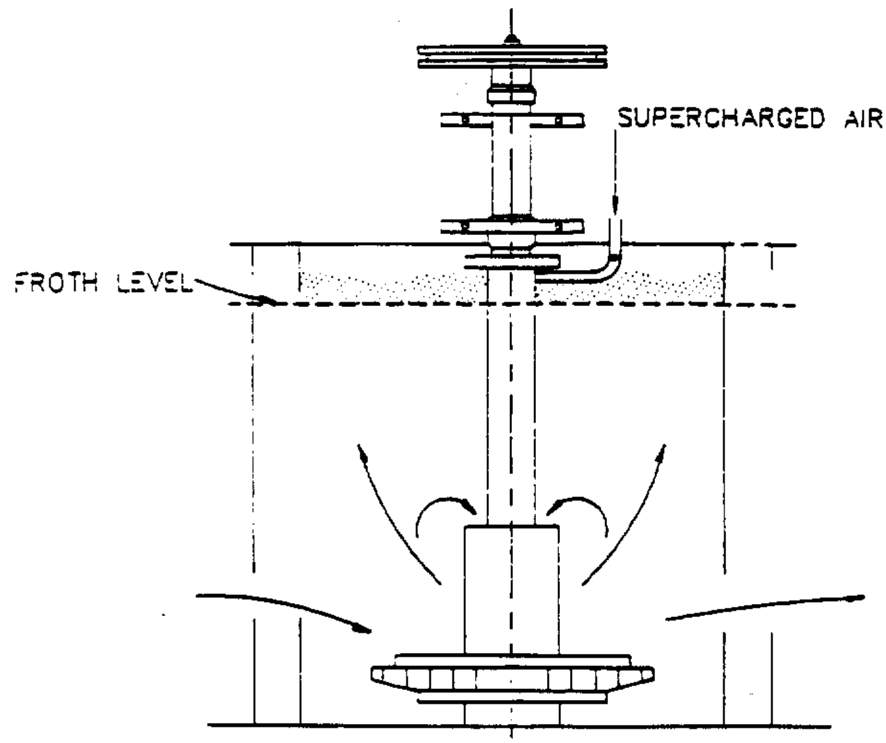



YUKON
CUSTOM/PORTABLE MILLING STUDY
MINERAL JIG

UMA ENGINEERING LTD. | C.W. HAWTHORN
APRIL 1987 | FIG. 3.4




DENVER SUB-AERATION CELL

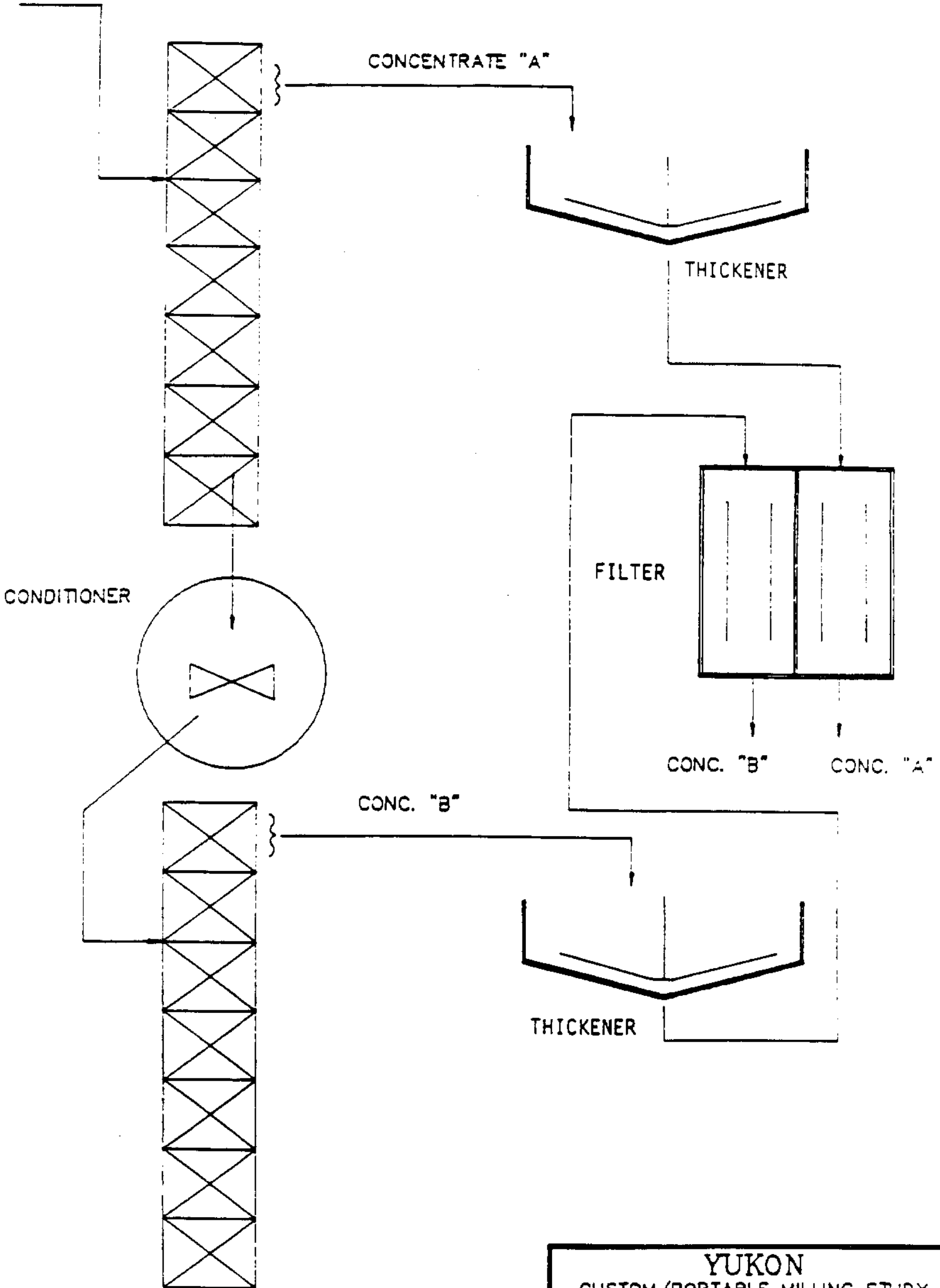



DENVER FREE-FLOW CELL

YUKON
CUSTOM PORTABLE MILLING STUDY

DENVER FLOTATION MECHANISM

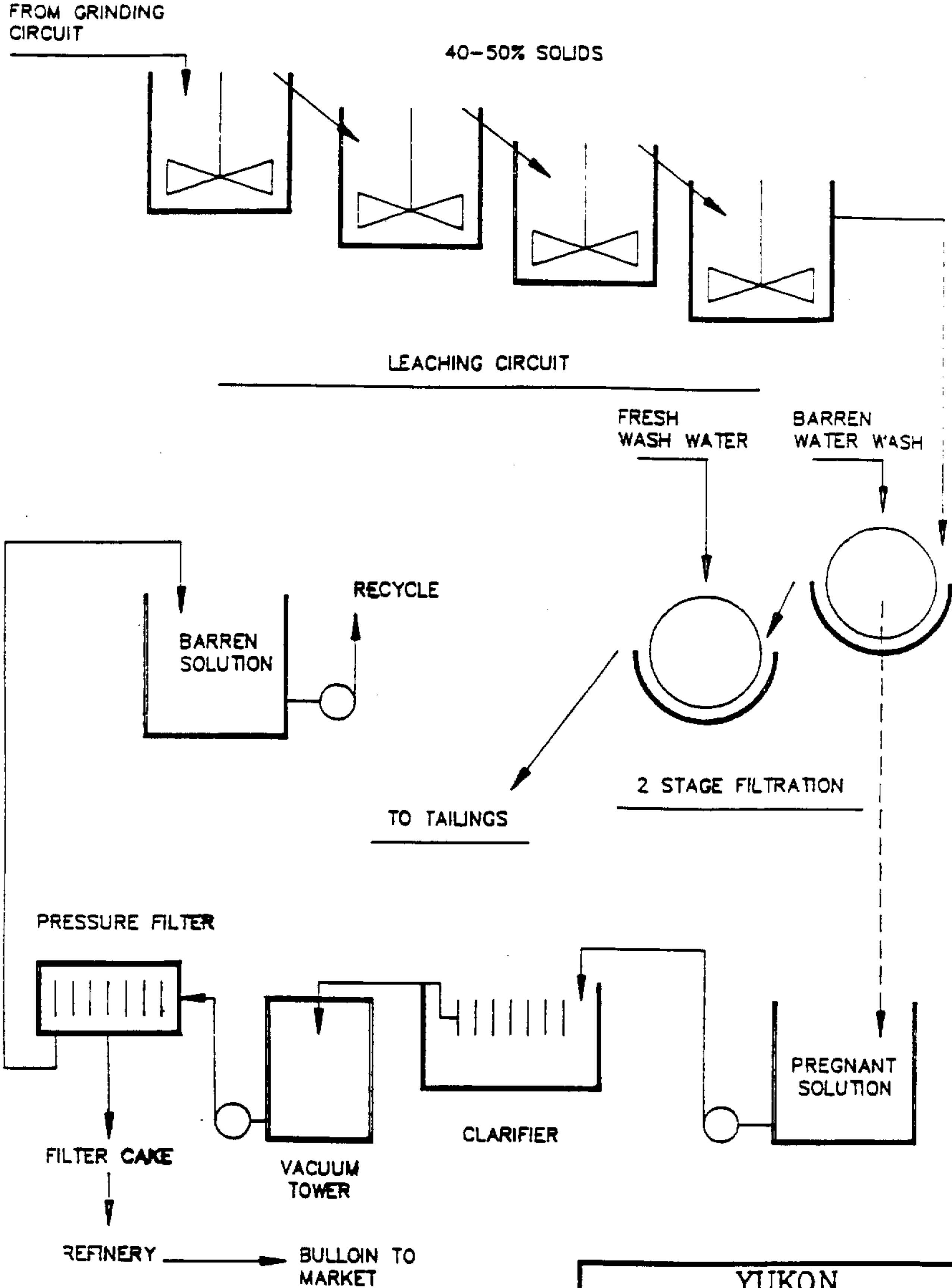
UMA ENGINEERING LTD. G.W. HAWTHORN
APRIL 1987 FIG. 3.5




YUKON
CUSTOM/PORTABLE MILLING STUDY

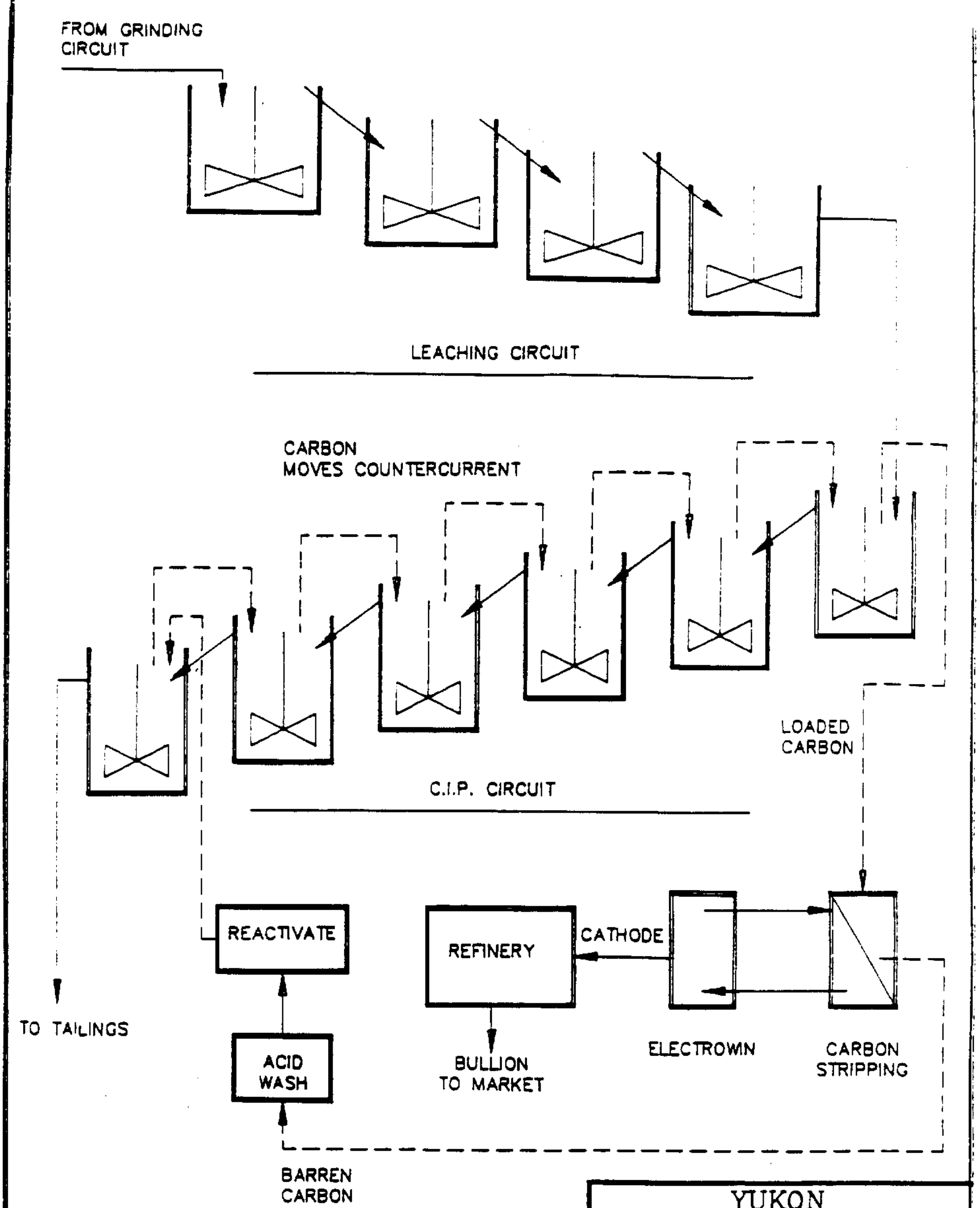
FLOTATION FLOWSHEET
CONCENTRATE DEWATERING

| | |
|---|---|
| UMA ENGINEERING LTD. | G.W. HAWTHORN |
| APRIL 1987 | FIG. 3.6 |



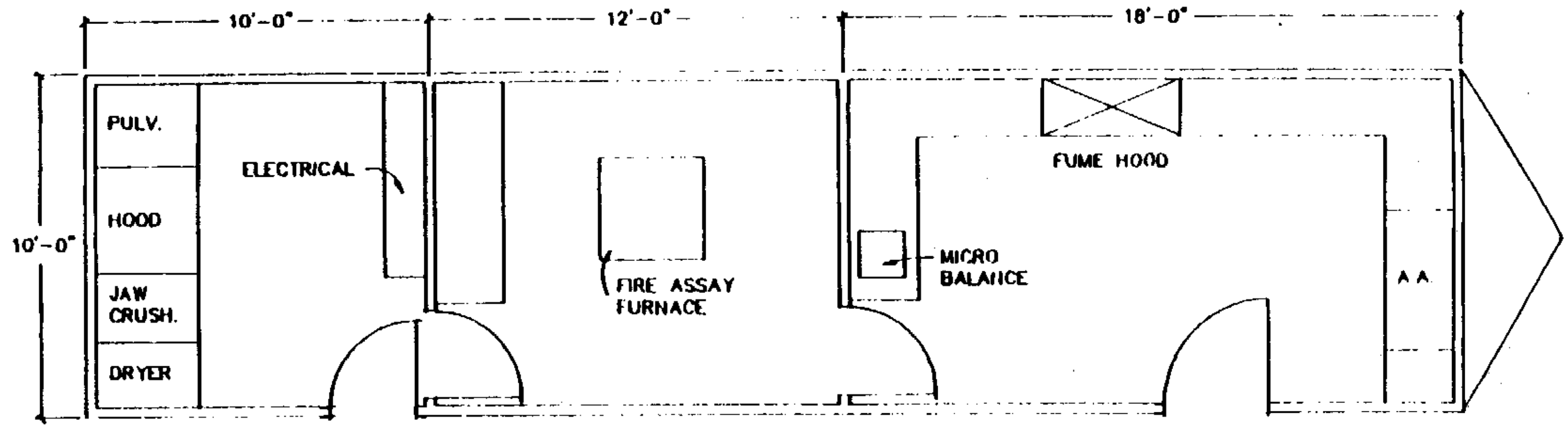

YUKON
CUSTOM/PORTABLE MILLING STUDY
MERRILL CROWE CYANIDATION

| | |
|---|---|
| UMA ENGINEERING LTD. | G.W. HAWTHORN |
| APRIL 1987 | FIG. 3.7 |




YUKON
CUSTOM/PORTABLE MILLING STUDY
CARBON-IN-PULP CYANIDATION

UMA ENGINEERING LTD. G.W. HAWTHORN
APRIL 1987 FIG. 3.8




10' X 40' TRAILER

YUKON
CUSTOM/PORTABLE MILLING STUDY
ASSAY LABORATORY

UMA ENGINEERING LTD
APRIL 1987

G.W. HAWTHORN
FIG 3.9

# SECTION IV

## PROCESS METALLURGY

### 4.1 Metallurgical Evaluation

No attempt should be made to process ore through a commercial scale processing plant without having previously performed laboratory bench scale testing to determine the optimum processing flowsheet.

The laboratory testing of most ores can be performed on as little as 20 kg of sample which represents the deposit from both the perspective of grade, and mineralogy.

If after the initial three or four tests, the deposit appears non-amenable to treatment or "refractory", the testing should be stopped, and an analyses of the technical and financial risks be made.

Laboratory testing will typically indicate very quickly whether a processing is going to be straightforeward or extremely difficult. If the later condition is indicated, the owner should be aware that considerable laboratory expenses may be incurred with no assurance of success.

A good example of a no-win situation, is a deposit which contains exsolution gold in arsenopyrite. This material cannot be cyanided effectively, and even a high grade flotation concentrate may be unprofitable due to limited smelter acceptability and high penalties for contained arsenic.

The prudent investigation of a mineral deposit should contain an allowance for perhaps $2,000 worth of metallurgical testing early in the program. If the results indicate straightforward metallurgy, the exploration can proceed with the reasonable anticipation that satisfactory recoveries and marketable products will result. During the exploration program, additional samples, perhaps more representative of the deposit, can be tested in detail to determine the operating parameters and prepare a detailed process flowsheet.

The exploration geologist must discuss with the mineral processing engineer, any significant variations in the mineralogy of the deposit.

The metallurgical investigation of a well known B.C. gold deposit and its subsequent design was performed on a sample from, but not representative of the deposit as a whole and without regard for variability of the deposit. The plant failed to operate successfully.

This study addresses 3 nominal ore types:
- gold/silver
- lead/zinc
- tungsten

The approach to the laboratory testing of these types of ores is quite dissimilar, and needs to be discussed separately.

All of the selected ore types should be taken as fresh samples and crushed to - 6 mesh. In most cases it is necessary to prepare a composite from several samples to correctly represent the grade and mineralogy of the deposit. The composite assay should reflect the as-mined grade, since failure to do so will create justifiable concern when the test results are extrapolated to mill feed grades.

Only 2-4 tests should be performed initially to determine the complexity of the deposit and the direction of the future testing. Depending on the ore types, some combination of gravity (tungsten only), flotation, (gold, silver, lead, zinc), and cyanidation (gold/silver) is warranted.

Beyond this initial investigation, the testing of the various ore type diverges considerably, and is treated separately in the subsequent sections.

## 4.2 Gold/Silver Deposits

The types of gold/silver deposits which may be encountered in the study area include:

a) Gold in a low sulphide or sulphide free ores.

b) Gold with limited silver and some galena, sphalerite, chalcopyrite, pyrite, and / or pyrrhotite. The value of the ore is contained in the gold / silver, although from a processing viewpont it may be possible to produce lead, zinc or copper concentrates as a vehicle to get the precious metals to the market.

c) Gold in complex high sulphide ores with some or all of silver, galena, sphalerite, chalcopyrite, pyrite, pyrrhotite., arsenopyrite, and other contaminants such as antimony. In this ore type, it is anticipated that one or more of the base metals will contribute to the overall economics of the mine operation.

d) Silver with galena.

The discussion in this section is limited to the testing of ores with economic concentrations of gold and/or silver only, i.e. ore types (a) and (b).

Generally lead/zinc/copper deposits (i.e. type (c) and (d)) containing gold/silver, are processed by froth flotation with a possible gravity circuit ahead of flotation. This type of deposit will be discussed in Section 4.3.

The most desirable gold/silver deposit from the mineral processing perspective is one which contains both free metallics and little or no sulphide mineralization. It may then be possible to produce both gravity and flotation concentrates of sufficiently high grade to market them both without incurring excessive sales costs. Note that the cost of marketing concentrates must include an allowance for: freight, treatment and refining charges, penalties for undesirable constituents, metal payment which may not exceed 91%, and deferred payment terms.

Most gold deposits are processed in a circuit which contains a cyanidation stage. The reason being that, in spite of the higher capital and operating cost of a cyanidation plant, the sales revenue of flotation concentrate is typically substantially less than that of bullion.

The owner of a deposit which is not constrained by low mineral reserves, and who can demonstrate the economics of a cyanidation circuit, will almost certainly endorse that approach unless the environmental constraints prohibit it.

The owner of a small deposit which can technically be processed by either cyanidation or flotation, may opt for the flotation route, even at the apparent lower overall revenue which a flotation circuit will provide.

Note that many deposits do not present the option of both cyanidation and flotation, in which case any production decision will have to stand on the merit of a single possible flowsheet.

A suggested laboratory testing strategy is contained as Figure 4.1.

Far too much laboratory testing is typically performed on gold ores based upon the owner's insistence that since visible gold is present in the deposit, almost all of the gold can be recovered by gravity concentration.

Although gravity concentration techniques are universally accepted for the recovery of gold in placer deposits, the authors are unaware of a single hard rock gold deposit which is processed by gravity-only techniques.

Gravity concentration can and should be included in a process flowsheet where free gold/silver is encountered. Invariably, gravity concentration will be followed by flotation and/or cyanidation to produce marketable products.

Those gold ores which contain pyrrhotite will probably require an unusual amount of care during testing and operation due to the rapid oxidation characteristic of pyrrhotite. This typically results in (1) concentrates which are pyrophoric (2) a need to preoxidize and perhaps filter the ore prior to cyanidation and (3) strong acid generating potential both as ore and tailing. The acid generation potential of an ore will come under severe scrutiny by officials responsible for environmental protection, since high pyrrhotite ores, once exposed to oxygen, can become acidic very quickly and for a long period of time.

Although cyanide contained in the effluent of a gold operation will cause some concern, and may require special control circuitry, the far greater concern is the acid generation potential of disturbed ores and tailing, since any problem is not readily rectified once having been created.

In summary, the deposits discussed in this Section leave the ore owner with three basic choices which depend on both metallurgical and smelter economics.

a) Gravity Circuit Concentration
   Flotation Circuit Concentration
   Concentrates to Smelter

b) Gravity Circuit Concentration
   Flotation Circuit Concentration
   Cyanidation of Concentrate
   Refining to Bullion

c) Possible Gravity Circuit Concentration
   Cyanidation of Mill Feed
   Refining to Bullion

For the small portable mill operation, this study considers that alternative (a) may be the best compromise for an itinerant plant with seasonal operators.

## 4.3 Lead/Zinc/Copper Deposits

The investigation of lead, zinc and copper deposits with or without precious metal values is typically more straightforward than that of a gold/silver deposit, since cyanidation is almost never required for the operation to succeed financially.

On the other hand, the current prices of lead and zinc, at Can. $0.34 and $0.50 per pound respectively will almost certainly require precious metal payables for the operation to succeed.

Laboratory testing is therefore limited to differential flotation concentration and minor gravity separation.

Deposits which contain more than one base metal in economic concentrations, will typically warrant the production of more than one concentrate to maximize the sales revenue. Where precious metals are recovered in lead/zinc concentrates, the payment for either will be essentially 91% of the contained values, providing the lead/zinc concentrate(s) support the cost of marketing.

Details of the proposed laboratory testing program are outlined in FIG. 4.2.

Note that where differential flotation is indicated to produce more than one concentrate, the control of flotation reagents can be much more complex than the typical bulk sulphide flotation which is indicated for gold/silver deposits.

## 4.4 Tungsten Ores

The type of ore which will be addressed in this section is limited to tungsten and other high specific gravity mineralization, such as cassiterite (tin ore).

These ore types lend themselves to concentration by gravity methods, although it is common to require flotation and acid treatment of the gravity concentrate for the removal of small quantities of impurities, such as sulphides. (See FIG 4.3)

It is unlikely that the potential operator will have or can attract the necessary skills to successfully control a circuit which contains any more than gravity concentration. If preliminary testing indicates that either of these technical requirements exist, the complexity of that portion of the circuit needs to be carefully assessed to determine whether the risk of failure is excessive.

## 4.5 Regional Mineralogy/Metallurgy

### 4.5.1 Gold

The present proliferation of recorded gold deposits are along the Whitehorse Trough, extending from Montana Mountain - Mount Skukum - Carmacks. Among the deposits examined, there appears to be no uniformity either in mineralogy nor in process requirements. The ores, even in a close regional context, are highly divergent in their sulphide content and economic metallurgical treatment.

Ores like that at Mount Skukum mine, which have very low sulphide, are probably an anomaly, with the nearby Omni Resources deposit with its mixed bag of sulphides being more normal.

Because of the high unit value of gold, the tendency is to design a site-specific process plant around a specified recovery circuit. At this time it seems conceivable that the Mount Skukum area may develop two plants, i.e. the present cyanide plant plus a gravity - flotation - cyanide plant. Should this be the case, it would appear more reasonable to have these plants accept a toll processing role, than to interject an itinerant toll plant to the area.

In addition to the cost-benefit to the plant owners, the major role of government participation would revolve around alleviation of the present high cost of diesel-electric generation.

Should subsequent events and discoveries make an itinerant plant feasible, a 100 Ton per day gravity - flotation circuit is favoured, either with or without a cyanide treatment addition.

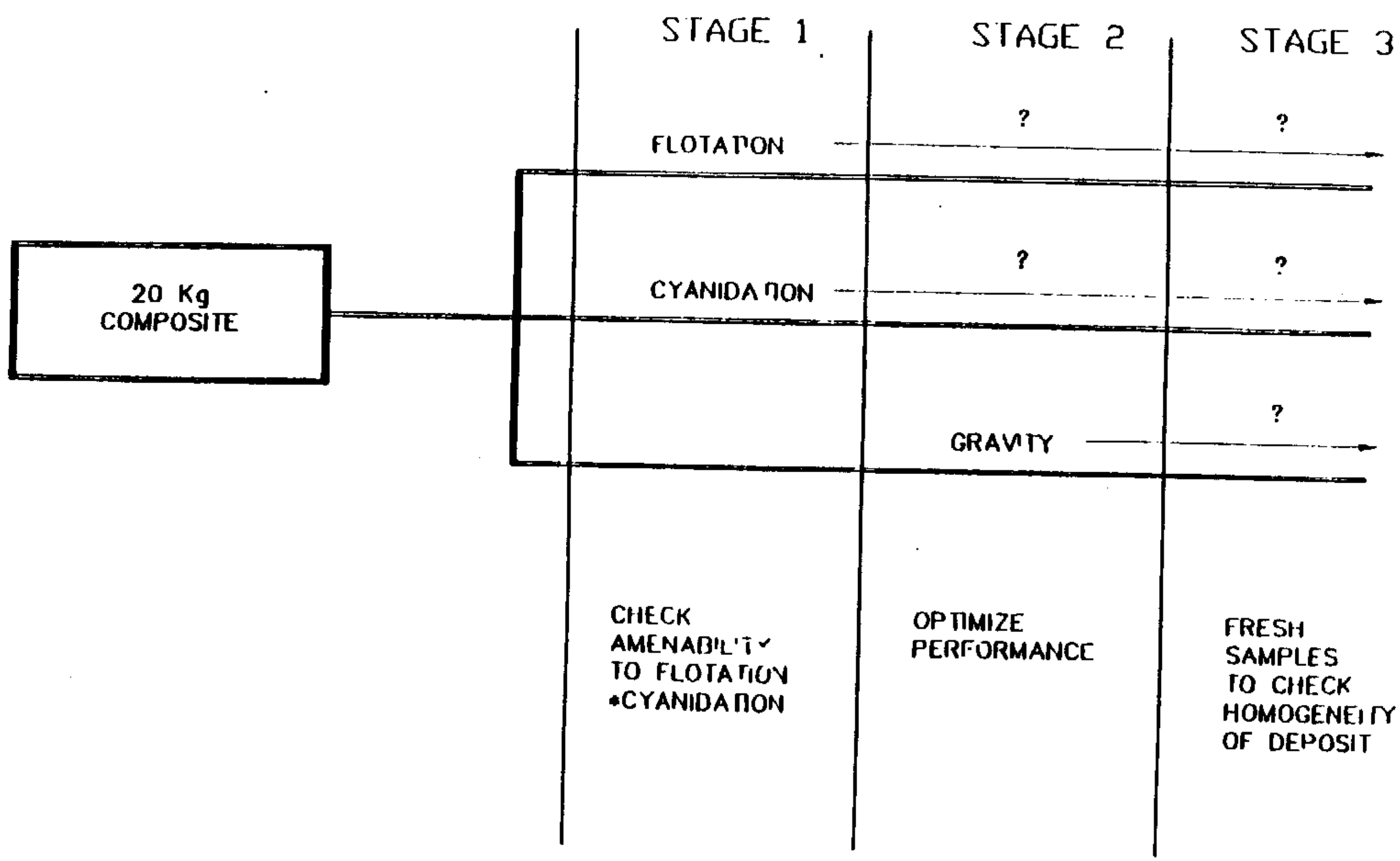
### 4.5.2 Silver

The present concentration of silver deposits are centered around the Keno City area, although not confined to this region. These ore occurrences are primarily associated with galena and/or tetrahedrite. Both Dawson Eldorado Mines and Springmount Operating Co. operate on a "hi-grading" or "pocket-hunting" basis in the Keno area, shipping hand-cobbed high grade ore. A 100 TPD (or smaller) flotation plant would permit lower grade and mine dilution material to be upgraded with little additional mining cost. Although power could be supplied by the Keno hydro plant for process equipment, a diesel-electric unit for intermittent crushing loads may be more economic. Considering that such a plant would require more widely ranging use throughout its life, a totally diesel-electric component may be a more long-term practical alternative.

In this type of plant, the ore may be processed to produce a single flotation concentrate based on a predominantly galena-rich lead ore containing economic silver values. Since such ores often develop high zinc content associated with gold, particularly at depth, it may be economically advantageous to produce two concentrates, i.e. a lead concentrate containing most of the silver and a zinc concentrate containing most of the gold. Testing research will determine whether and to what degree a dual concentrate is effective. Close examination of smelter contracts and their payment and penalty schedules will determine whether the dual concentrate has an economic advantage.

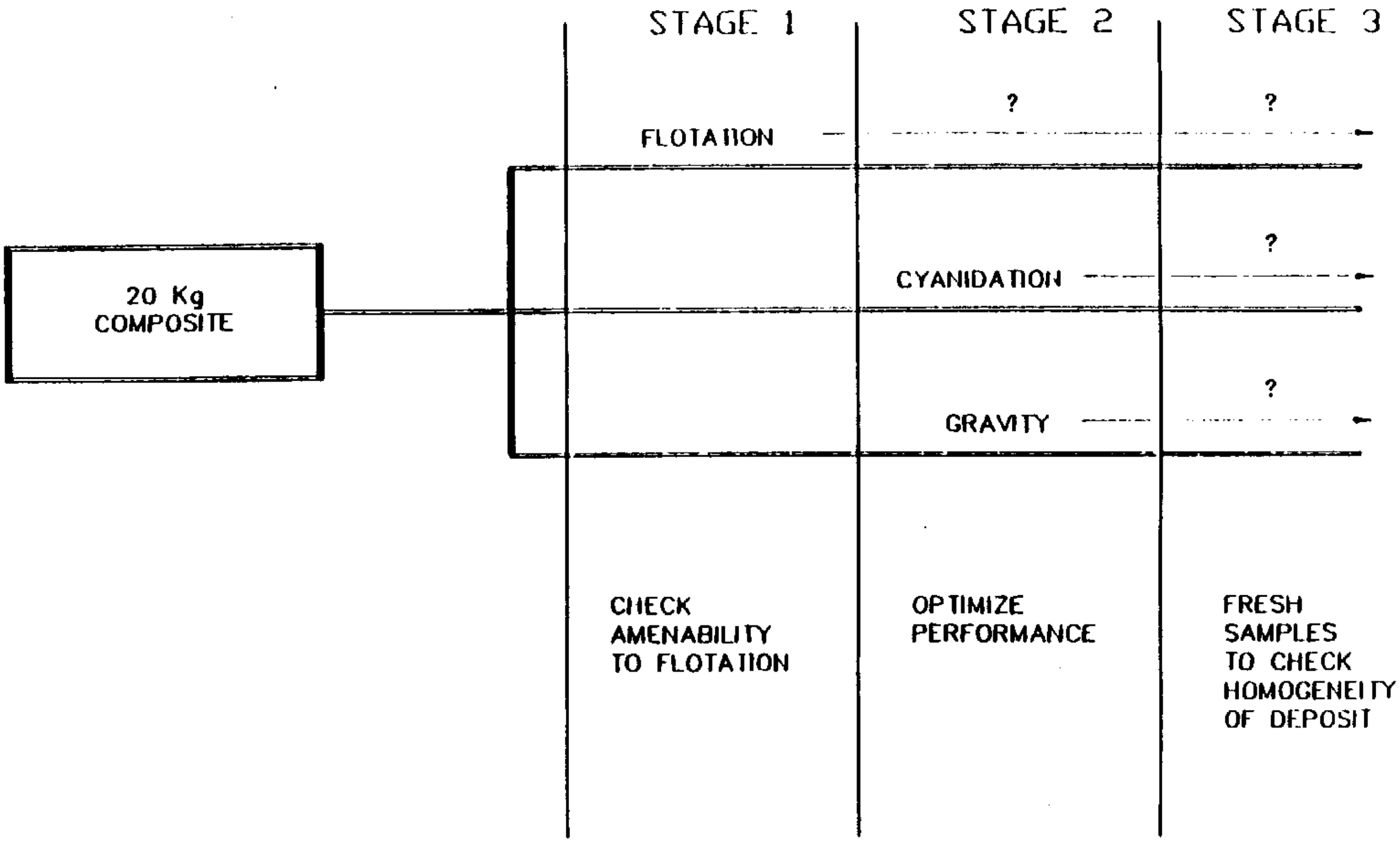
### 4.5.3 Tungsten

While a simple gravity system may be sufficient for some tungsten ores, a more sophisticated circuit involving flotation and acid leaching is more common. In addition, the tungsten market is presently not only depressed but the Territories already have one mine closed with 3 to 4 years of reserves intact, as well as another world-class deposit fully engineered to replace it. While the influence of China on the future world supply and price is not known, it would appear unlikely that any meaningful spot market will materialize for 3 to 5 years. For this reason, this study does not wish to encourage generalized optimism for custom plants in Yukon tungsten ores.



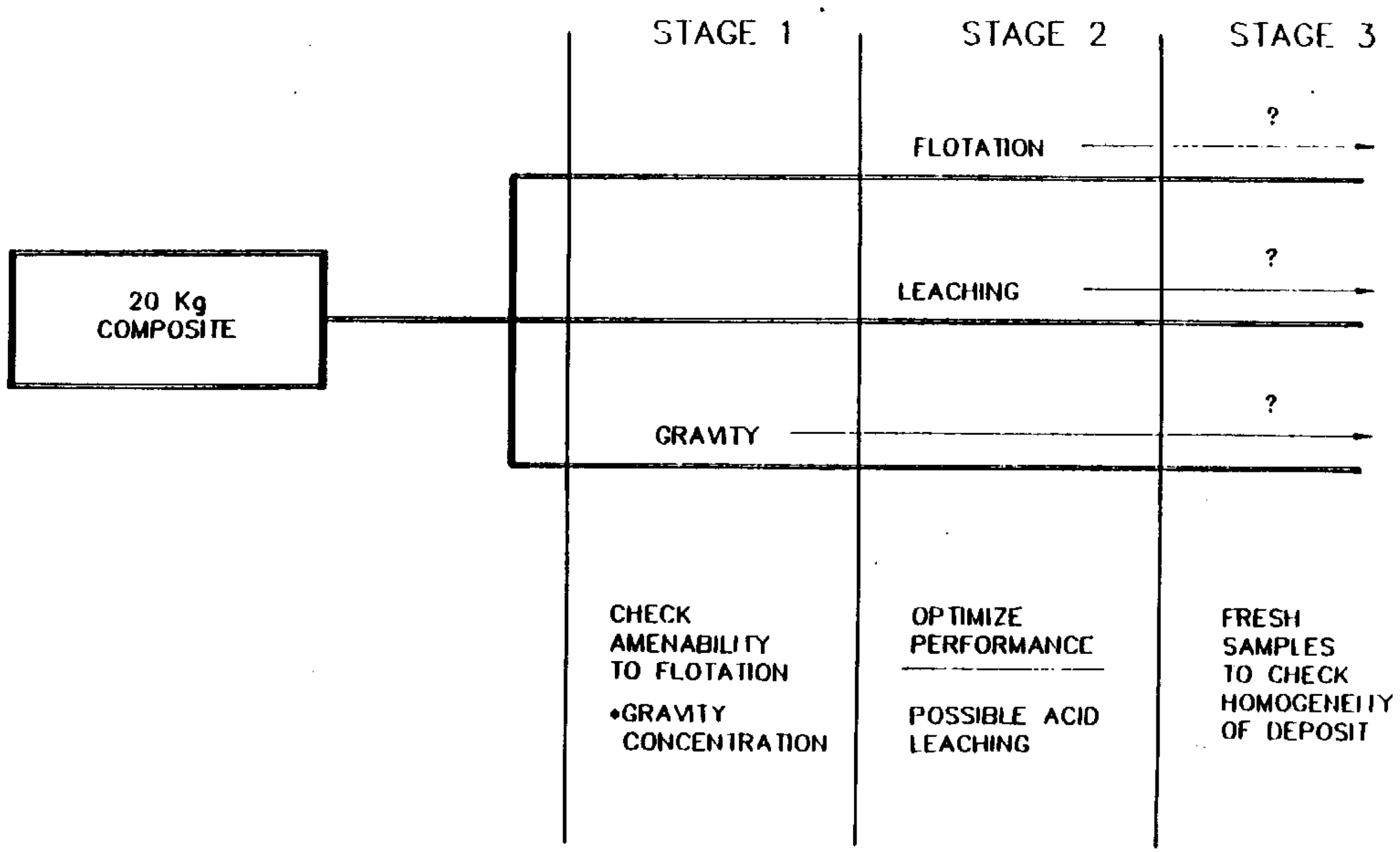

YUKON
CUSTOM/PORTABLE MILLING STUDY
LAB TESTING - GOLD/SILVER

UMA ENGINEERING LTD. G.W. HAWTHORN
APRIL 1987 FIG. 4.1




YUKON
CUSTOM/PORTABLE MILLING STUDY
LAB TESTING – GOLD/SILVER/BASE METAL

UMA ENGINEERING LTD | G W HAWTHORN
APRIL 1987 | FIG. 4.2




YUKON
CUSTOM/PORTABLE MILLING STUDY
LAB TESTING - TUNGSTEN

UMA ENGINEERING LTD — G.W. HAWTHORN
APRIL 1987 — FIG. 4.3

# SECTION V

## PLANT DESIGN DETAILS

### 5.1 Stationary Plants

The detailed design of a stationary, all weather plant is beyond the scope of this report.

### 5.2 Mobile Plant and Modules

The mobile plant will be fabricated at a site which will provide the best value for construction dollar, and will be trucked to the first processing site.

The plant equipment components will be fully modularized as either skid mounted or trailer assembled units.

It is assumed that the owner will purchase older but roadworthy nominal 40' highway trailers for the installation of the plant components and transportation of the plant and operating supplies.

### 5.2.1 Design Criteria

The following design criteria have been selected for the crushing and grinding circuits of the proposed modular mill. It is assumed that the processing plant will treat 90 t/d (100 TPD) of ore through the crushing and grinding circuits to provide feed for the recovery circuit(s).

The various recovery circuit modules can be included as required to satisfy the processing needs of whichever ore type is being processed at the time.

It is not reasonable to illustrate every possible configuration which might be made in the assembly of a small portable modular mill. The report attempts to address the equipment and configuration options which are available so that the ultimate designer of a portable mill can best ulitize the equipment and services which are available.

The indicated 90 t/d (100 TPD) plant capacity was selected for illustration purposes only. Although the equipment cost for a smaller capacity plant will be somewhat lower, it is anticipated that the capital cost of a say 50 TPD plant will be 80% of that of a 100 TPD plant.

| Design Criteria | English | S.I. |
|---|---|---|
| Milling rate (1) | 100 TPD | 90 t/d |
| Ore size | - 12" | - 300 mm |
| Crushing rate | 25 TPH | 22 tph |
| Ball mill feed size | - 0.5" | - 12 mm |
| Ball mill power | 100 HP | |
| Grinding circuit | | |
| Product size | 50 % - 200 mesh | P80 = 200 micron |

(1) per 24 hour day, dry, tons (tonnes) per day. Includes allowance for 95% operating time.

### 5.2.2 Crushing

The proposed crushing plant consisting of a jaw crusher followed by a closed circuited cone crusher, will be installed on a single 40 foot trailer, as shown in Figure 5-1

The crushing plant will require the dedicated services of a small front end loader to move rock from the coarse ore stockpile to the coarse ore bin, and to move crushed ore to the ball mill feed hopper.

The crushing plant equipment has been sized to accept -300 mm (12") ore, and will have a capacity of 25 tons per hour. An electro-magnet to trap scrap steel prior to the secondary crusher is a desirable feature.

### 5.2.3 Grinding

The proposed 100 HP ball mill and feeding system can be installed on half of a 40' reinforced trailer unit, as shown in Figure 5-2.

Note that the weight of the nominal 6' X 6' ball mill which is required for this application is approximately 13.5 t (30,000 lbs.) plus an additional 6.7 t (14,000 lbs.) for metal liners. The ball charge will add a further 10 t (23,000 lbs.) to the weight for a total of 30.2 t.

Although it has been recommended that rubber liners be used in the mill, a serviceable set of metal liners purchased with the mill should be consumed before changing to rubber.

When transporting the grinding mill, the ball charge must be emptied to avoid damaging the trunion bearings, and the mill must be raised off the trunion bearings. If the mill is to be relocated frequently, a special cribbing should be provided to support the mill in the elevated position.

Note that the operating grinding mill has a substantial dynamic mass, and requires a heavily reiforced and well supported base structure. Failure to satisfy this requirement will undoubtedly result in drive misalignment which will cause rapid failure of the pinion gear.

5.2.4 Recovery Circuit

Gravity

The gravity equipment in the proposed plant will consist of an 8" x 12" duplex jig located at the discharge end of the ball mill, and a 2' x 4' snaking table which will be used to periodically upgrade the gravity concentrate into a marketable product. Because of the anticipated low production rate of the jig concentrate, the concentrate will be bucketed to the table as required. Note that the table is located at the discharge end of the grinding mill so that the table tailing can be returned by gravity to the grinding circuit.

A sealed tray should be installed below the jig to contain any spilled concentrates.

Flotation

The flotation equipment for a single product circuit will consist of a single bank of "Denver" cells which will provide two stages of cleaning to produce a marketable product.

This bank of cells can be installed along one side of the trailer so that the trailer deck can provide the walkway.

Where two flotation concentrates will be marketed, the installation of two flotation banks back-to-back is feasible, as shown in Figure 5-4.

Cyanidation

From a technical viewpoint, there is no good reason why either straight cyanidation or concentrate cyanidation cannot be performed in a mobile plant.

However, it must be cautioned that the permitting requirements will be much more severe for a cyanidation plant than for a flotation circuit. Undoubtedly, the permit will require:

- Sealed containment for the cyanidation circuit.
- No transportation of cyanide solutions off-site.
- Complete destruction of cyanide in the waste solutions before the mobile plant can be relocated to a new site.

Although the design provides for the installation of a cyanide circuit, such circuitry may well be difficult for a junior operator to operate safely and efficiently.

From a regulatory perspective, the in-house technical capabilities of the prospective operator should be evaluated, since it is quite likely that the junior operator does not have and cannot afford to have an in-house "expert". In this case, any environmental permit should be issued subject to the retention of a consultant, as is done for tailing dam structures.

Note that a relatively large number of leaching tanks (8) is indicated. This has occured because of the perceived desire to transport the plant as intact modules.

The proposed process flowsheet utilizes a Merrill Crowe circuit, since it will maintain a closer control over the inventory of cyanide solutions than is attainable in a conventional carbon cyanidation circuit.

Note the requirement for 3 trailer units to support the entire cyanidation circuit.

Another option, not shown, is for the cyanidation of a flotation concentrate. Normally, this is not cost effective unless a substantial portion of material can be discarded to waste from the flotation circuit. This can be ascertained only after having performed both laboratory testing and a financial feasibility.

5.2.5 Dewatering

In all likelyhood, the concentrate dewatering equipment can be located on the same trailer unit as the flotation circuit.

Where more than one flotation concentrate is produced, the use of a single disc filter with a divided tank will serve well, and is frequently used in smaller capacity lead/zinc concentrators

For reasons of space economy, the flotation concentrate will be fed directly from the flotation concentrate launder to the disc filter boot. More conventionally, a thickener is installed between flotation and concentrate filtration to provide both surge capacity and decrease the water removal requirement on the filter. The deletion of the concentrate thickener is a compromise which has been made for reasons of capital economy.

5.2.6 Power

The truly portable/modular mill will be powered by a single diesel electric generator which will be enclosed with the distribution switchgear.

Depending on floor space requirements of the ball mill, it may be possible to install the generator and distribution switchgear on the same trailer as the ball mill. In any case, the generating / distribution system should be located in close proximity to the ball mill which represents the highest power load in the plant.

The noise produced by the generator is sufficiently high that, if a van is underutilized, the balance of the space can be used only for storage and not as a working place.

5.2.7 Assaying

The on-site assay facilities must be able to supply a sufficient range of capability so that the operating requirements of the mine and mill will be met.

The equipment choices are discussed in some detail in 3.3.4 and will not be repeated here.

5.2.8 Personnel Housing

Ideally, the mill will be located so that no on-site housing will be required. If this is not possible, a mobile home (to provide kitchen, washing, and entertainment) and a sleeper will probably satisfy the requirements for the estimated 6-8 full time employees.

Septic facilities and a potable water supply will be required for the camp.

5.3 Environmental

The environmental impact of the operation of a concentrator requires careful consideration at the conceptual stage to avoid committing to do something which is not achievable.

The area of greatest concern relates to the chemical quality of the tailings and effluent water.

The following characteristics of the plant tailings need to be addressed at the laboratory testing stage:

- Acid generation potential of the plant tailings
- Dissolved "metals" in the plantsite effluent
- Cyanide in the plantsite effluent

5.3.1 Acid Generation Potential

Within the last several years, it has become apparent that the most important long term legacy of a poorly planned and executed mining operation relates to the disposal of tailings and waste rock which are acid generating.

Tailings which contain significant sulphide mineralization can, on exposure to oxygen, oxidize and create a strongly acid environment which may generate acidic run-off for many years.

It is therefore manditory that acid generation potential testing be performed, ideally in conjunction with the metallurgical study.

Two test techniques are employed, chemical and biological.

A typical chemical acid generation potential test result is as follows:

| | % S | $H_2SO_4$ - kg/T Generate | Consume | Net Generate |
|---|---|---|---|---|
| Sample A | 2.12 | 66.3 | 32.7 | 33.6 |

If the material is net acid consuming or only slightly (<10 kg/T) generating, the material can be disposed of, having determined that no potential problem exists.

If a positive acid potential is reported, a biological test will normally be made to indicate whether the potential will be realized in practice.

The cost of the testing is as follows:

- Chemical Test $50
- Biological Test $400

If the tailings are acid generating, the tailings pond should be operated in a flooded state and, on abandonment, should be flooded, capped or otherwise engineered to effectively prevent oxidation.

Revegetation of tailings which are high in sulphur will be expensive and, in many regions, may not be entirely successful.

5.3.2 Dissolved Metals

Although not a frequent problem, the dissolved metal content (typically Cu, Pb, Zn, Fe, Ni, Sb, As, Hg) and other contaminants (CN, T.D.S., pH, conductivity) need to be determined.

5.3.3 Cyanide

It is very unlikely that permitting can be obtained for a cyanide concentrator without any requirment for the installation of a cyanide destruction system. The potential operator should anticipate that chemical destruction of cyanide will be required.

The cyanide destruction circuit can be located in several possible positions within the process flowsheet. The preferred choice will depend on:

- Process flowsheet
- Solution chemistry
- Climate
- Site topography
- Climate
- Policy of the regulatory agencies

Typical siting of the destruction circuit include:

- Plant barren bleed (Merrill Crowe Circuit)
- Plant tailing (carbon cyanidation)
- Tailing pond decant solution

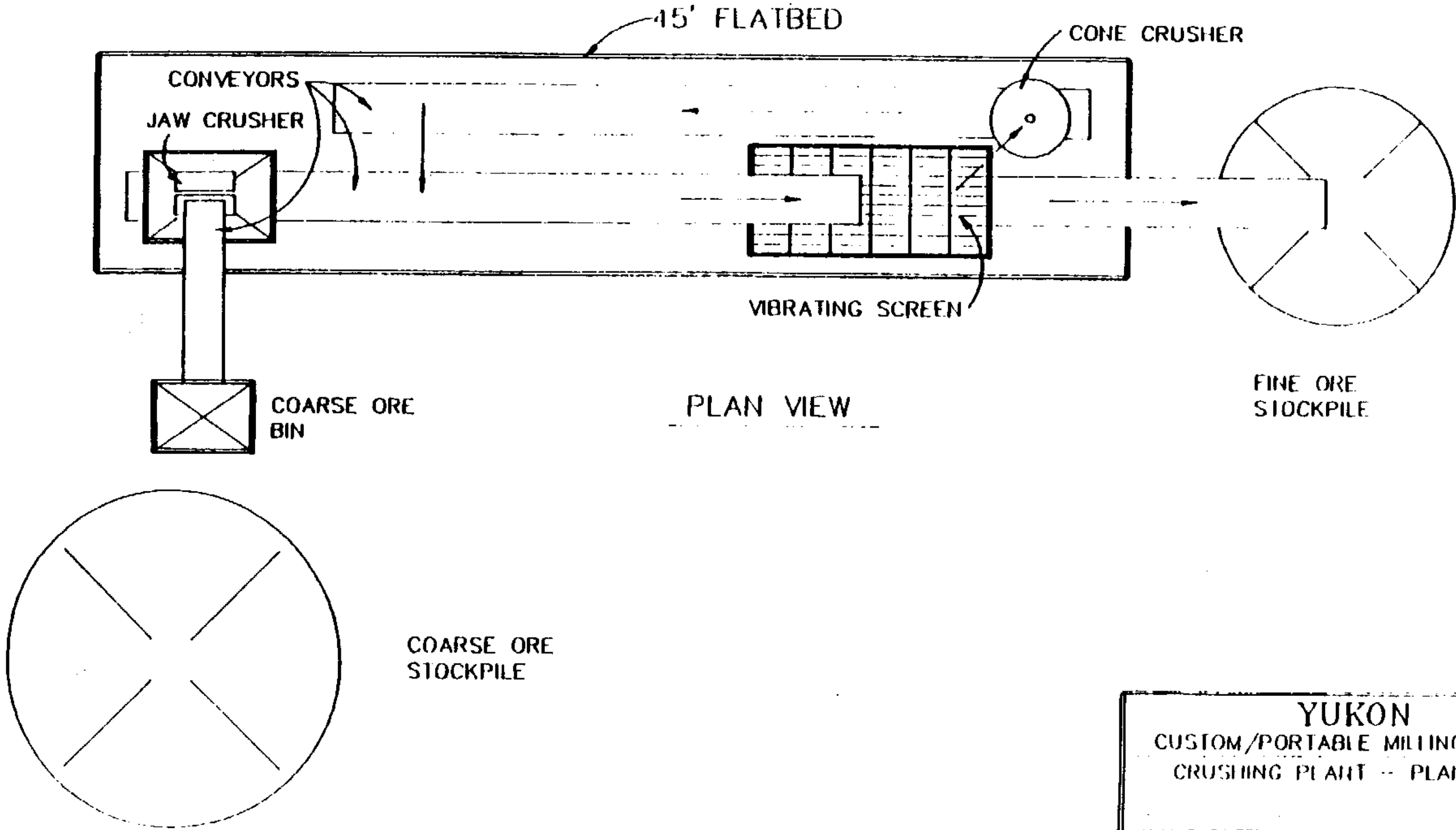
Generally, the preferred choice is to operate a "dirty" tailings pond from which solutions can be recycled to the plant. If the pond accumulated solutions beyond the process requirements, it may be necessary to discharge excess solution as it is being discharged from the pond.

This approach requires a larger tailing containment than is normally required for the settled solids, but it will maximize the natural "no cost" destruction of cyanide which will occur within a "few" weeks or months. This should provide an adequate level of protection for both the operator and the regulatory agency, and will minimize the operating cost of cyanide destruction.

Site conditions will dictate whether this option is technically feasible.

### 5.3.4 Air Emission

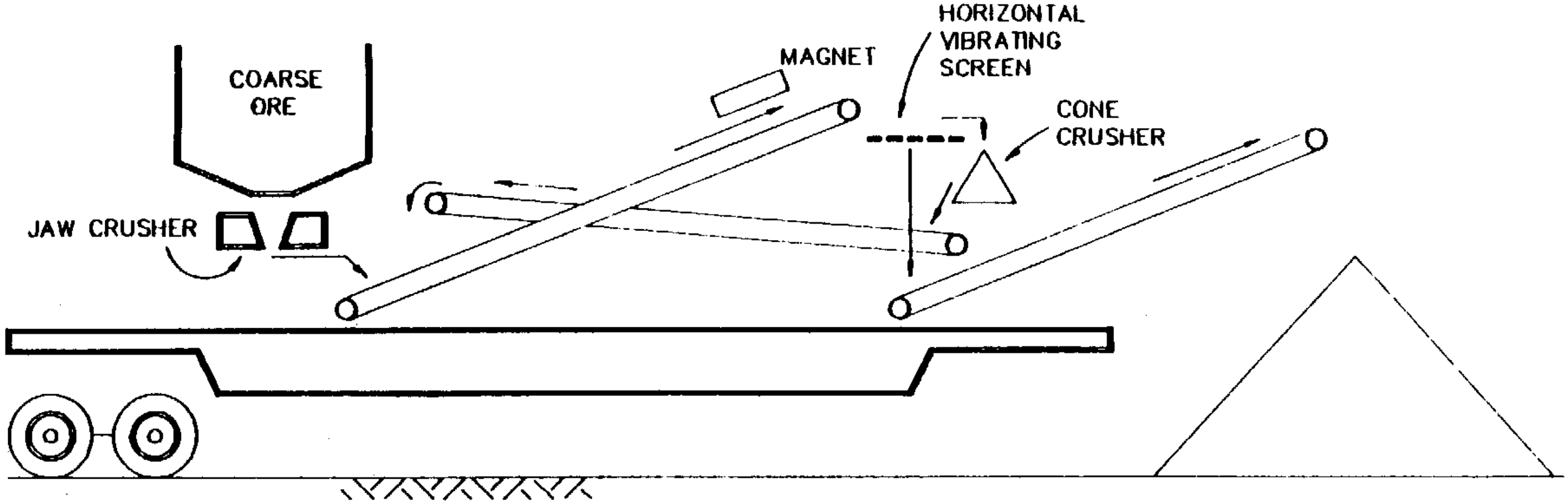
Normally, a dust collecting system will be required over the crushing plant process equiment. This will include one of: cyclone, baghouse, or wet scrubber.




PLAN VIEW

YUKON
CUSTOM/PORTABLE MILLING STUDY
CRUSHING PLANT -- PLAN VIEW

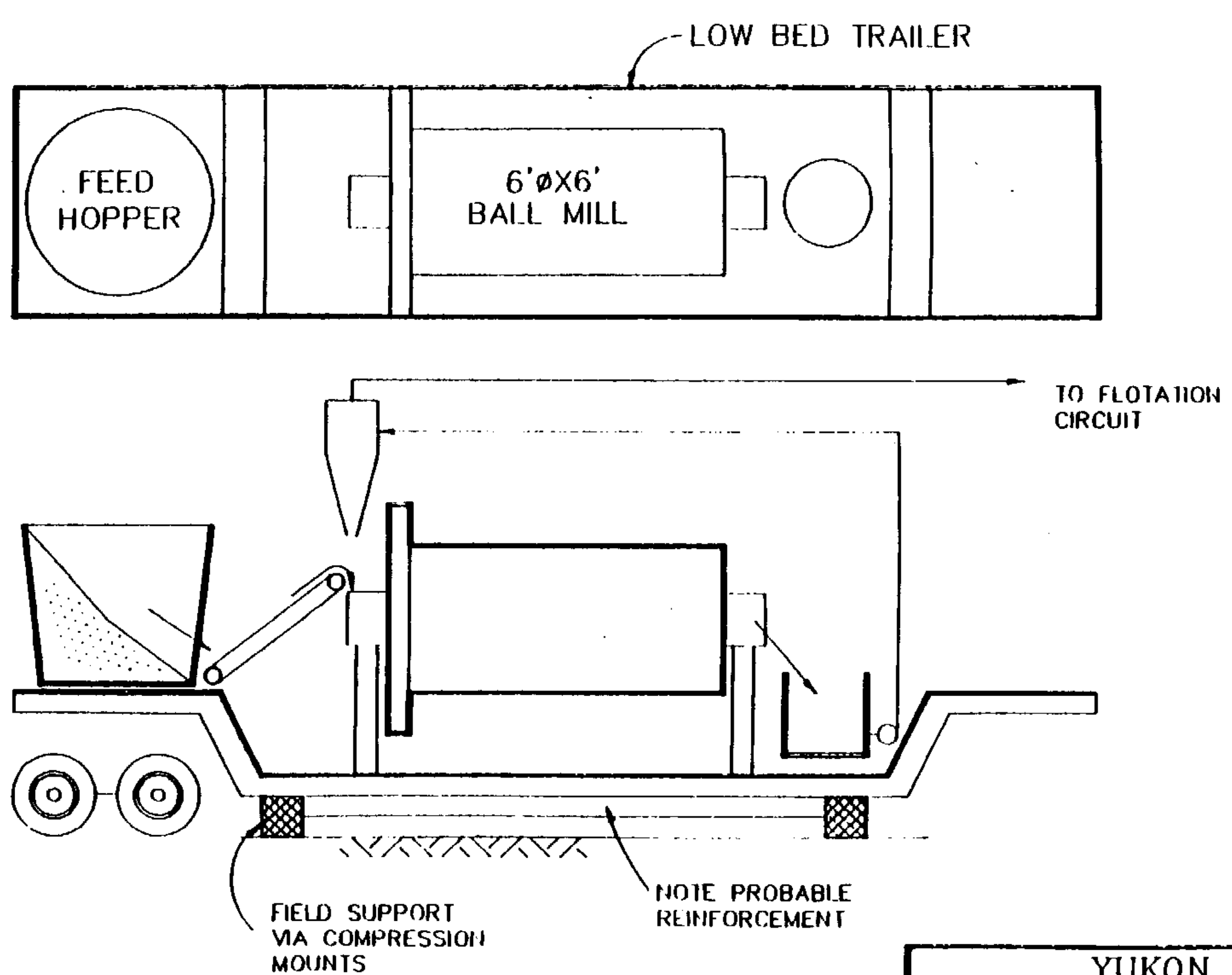
UMA ENGINEERING LTD. | C.W. HAWTHORN
APRIL 1987 | FIG. 5.1




ELEVATION VIEW

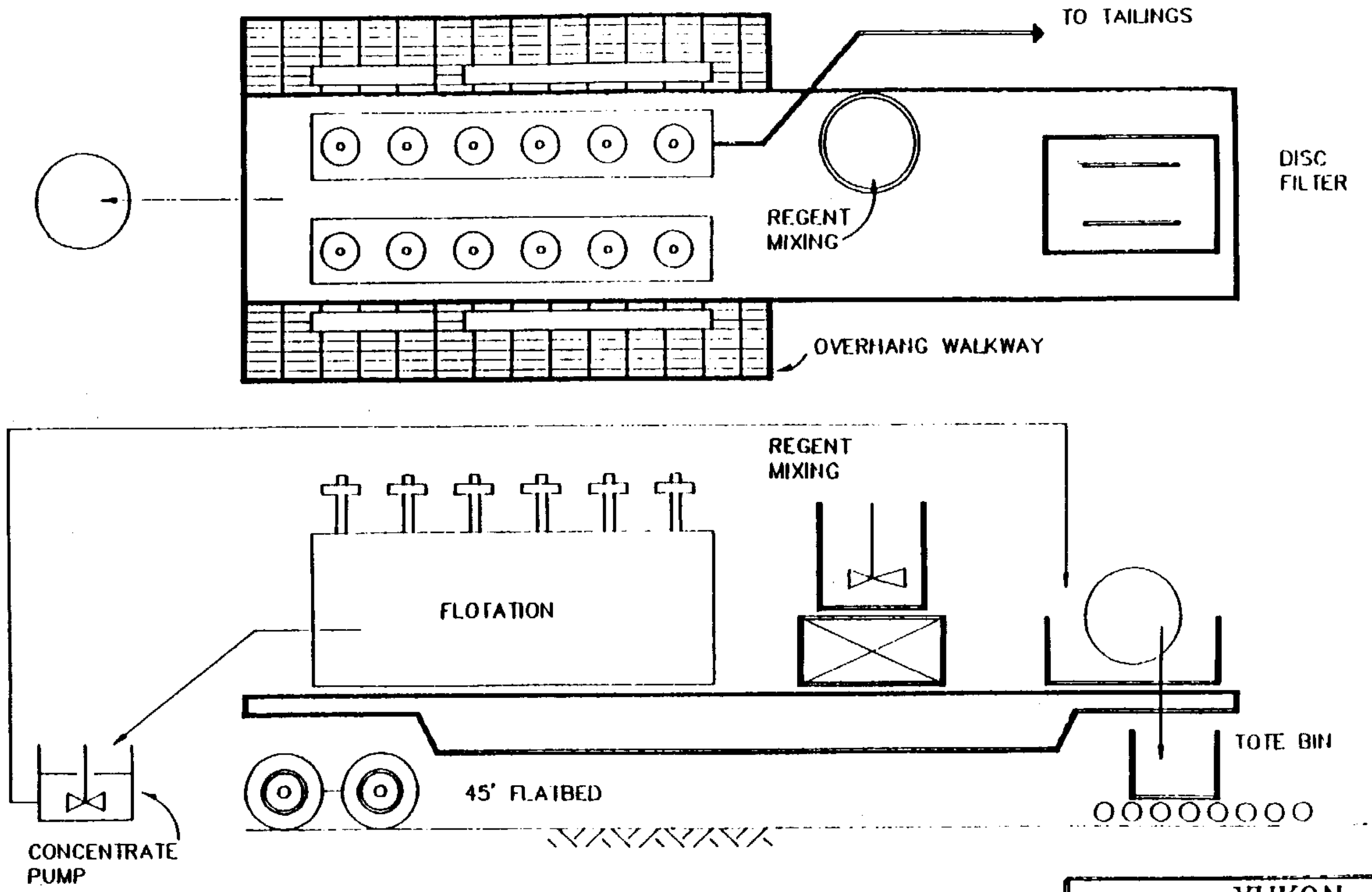
YUKON
CUSTOM/PORTABLE MILLING STUDY
CRUSHING PLANT - ELEVATION VIEW

UMA ENGINEERING LTD. G.W. HAWTHORN
APRIL 1987 FIG 5.2



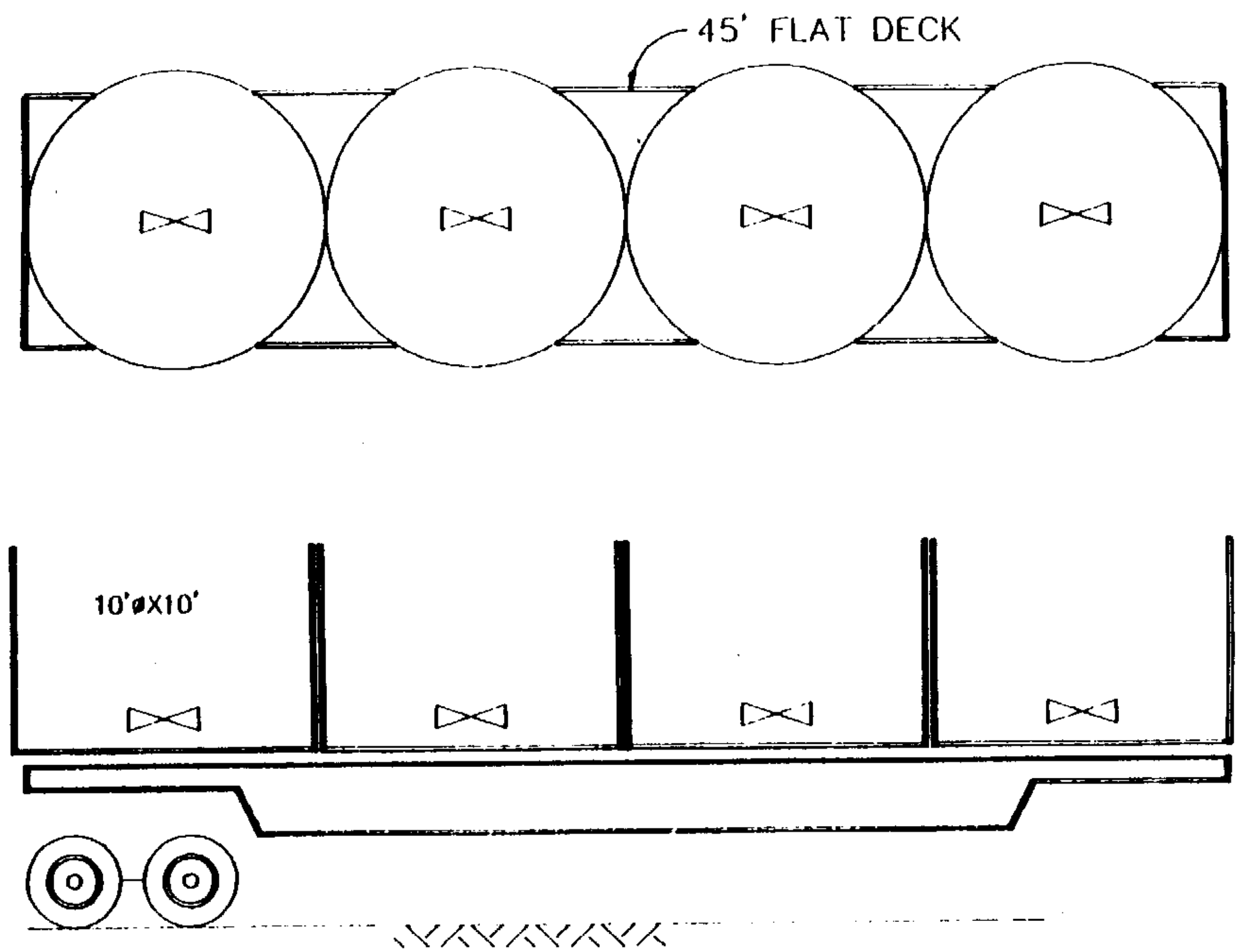

YUKON
CUSTOM/PORTABLE MILLING STUDY
GRINDING MODULE

UMA ENGINEERING LTD. — G.W. HAWTHORN
APRIL 1987 — FIG. 5.3




YUKON
CUSTOM/PORTABLE MILLING STUDY
FLOTATION / DEWATERING

UMA ENGINEERING LTD. G.W. HAWTHORN
APRIL 1987 FIG. 5.4

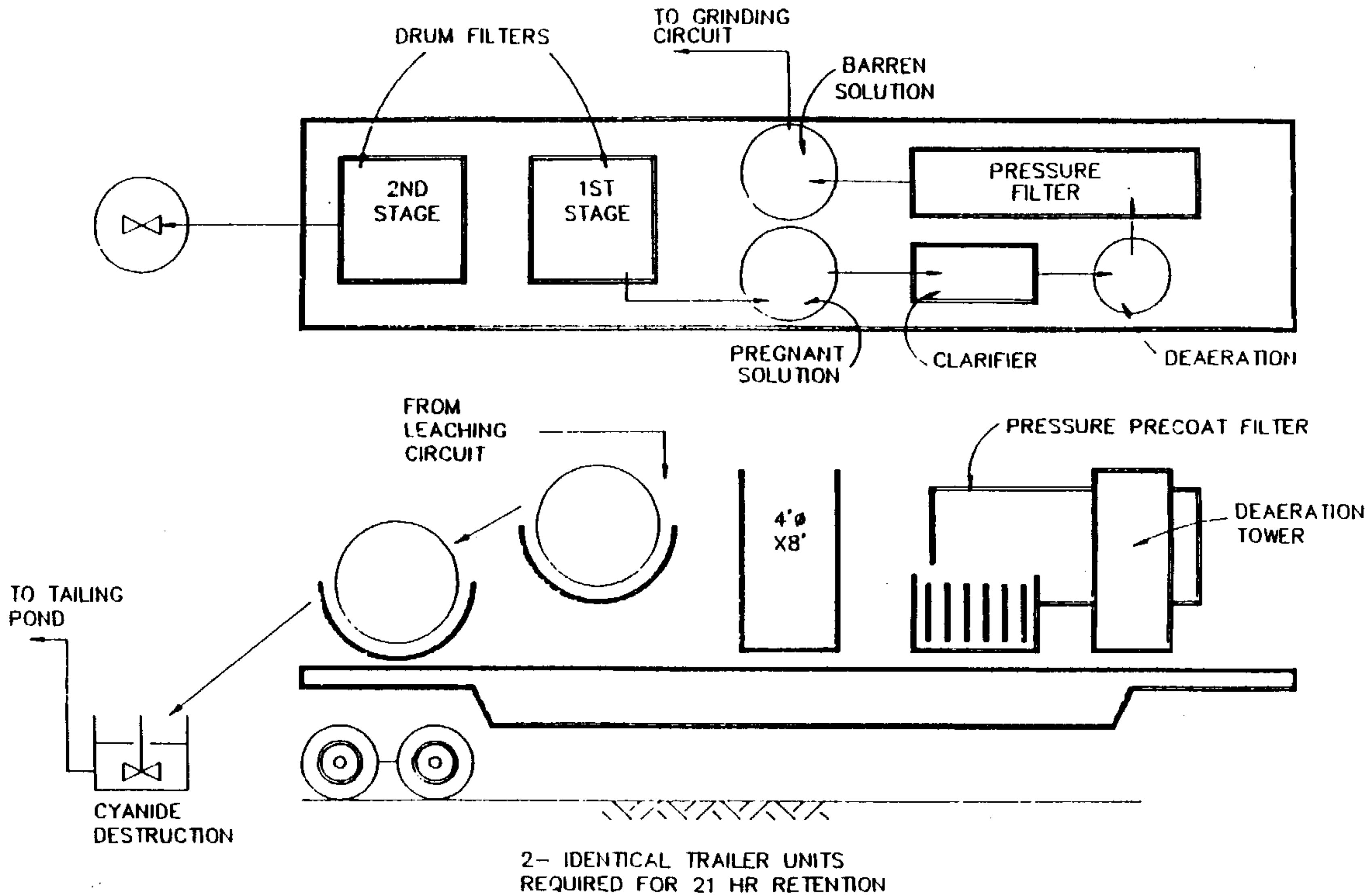



2- IDENTICAL TRAILER UNITS
REQUIRED FOR 21 HR RETENTION

YUKON
CUSTOM/PORTABLE MILLING STUDY
CYANIDATION – LEACHING

UMA ENGINEERING LTD.
APRIL 1987

G.W HAWTHORN
FIG. 5.5




YUKON
CUSTOM/PORTABLE MILLING STUDY
CYANIDATION – PRECIPITATION

UMA ENGINEERING LTD. | G.W. HAWTHORN
APRIL 1987 | FIG. 5.6

## SECTION VI

## MARKETING

### 6.1 General

A vital part of both the economic evaluation of a property and its successful operation, is a detailed sales revenue analysis for the product(s) of the operation.

If the products consist of only gold and silver as either bullion or high grade gravity concentrate, the net sales revenue can be expected to be 98% to 99% of the contained values, less modest shipping and treatment charges. The net return will exceed 97%, and full payment will be within less than 10 working days.

The sale of concentrates and high grade ores is much more costly, and therefore requires a thorough net smelter return (NSR) analysis prior to making any production decision.

Detailed smelter schedules follow this Section.

### 6.2 Sale of Ores

The small mine operator who elects to have his ores processed by others may have the option of either selling the ore to the processor, or to have the ore toll processed and the products returned to himself for sale.

For the toll processing option to satisfy both parties, it will be necessary in the case of a gold/silver ore to shut down the grinding circuit for several days and remove, clean, and replace the liners to recover inevitable free gold. The cost of this nonproductive period will have to be borne by the seller.

A large processing plant which receives small shipments of ore for custom milling will not be prepared to shut down his operation since the production loss will exceed any revenues which tolling would have created. The only rational approach would be to sell the ore to the custom mill under terms which would contain the following clauses.

Item

Treatment charge
Pay:
Assay feed grade less 0.01 oz/t Au
Assay feed grade less 0.01 oz/t Ag
Recovered Au/Ag based upon lab test, less 1%.

Treatment charge includes the cost of weighing the ore (ideally truck scale, alternatively use belt cuts), determining the moisture content, transporting it from the stockpile to the crusher, processing, head sampling and assaying. If the material is not comingled, the processing circuit will be sampled to determine the actual plant metallurgy of the material, so that if any change in recovery compared to the laboratory testing is indicated, an adjustment to the payables can be made. In any case, a sample of the feed composite should be retained from each production run for possible laboratory testing in case of dispute.

Even among professionals, there is a tendency toward too much emphasis on assays. Both the buyer and seller must appreciate the equal importance of ore feed weight, moisture content and representative sampling.

A minimum lot size will need to be defined under any scenario where the mine's ore is processed by others. This will be a function of the compatability of the various ores which will be processed through the plant; whether they can be comingled; whether it is necessary to thoroughly clean any accumulated metallics from the circuit prior to processing other material; and the sellers willingness to pay a premium for small lot processing.

An inherent limitation of the itinerant mill approach, is the need to queue suppliers until such time as the plant can make an orderly move to the various minesites. The preferred choice, unless trucking costs become prohibitive, would be to locate the mobile plant centrally to the assured suppliers and have most customers truck-haul their ore to the mill site. This way, the delays of mobilization and demobilization can be minimized.

A possible scenario may be such that the mobile plant moves infrequently within a given field season to the various camps to operate at a central location in each area.

The sales contract of ores must include a statement on the event which transfers ownership of the ore, and which protects the seller from possible business failure of the processor.

Once a commitment has been made to both supply and process, a binding document should be made in which the failure of either parties to perform is subject to a penalty.

## 6.3 Purchase of Ores

A company which constructs and operates a mineral processing plant for the sole purpose of treating the ores of others, is at risk that the good intentions of the ore suppliers will not be fulfilled. With this eventuality in mind, it may be prudent to consider constructing a plant on a co-op basis, such that the anticipated ore suppliers indicate their sincerity by contributing some portion of the capital cost of the plant, which would then be owned by a limited company in proportion to the initial contribution. This will provide all parties with greater risk, but greater commitment. To keep this arrangement unencumbered, the firm which is responsible for the design and construction of the plant should be at arm's length to the various owners.

## 6.4 Sale of Concentrates and Bullion

The smelter schedules for the sale of flotation concentrates are lengthy documents, and have been condensed. (See Tables 6.1 to 6.6)

The report contains several sets of calculations on smelter payment for several theorized concentrate types. The mine owner must pay particular attention to the use of these schedules in preparing a feasibility study.

Smelters have been accused of charging excessively for their services, but almost always the complaintant has failed to read and comprehend the typically very detailed smelter schedule which the smelters provide.

A typical smelter schedule will contain the following general considerations:

- Basic treatment charge, typically as $/ton
- Additions to treatment charge, if the chemical characteristic of the ore or concentrate indicates high concentrations of, for example, iron, and sulphur. This is what creates high treatment charges for pyrite concentrates.
- Percentage of the "valuable" component which will be paid for. Typically only 93 % of the gold and silver will be paid for, subject to a minor deduction.
- Derivation of metal pricing
- Penalties for undesirable metals such as antimony, arsenic, and mercury.
- Terms and timing of payment
- Delivery schedule and sampling practice

As complicated as smelter schedules appear at first glance, it is imperative that the seller familiarize himself with the terms of the schedule to avoid any unpleasant surprises.

The sale of gold bullion and high grade (+10 %) gravity concentrate is straightforward, since high percentage payments are the norm, and final settlement is typically within 10 working days. Once an ore or concentrate type has been defined, the actual sales contract becomes more specific than a general smelter schedule in addressing the chemical characteristics of the specific ore in question.

## 6.5 Smelter Locations

The relatively small number of smelters in northwestern North America, are located as follows:

- Cominco Ltd, Trail B.C., ore buying department (604) 364-4165

- Cominco will buy: lead ores and concentrates, zinc concentrates, and pyrite concentrates

- Asarco Incorporated , East Helena, Montana. will buy concentrates and ores

## 6.6 Toll Leaching of Flotation Concentrates

A further option for the treatment of cyanidable flotation concentrates includes the sale of the concentrate to an operating cyanidation plant for leaching in their own circuit. For a concentrate which exhibits high recovery in cyanide, the financial attractions are typically vastly superior to that of sale to a smelter. The important characteristic of the concentrate which needs to be established is its amenability to cyanidation. If this can be established, it may be prudent to approacn the operator of an existing cyanidation concentrator to determine whether an arrangemant can be made.

On a ton per ton basis, it is much less expensive to process concentrates througn a cyanidation circuit than through a smelter. The typical direct operating cost of cyaniding a non-refractory ore or concentrate is approximately $10 to $20 per ton, depending on the rate of production.

## 6.7 Transportation

Typically, Yukon concentrates will be shipped to either the seaport or the final smelter on trucks. Depending on the value of the concentrate, it may be prudent to store and ship the concentrate in one way woven fabric one tonne containers. Less valuable products can be stored uncovered on a prepared slab for haulage in end dump trucks.

Sometimes the smelter will have specific exclusions for certain types of containers, which must be adhered to.

Generally the more valuable the product, the greater the justification for containerizing.

## REFERENCES

Bostock, H.S. - Yukon Territory: Selected Field Reports of the Geological Survey of Canada, 1898 - 1933, G.S.C. Memoirs 284.

Grundmanis, A. - (1978) United Keno Hill Mines Ltd. - Elsa Concentrator, pages 227-229, Milling Practice in Canada

T.R.M. Engineering - (1986) Resource Assessment for Coastal and Western B.C. and the Development of a Portable Modular Mill Design.

British Columbia and Yukon Chamber of Mines - (1987) Location Map of Mining Properties in British Columbia and the Yukon Territory

UMA Engineering Ltd. - (1986) Micro Hydro Developments for Highway Maintenance Camps

Environment Canada, Atmospheric Environment Services - Canadian Climatic Normals, 1951 - 1980, The North - Y.T. and N.W.T.

Government of Yukon, Department of Economic Development and Tourism - Yukon Data Book 84-85

Indian and Northern Affairs Canada - (1986) Canada's North, The Reference Manual

Public Affairs North 60° Incorporated - (1985) A Compendium of the Northern Regulatory Regime

Federal Environmental Assessment Review Office - (1986) Initial Assessment Guide

Indian and Northern Affairs Canada - (1986) Northern Mineral Policy

Department of Indian Affairs and Northern Development, Office of Acting Regional Manager, Mineral Rights - (1987) Mining Claims Staked and Royalty Paid on Gold, Calendar Year 1973 to 1986

## ACKNOWLEDGEMENTS

Canamax Resources (Mount Hundre property)

Dawson Eldorado Gold Explorations Ltd. (Plata-Inca property)

Omni Resources Inc. (Skukum & Montana area properties)

Queenstake Resources ( Dublin gulch property)

Silver Hart Mines (C.M.C./Midnight property)

Silver Tusk Mines Ltd. (Tinta Hill deposit)

Springmount Operating Company

Total Ericksen Gold Mines Ltd. (Skukum Mine operator)

Tintana Mines (Eagle property)

United Keno Hill Mines Ltd.

Yukon Electric Company

Yukon Freight Lines

## 10.4 Trends in Gold

With the glamour attached to this metal, the present availability to access flow-through capital, the value of gold, and the economics of maximizing mill recovery, the present tendency is toward a dedicated mill and the continuation of exploration until ore reserves warrant such a decision.

The decision to have such plants accept other ores on a toll basis should be encouraged. While problems of mingling of ores and related metallurgical problems will occur, these may be technically resolved given profit or concessional incentives.

For ores easily treated by cyanide, heap leaching may limit the milling plant to a simple crushing operation combined with indoor leaching as practiced, for example, at Cripple Creek, Colorado. While recovery of gold will not reach that of plant operations, there may well be a "Mom and Pop" type application for the small entrepreneur.

## 10.5 Trends in Silver

There continue to be entrepreneurs who prospect for, find and hi-grade small silver deposits in the Yukon. Their present operations are limited to hand cobbing high grade ore to smelter, relying on the high silver content to supplement the near break-even return on lead-zinc. A small custom plant would assist such operators and encourage others since lower grade material must presently be discarded.

## 10.6 Incentives

The two largest cost items relating to plant operation in the Yukon are electrical power and road access. Any serious attempt to encourage mining operations should address these items with vigour.

## SECTION X

## SUMMARY AND CONCLUSIONS

### 10.1 Summary

This study does not include a detailed analysis of potential markets for custom mills in the Yukon, confining itself to the technical metallurgy, specific equipment use and related economics of prevalent ore types. While the report attempts to cover all aspects related to custom milling in general terms, its purpose is to be cost and equipment specific while realizing that individual ore deposits are each site-specific and unique.

The following summarizes the subject of custom milling in the Yukon.

### 10.2 Ore Types

The two ore types most deserving of economic attention are those containing gold and silver. While base metal properties have, and will continue to provide, a great contribution to the northern economy, their smelter return profitability without precious metal content provides a low profit margin thus requiring much greater annual tonnages than those available in a small custom mill.

The gold ores are most prevalent in, but not confined to the Whitehorse Trough region extending from Montana Mountain, through the Mount Skukum area and onward to Carmacks. The mineralogy of these ores ranges from free milling, low sulphur deposits to those containing extremely complex sulphide mineralization.

The silver ores are most prevalent in, but not confined to the Tintina Fault region extending from Watson Lake - Rancheria to Keno City. These ores are all associated with galena and, to varying degrees, with tetrahedrite and sphalerite.

### 10.3 Custom Mill Size

This study categorizes custom milling plants into two general types.

a) The mobile, itinerant mill which is capable of quick mobilization and demobilization and is generally limited for this reason to the 100 Tons Per Day range.

b) The more stationary milling plant ranges up to 300 Tons Per Day. Such a plant could be centrally located and serve many clients but, because of non-assurance of such clients over an extended period, would be more likely to have one prime client and accept other ore on a toll process basis.

SECITON IX

## FINANCIAL ANALYSIS

Previous Sections in this study contain the direct capital and operating cost derivations for the typical types of Yukon ores which could potentially be profitably exploited at this time.

While other specific cases may arise, it is felt that sufficient data has been provided to permit manipulation and interpolation of any desired scenario.

The following Table serves as an example of Toll Charges for various custom plants under varying Rates-of-Return for the owner.

TOLL CHARGE ESTIMATE ($ Per Short Dry Ton)

| | TYPE | | | |
|---|---|---|---|---|
| | PORTABLE | PERMANENT | PERMANENT | PERMANENT |
| Capacity, TPD | 100 | 100 | 300 | 300 |
| Flow Sheet | Single Flot.Conc. | Single Flot.Conc. | Single Flot.Conc. | Cyanidatin |
| Capital $ x $10^6$ | 0.59 | 1.54 | 2.12 | 3.22 |
| Annual Tons | 15,000 (1) | 36,500 | 109,500 | 109,500 |
| Capital Cost $ per Ton (2) | | | | |
| - 15% | 11.63 | 12.62 | 5.78 | 8.77 |
| - 20% | 13.04 | 14.14 | 6.48 | 9.83 |
| - 25% | 14.50 | 15.73 | 7.21 | 10.93 |
| - 30% | 16.01 | 17.37 | 7.96 | 12.07 |
| Operating Cost | | | | |
| Operating | 23.77 | 23.77 | 18.62 | 24.51 |
| Working Capital | 0.95 | 0.97 | 0.60 | 0.41 |
| Cost Per Ton | | | | |
| - 15% | 36.35 | 37.36 | 25.00 | 33.69 |
| - 20% | 37.76 | 38.88 | 25.70 | 34.75 |
| - 25% | 39.22 | 40.47 | 26.43 | 35.85 |
| - 30% | 40.73 | 42.11 | 27.18 | 36.99 |

(1) Operation Time - Demobilization extra

(2) 5 Year Return on Investment

Notes: Water Supply and Tailings Pond not included
Taxes not included
Profit margin included in Rate of Return

(C) Data:

- 300 Tons/Day gravity/cyanidation plant

| | $/ton | $/month |
|---|---|---|
| **Labour** | | |
| Supervision (mill superintendent) | | 5,800 |
| Wages - operating (8 operators) (1) | | 33,400 |
| Wages - repair (2) | | 8,350 |
| Wages - assaying | | 4,800 |
| Wages - labour (2) | | 8,350 |
| Sub total - Labour | 6.74 | 60,700 |
| **Materials** | | |
| Liners - Crushing (2) | .17 | |
| - Grinding | .27 | |
| Grinding Balls (3) | .80 | |
| Reagents - Flotation | .20 | |
| - Cyanide (4) | 2.00 | |
| - Lime (5) | .05 | |
| - Carbon | .10 | |
| Assaying supplies | .18 | |
| Miscellaneous maintenance supplies | 1.00 | |
| Miscellaneous operating supplies | .50 | |
| Sub total - materials | 5.27 | 47,430 |
| **Power** (generated) | | |
| 50 kWh/T x $0.25/kWh | 12.50 | 112,500 |
| TOTAL | 24.51 | 220,630 |

NOTE:

(1) Includes direct wages + 25% benefit loading. $15/hr x 1.25 x 42 hr/week = $3,375/month + $800/month camp cost = $4,175/man month

(2) Assume 2 stage jaw/cone crusher

(3) .15 lbs/kWh x 15 kWh/Ton x $0.35/lb.

(4) 2 lb/Ton @ $1.00/lb.

(5) 0.5 lb/Ton @ $0.10/lb.

(B) Data:

- 300 Tons/Day gravity-flotation plant

| | $/ton | $/month |
|---|---|---|
| Labour | | |
| Supervision (mill superintendent) | | 5,800 |
| Wages - operating (8 operators) (1) | | 33,400 |
| Wages - repair (2) | | 8,350 |
| Wages - assaying | | 4,800 |
| Wages - labour (2) | | 8,350 |
| Sub total - Labour | 6.74 | 60,700 |
| Materials | | |
| Liners - Crushing (2) | .17 | |
| - Grinding | .27 | |
| Grinding Balls (3) | .80 | |
| Reagents - Flotation | .20 | |
| Assaying supplies | .18 | |
| Miscellaneous maintenance supplies | 1.00 | |
| Miscellaneous operating supplies | .50 | |
| Sub total - materials | 3.13 | 28,170 |
| Power (generated) | | |
| 35 kWh/T x $0.25/kWh | 8.75 | 78,750 |
| TOTAL | 18.62 | 167,620 |

NOTE:

(1) Includes direct wages + 25% benefit loading. $15/hr x 1.25 x 42 hr/week = $3,375/month + $800/month camp cost = $4,175/man month

(2) Assume 2 stage jaw/cone crusher

(3) .15 lbs/kWh x 15 kWh/Ton x $0.35/lb.

## 8.2 Operating Costs

(A) Data:

- Milling rate 100 Tons/Day: 3,000 Tons/Month
- Gravity-Flotation

| | $/ton | $/month |
|---|---|---|
| **Labour** | | |
| Supervision (mill superintendent) | | 5,800 |
| Wages - operating (6 operators) (1) | | 20,875 |
| Wages - repair | | 4,175 |
| Wages - assaying | | 4,800 |
| Sub total - Labour | 11.88 | 35,650 |
| **Materials** | | |
| Liners - Crushing (2) | .17 | 500 |
| - Grinding | .27 | 810 |
| Grinding Balls (3) | .80 | 2,400 |
| Reagents - Flotation | .20 | 600 |
| Assaying supplies | .18 | 600 |
| Miscellaneous maintenance supplies | 1.00 | 3,000 |
| Miscellaneous operating supplies | .50 | 1,500 |
| Sub total - materials | 3.13 | 9,410 |
| **Power** (purchased power) | | |
| 35 kWh/T x $0.25/kWh | 8.75 | 26,250 |
| TOTAL | 23.77 | 71,310 |

NOTE:

(1) Includes direct wages + 25% benefit loading. $15/hr x 1.25 x 42 hr/week = $3,375/month + $800/month camp cost = $4,175/man month

(2) Assume 2 stage jaw/cone crusher

(3) .15 lbs/kWh x 15 kWh/Ton x $0.35/lb.

### 8.1.6 Comparison Summary

| Type | Capacity | Flowsheet | $ x 10^6 |
|---|---|---|---|
| Portable | 100 Tons/Day | Single Flot. Conc. | 0.59 |
| Permanent | 100 Tons/Day | Single Flot. Conc. | 1.54 |
| Permanent | 300 Tons/Day | Single Flot. Conc. | 2.12 |
| Permanent | 300 Tons/Day | Cyanidation | 3.22 |

C. 300 TPD Gravity, Cyanidation

| Item | HP | $ Equipment | $ Install | Total |
|---|---|---|---|---|
| Building (1) | 55 | - | 440,000 | 440,000 |
| Crushing | 93 | 85,500 | 171,000 | 256,500 |
| Fine Ore Storage (4) | - | 22,500 | 22,500 | 45,000 |
| Grinding | 320 | 150,000 | 225,000 | 375,000 |
| Gravity | 2.5 | 17,400 | 12,600 | 30,000 |
| Reagent Feed | 2 | 5,000 | 5,000 | 10,000 |
| Cyanidation | 150 | 300,000 | 600,000 | 900,000 |
| Dewatering | 25 | 27,300 | 54,600 | 81,900 |
| Direct Cost | | | | 2,138,400 |
| Engineering | | | | 120,000 |
| Sales Tax | | | | - |
| Freight | | | | 100,000 |
| Power (3) | | | | 250,000 |
| Assay Office (2) | 50 | | | 75,000 |
| Sub Total | 697.5 | | | 2,683,400 |
| Contingency 20% | | | | 536,700 |
| TOTAL | | | | 3,220,000 |

1) Building - 8,000 sq. ft. @ $55/sq. ft.
2) Fire Assaying and AA Trailer Unit
3) 520 kW connected power with 33% standby capacity i.e. (3) 300 kW generators
4) 300 Ton live capacity

B. 300 TPD Gravity, Flotation

| Item | HP | Equipment ($) | Install ($) | Total ($) |
|---|---|---|---|---|
| Building (1) | 55 | - | 385,000 | 385,000 |
| Crushing | 93 | 85,500 | 171,000 | 256,500 |
| Fine Ore Storage (4) | - | 22,500 | 22,500 | 45,000 |
| Grinding | 320 | 150,000 | 225,000 | 375,000 |
| Gravity | 2.5 | 17,400 | 12,600 | 30,000 |
| Flotation | 30 | 50,000 | 100,000 | 150,000 |
| Reagent Feed | 2 | 5,000 | 5,000 | 10,000 |
| Dewatering | 25 | 27,300 | 54,600 | 81,900 |
| Direct Cost | | | | 1,333,400 |
| Engineering | | | | 80,000 |
| Sales Tax | | | | - |
| Freight | | | | 80,000 |
| Power (3) | | | | 225,000 |
| Assay Office (2) | 50 | | | 50,000 |
| Sub Total | | | | 1,768,400 |
| Contingency 20% | | | | 353,700 |
| TOTAL | | | | 2,122,000 |

1) Building - 7,000 sq. ft. @ $55/sq. ft.
2) Fire Assaying Trailer Unit
3) 430 kW connected power with 100% standby capacity i.e. (2) 500 kW generators
4) 300 Ton live capacity

### 8.1.5 Typical All-Weather Plants

#### A. 100 TPD Gravity - Flotation

Same as Section 8.1.3 (Portable Modular Mill) except built as permanent and on-site.

| Item | HP | $ Equipment | $ Install | $ Total |
|---|---|---|---|---|
| Building (1) | 55 | - | 302,500 | 302,500 |
| Crushing | 93 | 85,500 | 171,000 | 256,500 |
| Fine Ore Storage (4) | - | 7,500 | 7,500 | 15,000 |
| Grinding | 106 | 65,600 | 131,200 | 196,800 |
| Gravity | 1.5 | 8,400 | 12,600 | 21,000 |
| Flotation | 16 | 22,200 | 44,400 | 66,600 |
| Reagent Feed | 1 | 3,800 | 2,200 | 6,000 |
| Dewatering | 6.5 | 16,800 | 33,600 | 50,400 |
| Direct Cost | | | | 914,800 |
| Engineering | | | | 60,000 |
| Sales Tax | | | | |
| Freight | | | | 50,000 |
| Power (3) | | | | 160,000 |
| Assay Office (2) | 50 | | | 50,000 |
| Sub Total | 329 | | | 1,234,800 |
| Contingency 25% | | | | 308,700 |
| TOTAL | | | | 1,544,000 |

1) Building - 5,500 sq. ft. @ $55/sq. ft.
2) Fire Assaying Trailer Unit
3) 250 kW connected power with 100% standby capacity i.e. (2) 300 kW generators
4) 100 Ton live capacity

### 8.1.4 All Weather Considerations

Construction

Both the portable/modular and the permanent mills will use the same processing equipment. The capital costs for the equipment components indicated in Section 8.1.1 apply equally well to the all weather plant.

Additional capital costs will be incurred in constructing the all weather plant for:

- Building
- Building heating
- Replacement of the fine ore stockpile with a bin
- Increased design cost

Building

The cost of "pre-engineered" structural steel and metal clad buildings is approximately $25 per sq. ft., erected. Also, the foundation costs will be $20 - $30 per sq. ft. depending on the competency of the underlying soil.

For purposes of estimating, $55 per sq. ft. has been used for a completed structural steel building with metal cladding and insulation.

Mine sites which depend upon diesel-electric power will be able to provide all of the concentrator building heating requirements using diesel engine jacket heat recovery. The power plant will need to be located beside or inside the mill building.

Plants which are supplied with "hydro" power will generally need to supply independent building heat.

Radiant heat losses from a typical <300 tonnes/day crushing plant and concentrator building are <500,000 BTU/hr. The main source of heat loss is in building air changes which can increase the total heat loss to 1.5 million BTU/hr.

Ore Bins

To insure the continuity of the operation during winter, the use of enclosed, and preferably heated, bin storage is necessary. The coarse and fine ore bins need not be indoors, but they must be constructed to prevent freezing of the contained ore.

A nominal cost of fine ore bins is $83/Ton, and coarse ore bins $165/Ton, not including building enclosures at approximately $55 per sq. ft.

## 8.1.3 Typical Modular Plant

100 Tons/Day - Gravity and Flotation

| Item | HP | Cost - $ |
|---|---|---|
| Trailers (1) | -- | 20,000 |
| Crushing | 93 | 105,500 |
| Grinding | 106 | 95,600 |
| Gravity | 1.5 | 11,400 |
| Flotation | 16 | 25,200 |
| Reagent Feed | 1 | 3,800 |
| Dewatering | 6.5 | 26,800 |
| Direct Capital | 224 | 288,300 |
| Engineering | | 30,000 |
| Sales Taxes | | - |
| Freight | | 20,000 |
| Power (3) | | 80,000 |
| Assay Office (2) | | 50,000 |
| Sub Total | | 468,300 |
| Contingency 25% | | 117,075 |
| TOTAL | | 585,000 |

1) 4 Trailers @ $5,000 ea.
2) Fire Assaying Trailer Unit
3) No standby capacity

8.1.2 Module Costs

| MODULE | CAPACITY | $ EQUIPMENT | FABRICATION | TOTAL |
|---|---|---|---|---|
| Crushing | 5 TPH | 26,500 | 7,000 | 33,500 |
| | 10 TPH | 55,500 | 10,000 | 65,500 |
| | 20 TPH | 85,500 | 20,000 | 105,500 |
| Grinding | 50 TPD | 43,800 | 15,000 | 58,800 |
| | 100 TPD | 65,600 | 30,000 | 95,600 |
| Gravity | 150 TPD | 8,400 | 3,000 | 11,400 |
| Flotation | 50 TPD | 12,200 | 3,000 | 15,200 |
| | 100 TPD | 22,200 | 3,000 | 25,200 |
| Reagent Mixing & Feeding | 100 TPD | 3,800 | - | 3,800 |
| Concentrate Dewatering | 12 TPD | 16,800 | 10,000 | 26,800 |
| Leaching- Flot. Conc. | 12 TPD | 52,400 | 15,000 | 67,400 |
| - Ore | 50 TPD | 47,000 | 20,000 | 67,000 |
| | 100 TPD | 81,500 | 20,000 | 101,500 |
| Carbon Stripping & Electrowin | 40 oz/Day Au + Ag | 12,800 | 5,000 | 17,800 |
| Carbon Reactivation | 200 lb/8 hr. | 10,000 | 2,000 | 12,000 |
| Assay Trailer | | | | |
| - Fire Assay | | | | 50,000 |
| - Fire Assay and AA | | | | 75,000 |
| Generator (1) | | | | |
| - 250 kW | | | | 60,000 |
| - 500 kW | | | | 125,000 |
| Trailer (2) | | | | 5,000 |

1) Trailer Mounted, Reconditioned
2) Used - Serviceable

| MODULE | PRODUCTION RATE | EQUIPMENT | HP | WT.LB. | $ |
|---|---|---|---|---|---|
| Carbon Stripping & Electrowin | 40 oz/DAY Au + Ag | Stripping Vessel | -- | 2,000 | 5,000 |
| | | Strip Solution Tank | -- | 2,000 | 800 |
| | | Electric Heaters | 40 | 100 | 2,000 |
| | | Circ. Pump | 0.5 | 50 | 600 |
| | | Specialty Valving | -- | -- | 600 |
| | | Electrolytic Cell | -- | 100 | 3,000 |
| | | Rectifier | 0.5 | 50 | 800 |
| | | Sub total | 41 | 4,300 | 12,800 |
| Carbon Reactivation Kiln | 200 #/CARBON IN 8 HR | (Propane) | | 2,000 | 10,000 |
| | | Sub total | | 2,000 | 10,000 |

| MODULE | PRODUCTION RATE | EQUIPMENT | HP | WT.LB. | $ |
|---|---|---|---|---|---|
| Flotation | 50 TPD | Flotation Machine (2 $m^3$) | 10 | 6,000 | 10,000 |
| | | Slurry Pump | 1 | 300 | 2,200 |
| | | Sub total | 11 | 6,300 | 12,200 |
| Flotation | 100 TPD | Flotation Machine (4 $m^3$) | 15 | 10,000 | 20,000 |
| | | Slurry Pump | 1 | 300 | 2,200 |
| | | Sub total | 16 | 10,300 | 22,200 |
| Flotation Reagent System | | 2 Clarkson Feeders | 0.5 | | 1,800 |
| | | Reagent Mixing Tank | 0.5 | 500 | 2,000 |
| | | Sub total | 1 | 500 | 3,800 |
| Conc. Dewatering | 12 TPD FLOT. CONC. | Settling Cone (1 m dia.) | 0.5 | 500 | 2,000 |
| | | Disc Filter (4' x 2 disc) | 1 | 3,000 | 12,000 |
| | | Vacuum Pump (250 cfm) | 5 | 800 | 2,800 |
| | | Sub total | 6.5 | 4,300 | 16,800 |
| Leaching | 12 TPD FLOT. CONC. | Conveyor (18" x 10') | 1 | 1,500 | 2,000 |
| | | Regrind Mix (250 cfm) | 5 | 1,200 | 8,000 |
| | | Leaching Tanks (4-6' x 6') | -- | 2,400 | 2,800 |
| | | Agitators (4 @ 3HP) | -- | 1,600 | 12,000 |
| | | Screens (2 - 18"O) | 0.5 | 200 | 5,500 |
| | | Pumps (2 Slurry) | 2 | 600 | 3,600 |
| | | Blower | 3 | 500 | 2,500 |
| | | Solution Tank & Pump | 0.5 | 900 | 1,200 |
| | | Disc Filter (4' x 2 disc) | 1 | 3,000 | 12,000 |
| | | Vacuum Pump | 5 | 800 | 2,800 |
| | | Sub total | 9.5 | 12,700 | 52,400 |
| Leaching | 50 TPD | Leaching Tanks (4 @ 10'Ox10') | -- | 18,000 | 18,000 |
| | | Agitators * (4 @ 5 HP) | 20 | 6,000 | 20,000 |
| | | Screens | 0.5 | 200 | 5,500 |
| | | Blower | 10 | 1,500 | 3,500 |
| | | Sub total | 30.5 | 25,700 | 47,000 |
| Leaching | 100 TPD | Leaching Tanks (5 @ 12'O x 12' High) | -- | 35,000 | 35,000 |
| | | Agitators * (5 @ 7.5 HP) | 42.5 | 10,000 | 35,000 |
| | | Screens (2 - 18") | 0.5 | 200 | 5,500 |
| | | Blower | 20 | 2,000 | 6,000 |
| | | Sub total | 63 | 47,200 | 81,500 |

## 8.1 Capital Costs

### 8.1.1 Equipment Cost Details

| MODULE | PRODUCTION RATE | EQUIPMENT | HP | WT. LB. | $ |
|---|---|---|---|---|---|
| Crushing | 5 TPH | Coarse Ore Hopper | -- | 4,000 | 6,000 |
| | | Coarse Ore Feeder | 3 | 2,000 | 3,500 |
| | | Jaw Crusher (10" x 16") | 20 | 6,000 | 12,000 |
| | | Conveyor (18"x 30') | 2 | 3,000 | 5,000 |
| | | Sub total | 25 | 15,000 | 26,500 |
| Crushing | 5-10 TPH | Coarse Ore Hopper | -- | 4,000 | 6,000 |
| | | Coarse Ore Feeder | -- | 2,000 | 3,500 |
| | | Jaw Crusher (15" x 24") | 50 | 12,000 | 25,000 |
| | | 2 Conveyors (18"x 40') | 3 | 4,000 | 6,000 |
| | | Jaw Crusher (10" x 16") | 20 | 6,000 | 12,000 |
| | | Vibrating Screen (10 sq.ft.) | 3 | 600 | 3,000 |
| | | Sub total | 76 | 28,600 | 55,500 |
| Crushing | 20 TPH | Coarse Ore Hopper | -- | 8,000 | 12,000 |
| | | Coarse Ore Feeder | 3 | 2,000 | 3,500 |
| | | Jaw Crusher (15" x 24") | 50 | 12,000 | 25,000 |
| | | 3 Conveyors (18"x 80') | 5 | 8,000 | 9,000 |
| | | Cone Crusher (2') | 30 | 10,000 | 30,000 |
| | | Vibrating Screen (40 sq.ft.) | 5 | 2,000 | 6,000 |
| | | Sub total | 93 | 42,000 | 85,500 |
| Grinding | 50 TPD | Fine Ore Hopper | -- | 4,000 | 6,000 |
| | | Feed Conveyor (18" x 15') | 1 | 1,500 | 2,500 |
| | | Ball Mill (5' x 5') | 50 | 18,000 | 30,000 |
| | | Slurry Pump (2" x 2") | 2 | 800 | 2,000 |
| | | Cyclone (6") | -- | 200 | 800 |
| | | Ball Mill Change | -- | 7,000 | 2,500 |
| | | Sub total | 53 | 31,500 | 43,800 |
| Grinding | 100 TPD | Fine Ore Hopper | -- | 3,700 | 6,000 |
| | | Feed Conveyor (18" x 15') | 1 | 1,500 | 2,500 |
| | | Ball Mill (6' x 6') | 100 | 36,000 | 50,000 |
| | | Slurry Pump (3" x 3") | 5 | 800 | 2,500 |
| | | Cyclone (10") | -- | 500 | 800 |
| | | Ball Mill Change | -- | 11,000 | 3,800 |
| | | Sub total | 106 | 53,500 | 65,600 |
| Gravity | Up to 150 TPD | Duplex Jig (12" x 18") | 1 | 1,800 | 6,500 |
| | | Table (2' x 4') | 0.5 | 300 | 1,900 |
| | | Sub total | 1.5 | 2,100 | 8,400 |

## SECTION VIII

### CAPITAL AND OPERATING COSTS

The equipment requirements for either the portable/modular or the permanent mill will be identical. Only detailed equipment costs at various production rates are shown.

The operating costs of both portable and permanent plants will be essentially identical.

Note the relatively high cost that diesel generated power contributes to the overall direct milling cost.

Profit

| | |
|---|---|
| N.S.R. | $ 132.48 |
| Mining Cost | 75.00 |
| Crude Ore Trucking 20 mi. at $0.25 | 5.00 |
| Toll Processing | 45.00 |
| Net Profit Per Ton Crude | $ 7.48 |

## Plant Metallurgy

| Product | Wt % | Pb % | Ag oz/T | Dist % Pb | Dist % Ag |
|---|---|---|---|---|---|
| Flotation concentrate | 11.6 | 82.0 | 160.0 | 95.0 | 92.0 |
| Flotation Tails | 88.6 | 0.57 | 1.8 | 5.0 | 8.0 |
| Feed | 100.0 | 10.0 | 20.0 | 100.0 | 100.0 |

### Flotation Concentrate Analysis

| | |
|---|---|
| Au | NIL |
| Ag | 160 oz/t |
| Fe | NIL |
| As | NIL |
| Sb | 0.1% |
| Cu | NIL |
| Pb | 82.0% |
| Zn | 2.0% |
| S | 13.7% |
| Insol | 1.5% |
| Moisture | 9.0% |

### Sale of Concentrate

### Calculation Lead

| | | |
|---|---|---|
| Contained (per ton conc.) | 1,640 lb. | |
| Paid (91.0%) | 1,492.4 lb. | |
| Price | $0.345/lb. | |
| Deduction | $0.12375/lb. | |
| Price Paid | $0.22125/lb. | $ 330.19 |

### Less

| | |
|---|---|
| Treatment Charge | 150.00 |
| Moisture Penalty | 0.40 |
| C.P. Index at 319.6 | 4.90 |
| Labour Adjustment at $19.52 | 6.35 |
| Sub Total | $ 161.65 |
| | |
| N.S.R. Lead | $ 168.54 |

### Calculation Silver

| | | |
|---|---|---|
| Contained (per ton conc.) | 160.0 oz. | |
| Paid 93% | 148.8 oz. | |
| Price | $7.50/oz. | |
| Paid 97% | $7.275/oz. | $1,082.52 |

### Gross N.S.R. $1,251.06

| | |
|---|---|
| Freight | $ 109.00 |
| N.S.R. FOB Minesite | $1,142.06 |
| N.S.R. Crude Ore/Ton | $ 132.48 |

Deductions

| | |
|---|---|
| Treatment Charge | $ 150.00 |
| CPI Index | 4.90 |
| Labour Rate Adjustment | 6.35 |

Penalties

| | |
|---|---|
| As and Sb at (1.1 - 0.5) at $1.75 | $ 1.05 |
| Moisture at (9 - 8) at $0.40 | 0.40 |
| Fe at (44 - 5) at $3.55 | 138.45 |
| S at (51 - 20) uat $4.00 | 124.00 |
| Sub Total Penalties | $ 425.15 |

| | |
|---|---|
| N.S.R. | $5,907.00 |
| Less Freight | 109.00 |
| N.S.R. FOB Millsite | $5,798.00 |
| N.S.R. FOB Mine (at 4.0% wt.) | $ 231.92 |

Gross Profit

| | |
|---|---|
| N.S.R. Gravity Concentrate | $ 125.28 |
| N.S.R. Flotation Concentrate | 231.92 |
| Sub Total | $ 357.20 |

Deduct

| | |
|---|---|
| Mining Cost | $ 75.00 |
| Crude Ore Trucking 20 mi. at $0.25 | 5.00 |
| Toll Processing | 45.00 |
| Sub Total | $ 125.00 |

| | |
|---|---|
| Net Profit Per Ton Crude | $ 232.20 |

Note: No allowance for administration or mining depreciation.

## 7.2 Silver Ore

Base Data

- Mining Rate: 25 tons per day / 8 months per year, 6000 Tons per year
- Mineralogy: Silver in galena
- Cost to Mine: $75.00 per ton
- Ore Haulage: 20 miles to millsite
- Milling Rate: 100 tons per day, once per year for 60 days
- Tolling Cost: $45.00 per ton
- Annual Flotation Concentrate Production: 702 sdt at 10% moisture
- Ship flotation concentrate to smelter in truckload quantities of 30 Tons each.

| | Total | Daily | Weekly |
|---|---|---|---|
| Tailings | | | |
| Au - oz. | 288 | 4.8 | 33.6 |
| Ag - oz. | 576 | 9.6 | 156.8 |
| Total | | | |
| Au - oz. | 4,800 | 80.0 | 560.0 |
| Ag - oz. | 2,400 | 40.0 | 280.0 |

Sale of Gravity Concentrate

Gravity concentrate is shipped weekly to a precious metal buyer.

Payable

| | |
|---|---|
| Gold 168.0 oz. at $540.00 at 98% | $ 88,906 |
| Silver 56.0 oz. at $7.50 at 98% | 412 |
| Sub Total Payables | $ 89,318 |
| Handling 980 oz. at $1.50 | 1,470 |
| Sub Total for Buyer | $ 87,848 |
| Air Freight and Insurance | 150 |
| Sub Total Per Lot | $ 87,698 |
| NET PER TON CRUDE ORE | $ 125.28 |

Flotation Concentrate Analysis

| | |
|---|---|
| Au | 12.8 oz/t |
| Ag | 5.6 oz/t |
| Fe | 44.0% |
| As | 1.0% |
| Sb | 0.1% |
| Cu | <0.1% |
| Pb | <0.1% |
| Zn | <0.1% |
| S | 51.0% |
| Insol | 4.0% |
| Moisture | 9.0% |

Concentrate will be shipped in 22.7 Mt (25 T) wet weight truckload lots to the Cominco smelter in Trail, B.C. and sold under the terms indicated.

Cominco does not have a pyrite schedule, but treats this type of material under the lead concentrate/ore schedule.

Payables

| | |
|---|---|
| Gold 12.8 oz/T at 93.0% of 98.0% at $540.00 | $6,300 |
| Silver 5.6 oz/T less 1.0 oz/T at 93% at $7.50 | 32 |
| Sub Total | $6,332 |

## SECTION VII

## CASE STUDIES

This section has been included so that the prospective operator has a format into which his own data can be inserted to perform a cash flow analysis based upon the toll processing concept. Case studies are presented for both a gold and a silver ore.

### 7.1 Gold Ore

#### Base Data

- Mining rate: 25 tons per day, 8 months per year, 6,000 tons per year of ore
- Mineralogy: minor sulphides (pyrite dominates with lesser arsenopyrite) in silica
- Cost to mine $75 per ton
- Ore haulage: 20 miles to millsite
- Milling rate: 100 tons per day, once per year for 60 days
- Tolling cost: $45/ton
- Annual flotation concentrate production: 240 sdt (short dry tons) @ 9% moisture
- Ship flotation concentrate to smelter in truckload quantities, i.e. approximately 10 truckloads per year
- Ship gravity concentrate to metal buyer weekly

#### Plant Metallurgy

| | | oz/T | | Dist % | |
|---|---|---|---|---|---|
| Product | Wt % | Au | Ag | Au | Ag |
| Gravity concentrate | 0.0048 | 5,000 | 1,667 | 30 | 20 |
| Flotation concentrate | 4.0 | 12.8 | 5.6 | 64 | 56 |
| | | | | 94 | 76 |
| Flotation tails | 96.0 | 0.05 | 0.1 | 6 | 24 |
| Feed | 100.0 | 0.8 | 0.4 | 100 | 100 |

#### Plant Products

| | Total | Daily | Weekly |
|---|---|---|---|
| Gravity Concentrate | | | |
| Weight - lbs. | 576 | 9.6 | 67.2 |
| Au - oz. | 1,440 | 24.0 | 168.0 |
| Ag - oz. | 480 | 80 | 56.0 |
| Flotation Concentrate | | | |
| Weight - lbs. | 480,000 | 8,000 | 56,000 |
| Au - oz. | 3,072 | 51.2 | 358.2 |
| Ag - oz. | 1,344 | 22.4 | 156.8 |

b) The treatment deduction shall be increased or decreased by $0.08 for each $0.01 per MMBTU that the average cost of fuel used at East Helena during the calendar month including the date of delivery of product is greater or less than $4.75, fractions in proportion.

c) The treatment deduction shall be increased or decreased by $0.16 for each 1 mill per kWh that the average cost of electric power used at East Helena during the calendar month including the date of delivery of product is greater or less than 13.4 mills, fractions in proportion.

d) The base treatment deduction shall be increased by 5% of the sum of the metal payments is excess of $2000 per short dry ton of product.

ADDITIONAL DEDUCTIONS

The deductions specified above are for product free of deleterious impurities. Product delivered containing such impurities shall be subject to additional deductions in accordance with the schedule below. If the product should contain any other deleterious impurities which in the smelter's sole judgement preclude economic treatment of product, then the smelter may terminate this contract on thirty (30) days written notice, unless mutual agreement is reached as to appropriate deductions for such impurities.

a) Arsenic: Deduct $5.00 per ton for each unit of arsenic content, fractions in proportion.

b) Antimony: Deduct $5.00 per ton for each unit of antimony content, fractions in proportion.

c) Bismuth: 0.1% unit free, $10.00 per unit excess, fractions in proportion.

# TYPICAL SMELTER LANGUAGE

# (U.S.A.)

## GOLD/SILVER CONCENTRATES

### PAYMENTS

Gold: Deduct 0.02 troy ounce per short dry ton of product and pay for 95% of the remaining gold content at the Daily London Final Gold Quotation, as published in Metals Week, averaged for the fourth calendar month following date of delivery of product less a deduction of $5.00 per troy ounce of payable gold.

Silver: Deduct one troy ounce per short dry ton of product and pay for 95% of the remaining silver content at the Handy & Harman New York quotation for refined silver as published in Metals Week, averaged for the fourth calendar month following date of delivery of product, less a deduction of $0.25 per troy ounce of payable silver.

No payment will be made for any metal or content except as above specified.

From the total of the above, make the following:

### DEDUCTIONS

### TREATMENT DEDUCTION

The treatment deduction shall be $200.00 per short dry ton based on the following,

a) An hourly cost of employment of $16.500 at East Helena,

b) A cost of fuel per MMBTU of $4.75 at East Helena,

c) A cost of electric power of 13.4 mills per kWh at East Helena plant.

d) A sum of the metal payments of $2000 or less per short dry ton of product,

and will be adjusted pursuant to clause 11.

### TREATMENT DEDUCTION ADJUSTMENT

a) The treatment deduction shall be increased or decreased by $0.08 for each $0.01 that the average hourly cost of employment at East Helena during the calendar month including the date of delivery of product is greater or less than $16.500, fractions in proportion.

DEDUCTIONS PER SHORT DRY TON:

| | |
|---|---|
| Treatment Charge: | The base treatment charge for lead concentrates will be $150.00. The base treatment charge for ores will be $165.00. Minimum base treatment charge for any one lot will be $1,000.00. |
| Canadian Consumer Price Index: | Increase the treatment charge $0.25 for each one point that the Canadian Consumer Price Index (Base of 1971 = 100) exceeds 300.00. (December 1986 319.6) |
| Labour Rate: | Increase the treatment charge by $0.05 for each $0.01 by which the average loaded hourly C.W.S. Rate 12 exceeds $18.25 per hour. (January 1987 $19.52/hour) |

PENALTIES PER SHORT DRY TON:

| | |
|---|---|
| Arsenic & Antimony: | Increase the treatment charge by $1.75 for each unit that the sum of antimony plus arsenic is greater than 0.5 units. |
| Alumina: | Increase the treatment charge by $0.90 for each unit greater than 0.5 units. |
| Moisture Content: | Increase the treatment charge by $0.40 for each unit of moisture greater than 8.0% but less than or equal to 10.0% and by $1.00 for each unit of moisture greater than 10.0%. |
| Iron Content: | Increase the treatment charge $3.55 for each unit of iron in excess of the sum of 5 units plus 1.44 times the zinc units. |
| Sulphur Content: | Increase the treatment charge by $4.00 for each unit of sulphur greater than 20.0%. |

# TYPICAL SMELTER CONTRACT LANGUAGE

## (Canadian)

## LEAD CONCENTRATES/ORES

PAYMENTS PER SHORT DRY TON:

Lead: Deduct 0.1 units of lead for each unit of contained copper over 0.75% and pay for 92% of the balance (Minimum deduction from the balance will be 20 pounds) at a weighted average composite price calculated as:

a) 60% of the Metals Week published monthly price for lead designated as "MW US Producer" in U.S. cents per pound plus,

b) 40% of the average of the Metals Week published monthly prices for lead designated as "LME CASH" and "LME THRMO" in pounds sterling per metric ton, for the quotational period.

The deduction from the composite price shall be $0.12 per pound plus $0.0025 per pound for each $0.01 the composite price exceeds $0.33 per pound.

Zinc: Deduct 0.7 units of zinc for each unit of iron by which the iron content is in excess of 1.44 times the zinc units and pay for 60% of the balance (minimum deduction from the balance will be 20 pounds) at the Metals Week published monthly price for zinc designated as "European Producer" in U.S. dollars per metric ton, for the quotational period less $0.15 per pound.

Silver: Deduct 0.2 troy ounces of silver for each unit of contained copper and pay for 93% of the balance (minimum deduction from the blanace 1.0 troy ounce) based on a commercial fire assay, at 97% of the Metals Week published monthly price for silver designated as "Handy & Harman" in U.S. cents per troy ounce, for the quotational period.

Gold: Pay for 93% of the contained gold (minimum deduction 0.03 troy ounces) based on a commercial fire assay, at 98% of the Metals Week published monthly price for gold designated as "London Final" in U.S. dollars per troy ounce, for the quotational period.

Copper: Pay for 40% of the contained copper (minimum deduction 10 pounds) at the Metals Week published monthly price for copper designated as "MW ATL SEABOARD" in U.S. cents per pound, for the quotational period less $0.20 per pound.

PENALTIES PER SHORT DRY TON

| | |
|---|---|
| Iron Content: | Increase the treatment charge by $1.80 for each unit of contained iron. |
| Silica Content: | Increase the treatment charge $0.50 for each unit of $SiO_2$ greater than 0.5% $SiO_2$. |
| Magnesia Content: | Decrease the payable zinc by one pound for each 0.05% over 0.3%. |
| Lime Content: | Increase the treatment charge $0.50 per 0.1% over 0.50%. |
| Moisture Content: | Increase the treatment charge by $0.50 for each unit of moisture greater than 6.0% but less than or equal to 8.0% and by $1.50 for each unit of moisture greater than 8.0%. |

# TYPICAL SMELTER CONTRACT LANGUAGE

(Canadian)

## ZINC CONCENTRATES

### PAYMENTS PER SHORT DRY TON

Lead: Pay for 80% of the contained lead (minimum deduction 20 pounds) at the average of the Metals Week published monthly prices for lead designated as "LME CASH" and "LMR-THR-MO" in pounds sterling per metric ton for the quotational period less $0.12 per pound.

Zinc: Deduct 0.15 units of zinc per unit of contained iron and 0.125 units of zinc for each unit of $SiO_2$ in excess of 0.5% $SiO_2$ and pay for 85% of the balance, at a weighted average composite price calculated as:

a) 60% of the Metals Week published monthly price for zinc designated as "MW US HG" in U.S. cents per pound plus,

b) 40% of the Metals Week published monthly price for zinc designated as "European Producer" in U.S. dollars per metric ton, for the quotational period.

Silver: Deduct 0.2 troy ounces of silver for each unit of contained copper and pay for 93% of the balance (Minimum deduction from the balance 1.5 troy ounces) based on a commercial fire assay, at 97% of the Metals Week published monthly price for silver designated as "Handy & Harman" in U.S. cents per troy ounce, for the quotational period.

Gold: Pay for 93% of the contained gold (minimum deduction 0.05 troy ounces) based on a commercial fire assay, at 98% of the Metals Week published monthly price for gold designated as "London Final" in U.S. dollars per troy ounce, for the quotational period.

### DEDUCTIONS PER SHORT DRY TON

Treatment Charge: The base treatment charge shall be $220.00. Minimum base treatment charge for any one lot will be $1,000.00

Zinc Price: Increase the treatment charge by $3.50 for each $0.01 by which the composite price for zinc exceeds $0.50 per pound.

Canadian Consumer Price Index: Increase the treatment charge $0.25 for each one point that the Canadian Consumer Price Index (Base of 1971 = 100) exceeds 300.00.

Labour Rate: Increase the treatment charge by $0.05 for each $0.01 by which the average loaded hourly C.W.S. Rate 12 exceeds $18.25 per hour.

Table 6.3

# NET SMELTER RETURN CALCULATION TYPICAL GOLD-SILVER CONCENTRATE

## BASE DATA

| Ore | Recovery | Concentrate |
|---|---|---|
| 0.419 oz/T Au | 93.0% Au | 3.90 oz/T Au |
| 0.256 oz/T Ag | 78.0% Ag | 2.00 oz/T Ag |
| | | 2.88% As |
| | | 0.25% Sb |
| | | 10.0 Wt% (of ore) |

## CALCULATION GOLD

| | | |
|---|---|---|
| Contained (per ton of conc.) | 3.90 oz. | |
| Paid 95% (3.90 less 0.02) | 3.686 oz. | |
| Price | $540.00/oz. | |
| Paid | $533.25/oz. | $1,965.56/T |

## CALCULATION SILVER

| | | |
|---|---|---|
| Contained (per ton of conc.) | 2.00 oz. | |
| Paid 95% (2.00 less 1.00) | 0.95 | |
| Price | $7.50/oz. | |
| Paid | $7.1625/oz. | $ 6.80/T |

## DEDUCTIONS

| | | |
|---|---|---|
| Treatment | $270.00/T | |
| Arsenic ($6.75 x 2.88) | $ 19.44/T | |
| Antimony ($6.75 x 0.25) | $ 1.69/T | |
| Total Deductions | | $ 291.13/T |
| | | |
| NET SMELTER RETURN | | $1,681.23 |
| FREIGHT | | $ 110.00 |
| NSR MINESITE | | $1,571.23 |
| NSR CRUDE ORE | | $ 157.12 |

Note: Realized gold = 93.3%
Realized silver = 45.3%

# NET SMELTER RETURN CALCULATION TYPICAL ZINC CONCENTRATE

## BASE DATA

| Ore | Recovery | Concentrate |
|---|---|---|
| 10.0% Zn | 92.0% Zn | 55.0% Zn |
| 0.05 oz/T Au | 92.0% Au | 0.274 oz/T Au |
| | | 10.0% Moist |
| | | 5.0% Fe |
| | | 5.0% $SiO_2$ |
| Freight | $100/T Dry | 16.7 Wt% (of ore) |
| Zn Price | $0.500/lb. | |
| Au Price | $540/oz. | |

## CALCULATION ZINC

| | | |
|---|---|---|
| Contained (per ton of conc.) | 1100.0 lb. | |
| Paid (100.0% less Fe, $SiO_2$) (98.68%) | 1085.56 lb. | |
| Price | $0.500/lb. | |
| Paid (85%) | $0.425/lb. | $461.36 |
| Less | | |
| Treatment Charge | | $220.00 |
| Iron Penalty (5% x $1.80) | | 9.00 |
| Silica Penalty (4.5% x $0.50) | | 2.25 |
| Moisture penalty (var.) | | 4.00 |
| Labour Rate Adjustment @ $19.52/hr. | | 6.35 |
| C.P. Index at 319.6 | | 4.90 |
| TOTAL DEDUCTIONS | | $246.50 |
| NSR FOB Smelter | | $214.86 |

## CALCULATION GOLD

| | | |
|---|---|---|
| Contained (per ton of conc.) | 0.274 oz. | |
| Paid (93%) | 0.255 | |
| Price | $540.00/oz. | |
| Paid (98%) | $529.20/oz. | $134.95 |
| NET SMELTER RETURN | | $349.81 |
| FREIGHT | | $110.00 |
| NSR MINESITE | | $239.81 |
| NSR CRUDE ORE | | $ 40.05/Ton |

Note: Gold in concentrate at list price 0.274 oz x $540.00 = $147.96
NSR $134.95
Realized 91.1%

# NET SMELTER RETURN CALCULATION TYPICAL LEAD CONCENTRATE

## BASE DATA

| Ore | Recovery | Concentrate |
|---|---|---|
| 10.0% Pb | 92.0% Pb | 75.0% Pb |
| 10.0 oz/T Ag | 92.0% Ag | 75.0 oz/T Ag |
| | | 9.0% Moist |
| | | 12.3 Wt% (of ore) |
| Freight | $100/T Dry | |
| Pb Price | $0.345/lb. | |
| Ag Price | $7.50/oz. | |

## CALCULATION LEAD

| | | |
|---|---|---|
| Contained (per ton of conc.) | 1500.0 lb. | |
| Paid (91.0%) | 1365.0 lb. | |
| Price | $0.345/lb. | |
| Deduction | $0.12375/lb. | |
| Paid | $0.22125/lb. | $302.01 |
| Less | | |
| Treatment Charge | | $150.00 |
| Moisture Penalty | | 0.40 |
| C.P. Index at 319.6 | | 4.90 |
| Labour Rate Adjustment @ $19.52/hr. | | 6.35 |
| TOTAL DEDUCTIONS | | $161.65 |
| NSR FOB Smelter | | $140.36 |

## CALCULATION SILVER

| | | |
|---|---|---|
| Contained (per ton of conc.) | 75.00 oz. | |
| Paid (93% less 1.0 oz.) | 68.75 oz. | |
| Price | $ 7.50/oz. | |
| Paid (97%) | $ 7.275/oz. | $500.16 |
| NET SMELTER RETURN | | $640.52 |
| FREIGHT | | $109.00 |
| NSR MINESITE | | $531.52 |
| NSR CRUDE ORE | | $ 65.38/Ton |

Note: Silver in concentrate at list price 75.00 oz x $7.50 = $562.50
NSR $500.16
Realized 88.9%