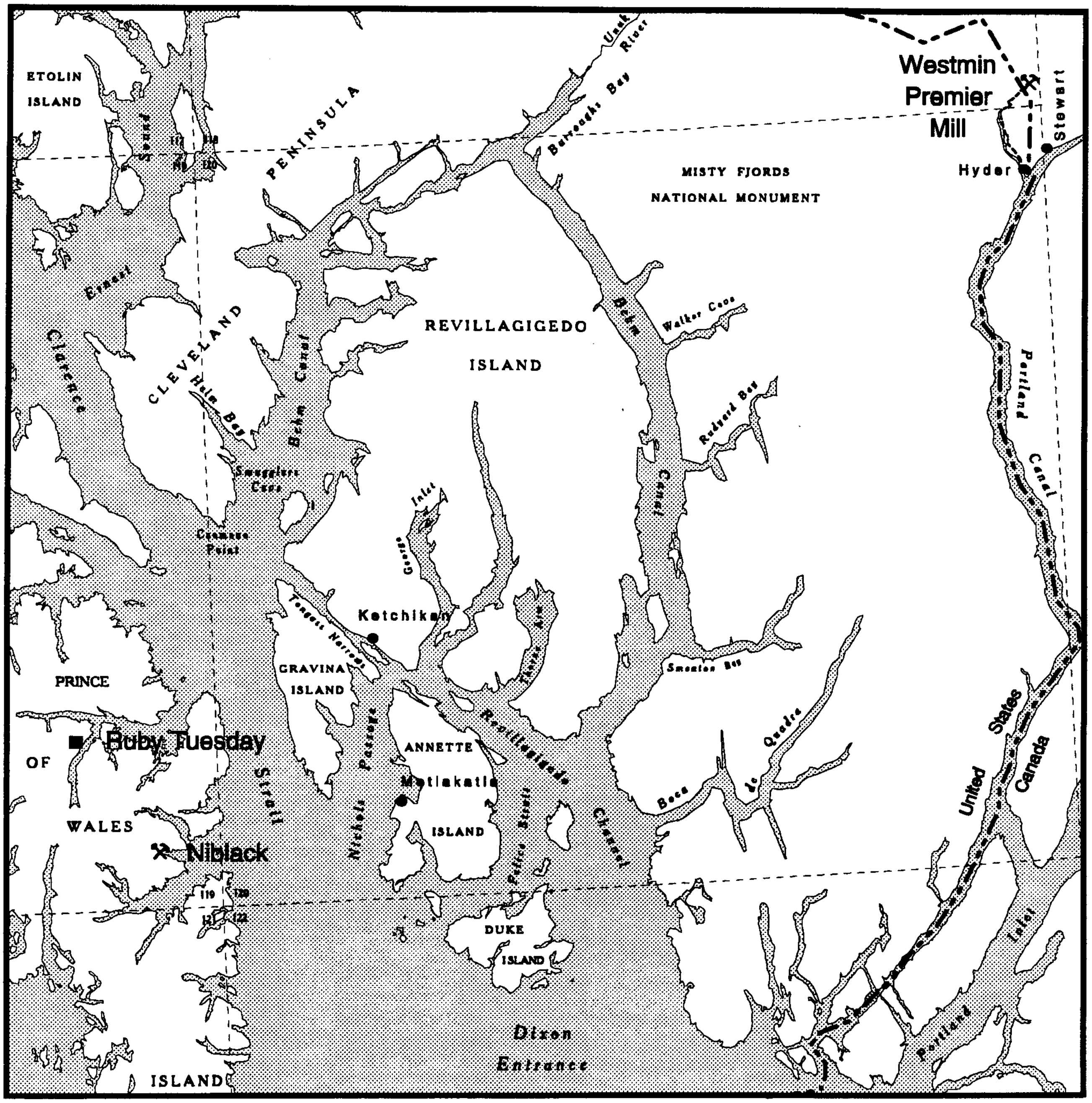
ECONOMIC FEASIBILITY OF MINING IN THE KETCHIKAN MINING DISTRICT, ALASKA



U.S. DEPARTMENT of the INTERIOR

OFR 06-95

Bureau of Mines

ECONOMIC FEASIBILITY OF MINING IN THE KETCHIKAN MINING DISTRICT, ALASKA

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February 1995

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm	centimeter
dpy	days per year
g	gram
g/mt	gram per metric ton
kg	kilogram
km	kilometer
lb	pound
m	meter
Mmt	million metric tons
mt	metric ton
mtpd	metric tons per day
mtpy	metric tons per year
ppm	parts per million
st	short ton
tr oz	troy ounce
yrs	years

METRIC TO ENGLISH CONVERSIONS

From	Multiply by	To
g/mt (= ppm)	0.02917	ounces/short ton
kg	2.2046	pounds
mt	1.1023	short tons
m	3.2808	feet
km	0.6214	miles
m^3	1.3080	cubic yards

Temperature conversion centigrade to fahrenheit:

$(°C \times 9/5) + 32 = °F$

ECONOMIC FEASIBILITY OF MINING IN THE KETCHIKAN MINING DISTRICT, ALASKA

by James R. Coldwell[1] and Edward C. Gensler[2]

ABSTRACT

Mining and processing cost analyses were conducted by the U.S. Bureau of Mines on massive sulfide copper-zinc and low sulfide vein gold deposit types that may be found in the Ketchikan Mining District. Reserves and recoverable metal values (RMV) needed to make these deposits economically viable were modeled. Methods for estimating ore grades and required RMV are presented.

Economic modeling for massive sulfide deposits indicated the RMV necessary for a 15% Discounted Cash-Flow Rate-Of-Return (DCFROR) for an underground cut-and-fill mine ranged from $137/mt for a 6,100 mtpd on-site milling operation to $526/mt for a 450 mtpd off-site milling operation. On-site milling was always less costly than off-site milling.

Economic modeling for low sulfide vein gold deposits indicated the RMV necessary for a 15% DCFROR for an open-pit mine, off-site mining operation ranged from $54/mt at 2,900 mtpd to $71/mt at 360 mtpd, and from $49/mt at 2,900 mtpd to $100/mt at 360 mtpd for an on-site milling operation. Off-site milling was less costly than on-site milling until production exceeded approximately 1,700 mtpd. Then, economies of scale reduced operating costs enough to offset the higher capital costs required for on-site milling.

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INTRODUCTION

This report is one of a series produced in conjunction with the USBM's ongoing statewide mining-district evaluation program. Economic prefeasibility studies were conducted on typical mineral deposit types that may be found in the Ketchikan Mining District (KMD) to determine reserves and the recoverable metal value which may allow mineral deposits to be minable. Two factors were addressed in this study: (1) the magnitude of reserve which would have to exist, and (2) the Recoverable Metal Value (RMV) which would be necessary to make a deposit economically feasible to mine. The RMV is the combined dollar value of all salable products from a given mineral deposit expressed in \$/mt. The interrelation between these factors is shown in tabular and graphical form.

In order to make these economic assessments for the massive sulfide copper-zinc and low sulfide vein gold deposit types that may be found in the KMD, existing mineral deposit information was used whenever possible. Mineral deposit grades and supporting background information were furnished by USBM Mineral Land Assessment (MLA) personnel. Results of field work and sample analytical results from the 1990-94 USBM investigations of the KMD were published in three open-file reports, and a comprehensive summary report will be published as a special publication (9,15-17)[3].

Because detailed deposit characteristics such as depth, thickness, attitude, and volume have not been determined for the partially explored deposits used as examples in this study, assumptions were made on some deposit characteristics. These assumptions are discussed at the beginning of each deposit characteristics section.

Location and Access

The following descriptions of location and access, land status, physiography and climate are modified from Maas, Bittenbender, and Still (17). The 2.8 million hectare KMD is located in the southern-most portion of Southeast Alaska and from west-to-east includes Prince of Wales and surrounding islands, Gravina, Revillagigedo and proximal Islands, Cleveland Peninsula, and the mainland east to the U.S.-Canadian border (Figure 1). The City of Ketchikan is the largest population center in the district with over 8,500 residents (14,110 within the Ketchikan Gateway Borough). Ketchikan is also the major transportation and supply center for the district, providing commercial airline, floatplane, ferry, and charter boat services to sites within the district.

Ketchikan has a limited road network that serves the west-southwest portion of Revillagigedo Island. Hyder is connected by road to Stewart, British Columbia where the North-America road network can be accessed. An extensive logging road network exists on Prince of Wales Island and adjacent smaller islands to the west. Shoreline and low-elevation properties are accessible by floatplane and boat. Four-wheel drive trucks and all-terrain vehicles are recommended to negotiate the logging roads, although any high ground clearance vehicle may be used. Helicopters are the preferred access method for high-elevation mineral occurrences.

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3 Underlined numbers in parentheses refer to references at the end of this report.

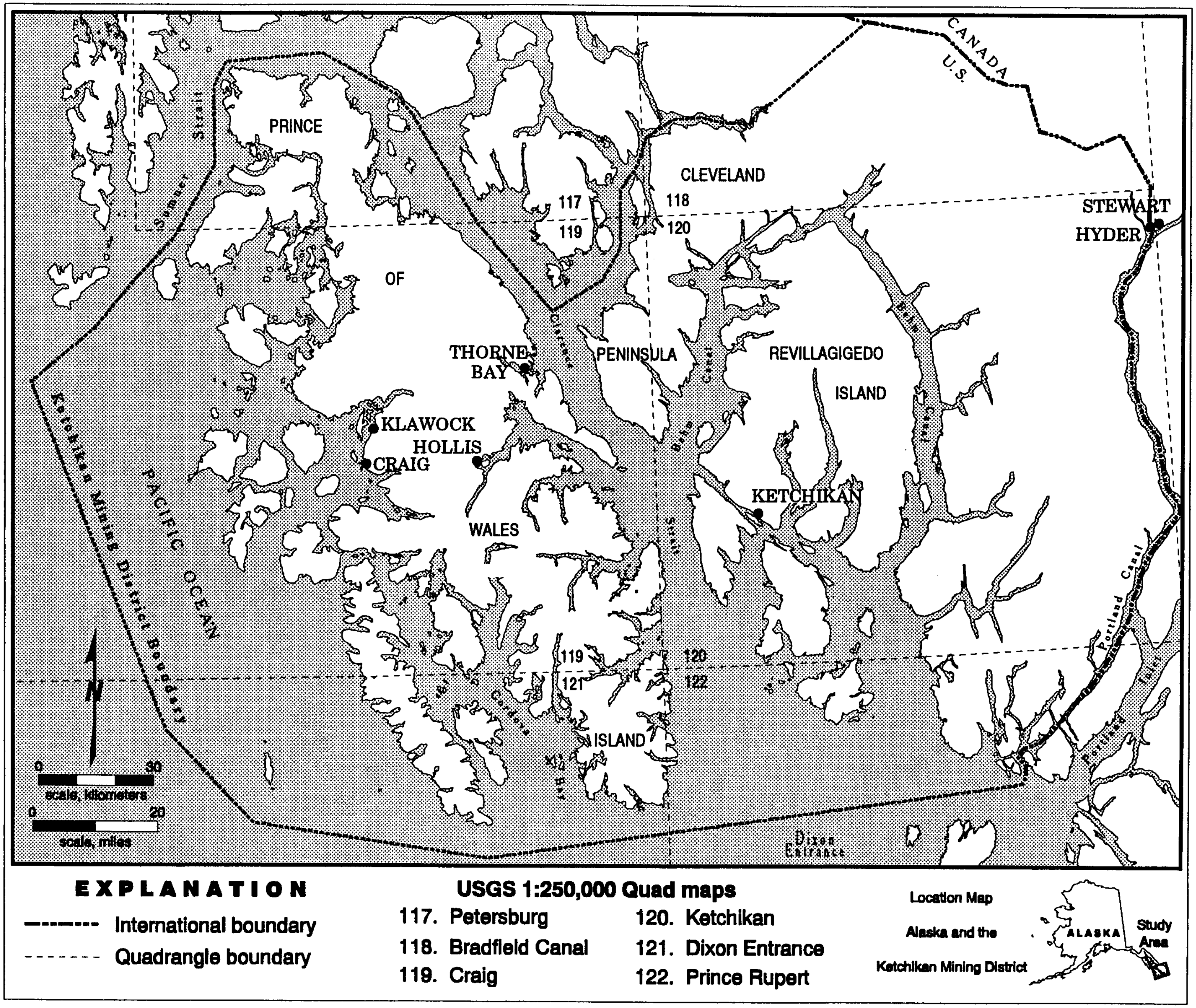

Figure 1. - General location map for the Ketchikan Mining District (includes the Hyder Mining District).

Land Status

Land status within the KMD is dominated by the U.S.D.A. Forest Service but Native regional and village corporations also own significant acreage. The State of Alaska, U.S. Bureau of Indian Affairs, U.S. Fish and Wildlife Service, U.S. Navy, U.S. Coast Guard, and private individuals own or manage the remaining acreage. The availability of land for mineral exploration and development is generally depicted in Figure 2.

Most Forest Service land is open to mineral exploration. Designated wilderness areas such as Misty Fiords, Southern Prince of Wales Island, Warren and Maurelle Islands, and Karta are closed to mineral entry and motorized or significant earth-disturbing exploration activities. There is an administrative closure to mineral entry at the Uncle Tom Natural Area, but the Maybeso Experimental Forest is open to mineral entry.

Sealaska Regional Corporation manages the subsurface or mineral estate on native corporation lands throughout the study area obtained under the provisions of the Alaska Native Claims Settlement Act, 1971. Native holdings in the KMD include the Craig-Klawock, Kasaan, Hydaburg, Klukwan, Angoon, and Saxman village withdrawals. Sealaska has also received full title to certain lands on Dall Island. Sealaska has been actively exploring and promoting the mineral potential on these lands and welcomes proposals from the minerals industry for lease arrangements on their land.

State of Alaska holdings in the KMD are sparse and can be found peripheral to several non-native communities in the study area. Most State land outside of residential subdivisions, airport right-of-ways, mental health lands, and commercial centers is open to mineral entry and development. There are scattered State-selected parcels which are closed to Federal claim-staking. These same parcels can be staked with State mining claims but no work can be performed on them until the lands are conveyed to the State. The State's primary management role in this part of Alaska involves tidelands and submerged lands. The Alaska Department of Natural Resources has developed area management plans for Prince of Wales Island (2,3)

The Metlakatla Indian Community, in cooperation with the U.S. Bureau of Indian Affairs, manages Annette Island, the only remaining Indian reservation in Alaska. Public prospecting and private mining ventures are not allowed without permission from the Metlakatla community and the U.S. Bureau of Indian Affairs. The U.S. Bureau of Mines did not investigate mineral occurrences on Annette Island during this study (9,15-17).

The U.S. Fish and Wildlife Service manages the Forrester Island National Wildlife Refuge, located in the southwest corner of the district. This area is closed to mineral exploration and development. U.S. Coast Guard and Navy stations are limited in size and are located respectively in Ketchikan and on Back Island, situated in Behm Canal.

Numerous unpatented and patented mining claims are present in the study area. Location information for the unpatented claims can be obtained from the State recorders offices in Ketchikan or Juneau. Patented claim locations are depicted on master title plats; details within the patent boundaries can be obtained from the mineral survey plats. Plats are available from the U.S. Forest Service or U.S. Bureau of Land Management.

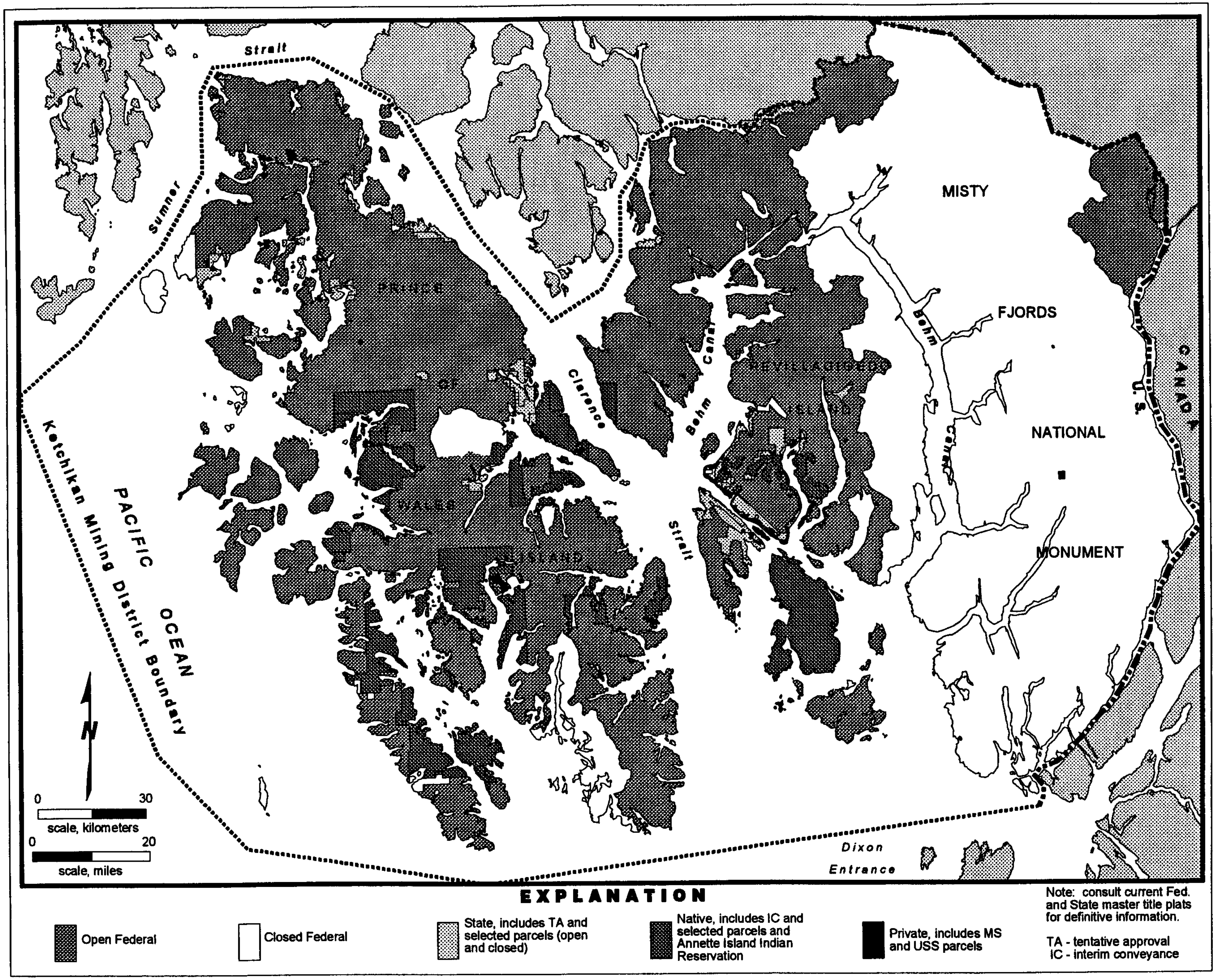

Figure 2 . - Generalized land status map.

Physiography and Climate

The physiography within the district varies from lowlands dominated by thick brush, muskeg, and forests to rugged, glacially carved peaks in the Hyder area which approach elevations of 2,000 m. Treeline occurs at various elevations throughout the district, but generally is around 750 m.

Conifers present include the commercially harvested Sitka spruce, red and yellow cedar, and western hemlock. Also present are hardwoods such as alder, willows and cottonwood; various berry bushes; and other shrubs and forbs including the formidable devil's club. Muskeg openings, which provide relatively easy cross-country access, contain a unique blend of stunted growth quite different than that of the forest.

Wildlife in the district is plentiful and there are no species on the endangered list under the Endangered Species Act (34). Land mammals include the Sitka black-tail deer, black bear, brown bear on the mainland, furbearers such as wolf, beaver, land otter, mink, marten and many species of small rodentia. Marine mammals, such as whales, porpoise, seals, sea lions and sea otters inhabit the inland and coastal waterways. Birdlife consists of bald eagles, crows, ravens, and many seabird and waterfowl species. There are numerous anadromous fish-spawning streams within the district.

Climatological data recorded at Annette Island from 1963-92 by the National Oceanic and Atmospheric Administration indicates a mean annual precipitation rate of 277 cm, with extremes of 335 cm measured in 1991, and 216 cm measured in 1985 (4). September through January are the wettest months, with October consistently being 33% wetter than any other month.

The average annual temperature over the same period is 7.6°C with an average maximum temperature of 10.6°C and an average minimum of 4.6°C. July and August are usually the warmest months with high temperatures reaching 18.1°C. January is typically the coldest month with average low temperatures dropping to -1.3°C.

The majority of the district is subjected to typical southeast Alaska maritime weather characterized by mild daily variations in temperature and frequent storms emanating from the Gulf of Alaska. Topography has a marked influence on temperature and precipitation patterns. As an example, the precipitous terrain surrounding Hyder experiences more extreme cold temperature and snow than other areas in the district.

Environmental and Socioeconomic Issues

This preliminary study does not address environmental and socioeconomic concerns in a direct manner. For each model the acquisition cost represents the cost of mine permitting activities, environmental studies such as baseline data collection, water quality sampling and monitoring, wildlife studies, preparation of permit applications to the required local, State, and Federal agencies and other related activities. Environmental issues that may arise during the course of mineral development in Southeast Alaska may include but are not limited to potential impacts on recreational opportunities, fishery habitat, water quality, marine environment, technical and economic feasibility, and regional population centers (33).

Socioeconomic concerns may include but are not limited to potential impacts on the population (e.g. population increase, movement, or relocation in response to the project), public services and facilities, housing supply, employment, education (e.g. student population increase), local, State and Federal tax revenues and expenditures, transportation, and quality of life (8).

Mitigation measures and associated costs developed during the permitting process are unique for each mineral development project. It is difficult to estimate these costs without benefit of public scoping and at least a preliminary environmental and socioeconomic assessment for the proposed mineral development project. These issues and the associated costs of mitigation are beyond the scope of this preliminary study, and are not addressed in the economic models.

ECONOMIC MINE PREFEASIBILITY STUDIES

Economic prefeasibility studies for two mineral deposits types were conducted to establish the recoverable metal value (RMV) per metric ton necessary to meet a 15% discounted cash-flow rate-of-return (DCFROR). The definition of RMV as given by Baggs and Sherman in previous Bureau feasibility studies was used (6,22).

The RMV is the combined dollar value of all salable products from a given mineral deposit expressed in \$/mt. The RMV was used to reduce the individual effects of commodity grades, recoveries, and metal prices to a common base so that a single curve relating ore value of the deposit to DCFROR could be created. See Appendix B for further information and a sample calculation of RMV.

A number of factors control the feasibility of mineral development including physical attributes and geographic location of the deposit, perceived risk, metallurgical attributes of the minerals, metal markets, infrastructure availability, political and economic climate, environmental constraints, and corporate policy. Any forecast of the development potential should weigh all of the factors. Results presented here should be considered preliminary.

Bureau policy prohibits issuing any report as to the value of any mine or other private mineral property. The models are arbitrarily assigned descriptive labels to disguise their actual identity. The models are based on resource and grade estimates or assumptions.

Capital and operating costs for the models were determined using simplified cost models for prefeasibility minerals evaluations (11), and were supplemented with additional cost estimates from the USBM's Cost Estimation System (CES 2.3) to customize the models for Alaska (27). Cost estimates were escalated using the USBM's Alaska Mineral Industry Cost Escalation Factors (AMICEF) which reflect the higher cost of labor, transportation, and electricity in Alaska (7). Published cost information drawn from permitting documents, environmental impact statements, and private reports were also used (33-36). All cost estimates were expressed in December, 1993 dollars.

Using the estimated capital and operating costs, economic models were compiled using cash flow analysis techniques. The RMV and DCFROR were computed. The RMV was compared with long-term average commodity prices. See Appendix A for the economic models and Appendix B for the inflation adjusted twenty and thirty year commodity price averages.

Volcanogenic Massive Sulfide Model

The volcanogenic massive sulfide (VMS) deposit models are based on the geology and mineralization present at the Niblack and Ruby Tuesday deposits (Figure 3). These VMS deposits are hosted in Wales Group rocks on Prince of Wales Island, which are the most likely rock package to host a significant VMS deposit in the KMD. Favorable drill intercepts and geological mapping during current exploration at the Niblack and Ruby Tuesday deposits justify additional exploration and possible development. The massive sulfide mine models assume that the structural characteristics of the orebody favor the use of underground cut and fill mining methods. Exploration expenditures range from $35-80 million, increasing as the size of the resource delineated increases from 1-32 Mmt.

Twelve underground cut and fill mine models were developed, patterned after the Greens Creek Mine, which is located approximately 29 km southwest of Juneau, Alaska. Six use an on-site mill, and six use the existing Westmin Premier Mill located approximately 19 km north of Hyder, Alaska. It was assumed a flotation circuit would be added to the mill, and based on a comparison of three-product flotation and carbon-in-leach milling costs, the custom milling fee was estimated at $48 per metric ton of ore, regardless of milling requirements. Average RMV required for the off-site mill models were 17% higher (ranging from 7% to 31%) than the equivalent on-site model, and increased as the size of the model increased from 1 Mmt to 32 Mmt of resources.

Material handling requirements were almost five times larger under the off-site mill scenario as compared to the on-site mill scenario. As an example, the 1 Mmt model had an annual ore production rate of roughly 160,000 mtpy, and a concentrate production rate estimated at 34,000 mtpy. Another difficulty for the off-site mill scenario is the requirement to find an alternative source of backfill material for the mine if all of the ore is transported off-site to the Westmin Premier Mill. Backfill material requirements were estimated at approximately half of the daily ore production. No modeling was done to estimate the additional costs of finding an alternative source of backfill, as it was found off-site milling was not advantageous even if this additional cost was not considered in the off-site mill scenario models.

The on-site scenario requires building and maintaining a 3.2 km road from the mine site to the port and trucking concentrates year round for shipment to a smelter assumed to be located in Japan. The off-site scenario requires building and maintaining the same road, trucking ore 3.2 km, barging the ore 150 km to Stewart, British Columbia, off-loading it, and trucking it an additional 19 km to the existing Westmin Premier Mill.

Underground cut and fill mine models incorporate the use of jackleg drills, stopers, and small jumbos. Slushers move ore from the stope to ore chutes, Load-Haul-Dumps (LHDs) move ore from chutes to ore storage pockets. Hydraulic sand fill is used to fill stopes. After processing, approximately half of the daily ore production would be backfilled into the mine, 28% would be sent to the tailings pond for disposal, with the remaining volume reporting to the concentrates.

Employees would work a 4 weeks on, 2 weeks off schedule, year-round. One-third of the employees would be on their scheduled days off at anytime. Two-thirds would be on-site for their scheduled work assignments. Employees would be transported to the mine site via two catamaran ferries under a time charter arrangement (19).

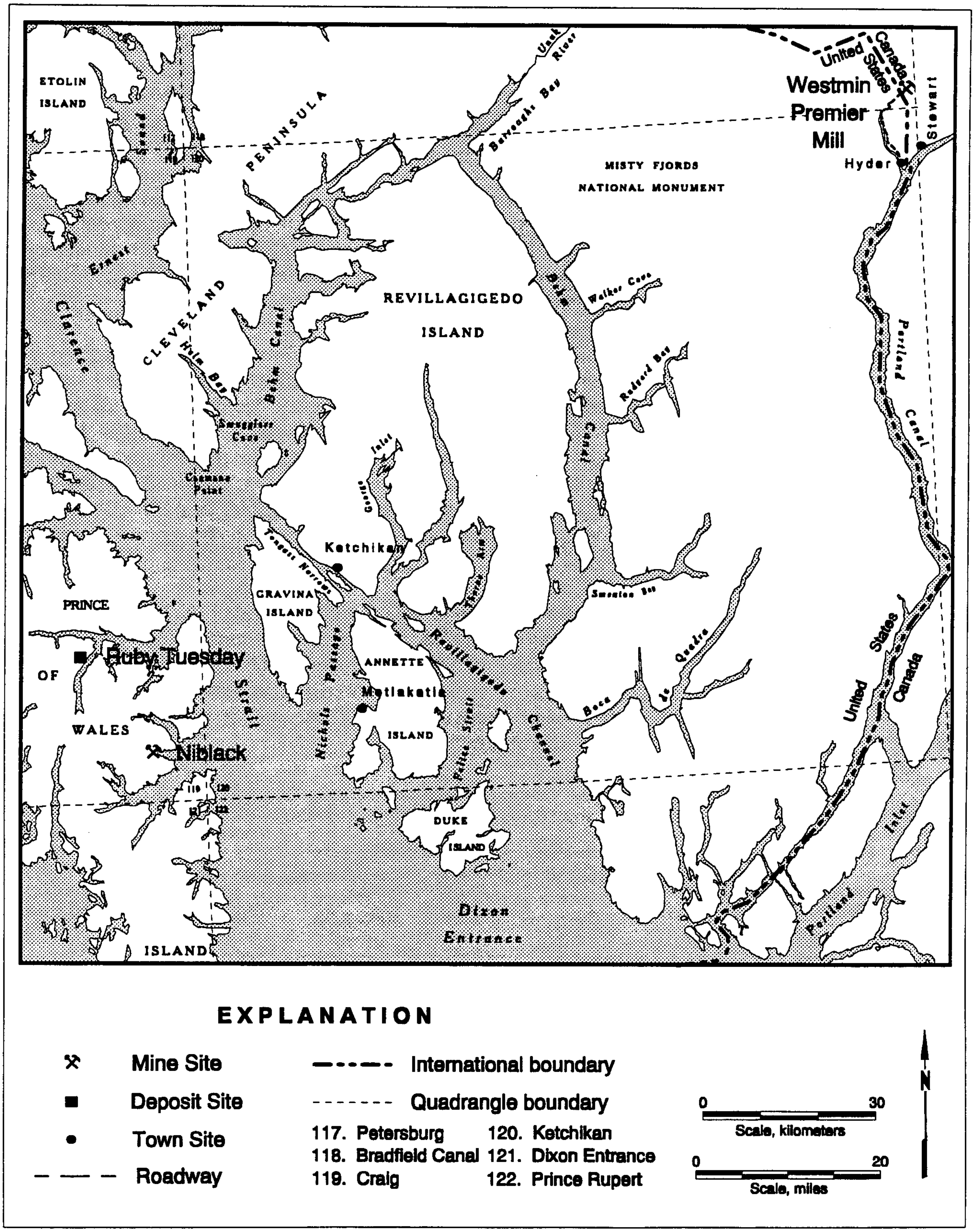

Figure 3. - Location map - Niblack, Ruby Tuesday deposits.

The primary ferry is 30.5 m long and has multiple backup systems for both safety and reliability, including three radar systems and four engines, a smaller ferry is available on standby. The work force would commute from Ketchikan, located about 55 km from the site. Based on these assumptions, transportation costs will be higher than that usually found in the lower-48. The project would produce its own electric power using diesel powered generators. Employees would be housed at a permanent accommodation complex built on-site.

Two concentrate storage buildings are included in the on-site model, one at the mill-site and one at the port-site, each capable of storing six weeks of production. The off-site model would not have concentrate storage buildings. Concentrates produced at the on-site or off-site mill would be shipped out to a smelter, assumed to be in Japan. Fuel storage facilities capable of supplying the operation year-round are located at the port-site and mill-site areas.

The difference in RMV under the off-site mill scenario varied. Average RMV required for the off-site mill models was 17% higher (ranging from 7% to 31%) than the equivalent on-site model. The difference in RMV increases as resource size increased from 1 Mmt to 32 Mmt of resources. Cost savings from the elimination of the mill, tailings pond, concentrate storage building construction, and reduction of power generation, employee transportation, and housing costs were not enough to offset the higher costs of trucking and barging ore to the off-site mill. The custom milling fee was another significant cost. All costs generated for each mine model are listed in Appendix A, Table A-1. In each mine model, the associated mill uses three-product flotation to process the ore.

Figure 4 graphically presents the results for the massive-sulfide deposit mine models. The downward sloping curve illustrates the cost advantage larger deposits achieve through economies of scale. Table 1 summarizes the results of the RMV vs. DCFROR analysis for the mine models. The RMV per metric ton of minable ore required to achieve a 15% DCFROR range from $526/mt for a 450 mtpd (1 Mmt) mine using an off-site mill, to a low of $137/mt for a 6,100 mtpd (32 Mmt) mine using an on-site mill.

Table 1. - Summary of cash flow analysis for massive sulfide mine models using cut and fill underground mining method

Deposit Type	Deposit Size (Mmt)	Mining rate (mtpd)	RMV On-site mill 15% ROR ($/mt)	RMV Off-site mill 15% ROR ($/mt)
Massive sulfide	1	450	$490	$526
Massive sulfide	2	760	327	361
Massive sulfide	4	1,300	245	274
Massive sulfide	8	2,100	194	224
Massive sulfide	16	3,600	159	194
Massive sulfide	32	6,100	$137	$175

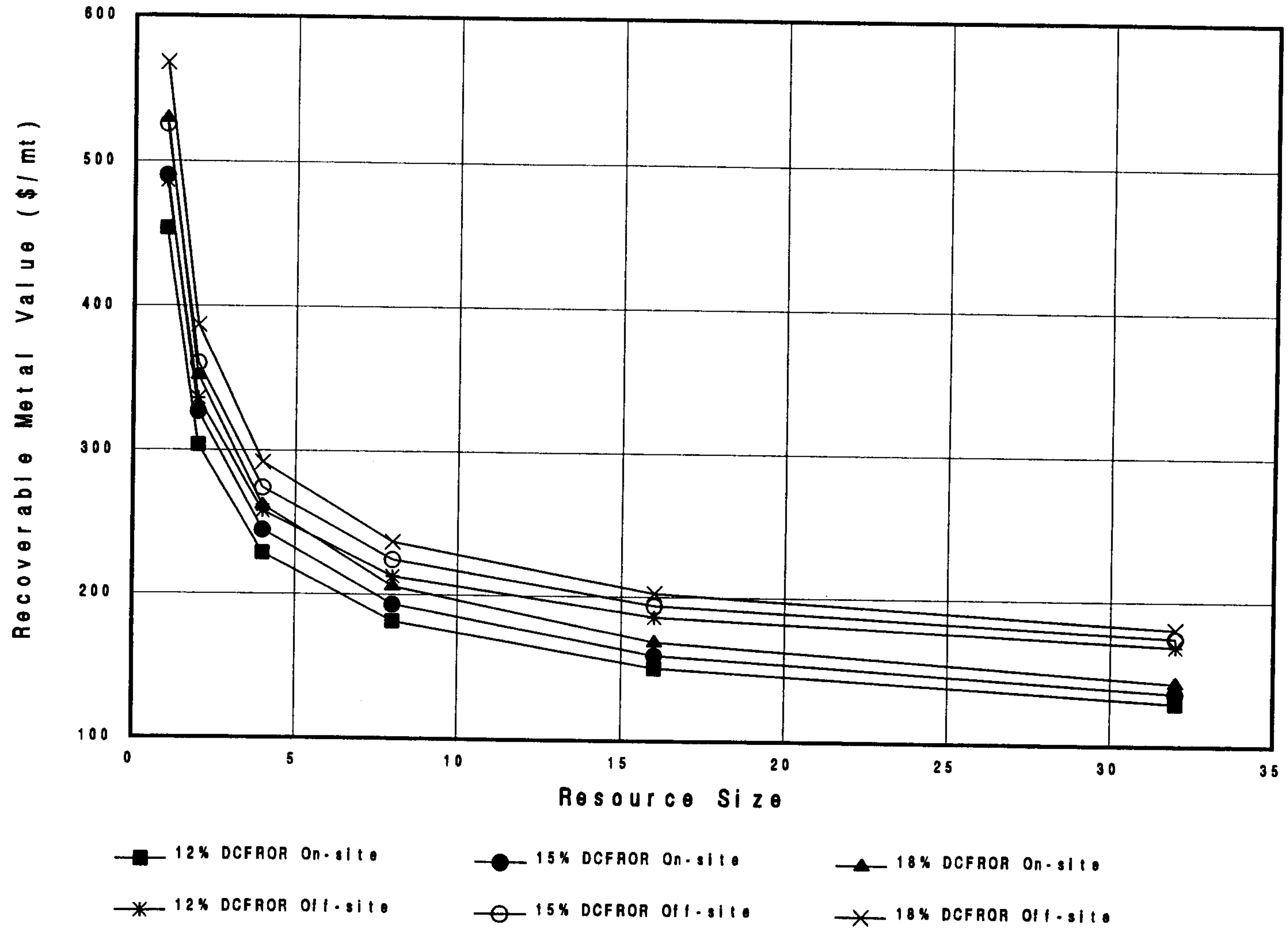

Figure 4. - RMV vs. resource size, massive sulfide underground mine models

Low Sulfide Vein Gold Models

Hazelton Group rocks which host the Premier Mine orebody are present in the Hyder area and provide the basis for this model (Figure 5). Though the Premier deposit contains high sulfide veins, an open-pit scenario requires diluting the sulfide content to a level consistent with a low sulfide vein gold model. The gold models developed for this prefeasibility study are patterned after the Silbak Premier pit and based on resource sizes from 1-16 Mmt.

The models assume ore is mined by open-pit methods using rubber-tired front end loaders, diesel trucks, and percussion drills. The ore is milled using carbon-in-leach processing. The stripping ratio is 3.96:1. An access road, capable of handling 50 mt ore trucks, built over fairly rugged terrain (4.3 m width x 9.6 km length) would be constructed to the mine site from the existing Granduc road (24). For off-site mill models, ore will be hauled 19.2 km one way. Electric power will be produced by on-site diesel generators. Employees will commute at their own expense from Hyder, Alaska. Exploration costs are estimated at $2.00/mt.

For the on-site mill scenario, material requirements for tailings impoundment construction will be equal to 10% of the resource size, and the tailings will be 50% by weight solids. The power plant cost for the off-site scenario will be 40% of the comparable on-site scenario. The milling fee for the off-site mill scenario is assumed to be $38.58/mt regardless of the milling rate (13). It is assumed the Westmin Premier Mill can process the ore.

To date, no economically viable low sulfide gold deposits as modeled in this report have been discovered in the district. Table 2 summarizes the results of the RMV vs. DCFROR analysis for the mine models. The RMV per metric ton of minable ore required to achieve a 15% DCFROR range from $100/mt for a 360 mtpd (1 Mmt) open pit mine using an on-site mill, to a low of $49/mt for a 2,900 mtpd (16 Mmt) open pit mine using an on-site mill.

Figure 6 graphically presents the relation between RMV per metric ton and deposit size for the low sulfide gold deposit mine-models. This graph illustrates that sending ore to the Westmin Premier Mill is an advantageous alternative for the smaller models. This has also been demonstrated in practice, the Silver Butte property, located approximately 12 km from the Westmin Premier Mill had 113,000 mt of its ore milled in 1991. An on-site mill is more cost-effective for larger deposits.

Table 2. - Summary of cash flow analysis for open pit gold models

Deposit Type	Deposit Size (Mmt)	Mining rate (mtpd)	RMV On-site mill 15% ROR ($/mt)	RMV Off-site mill 15% ROR ($/mt)
Gold	1	360	$100	$71
Gold	2	610	80	63
Gold	4	1,000	67	58
Gold	8	1,700	57	56
Gold	16	2,900	$49	$54

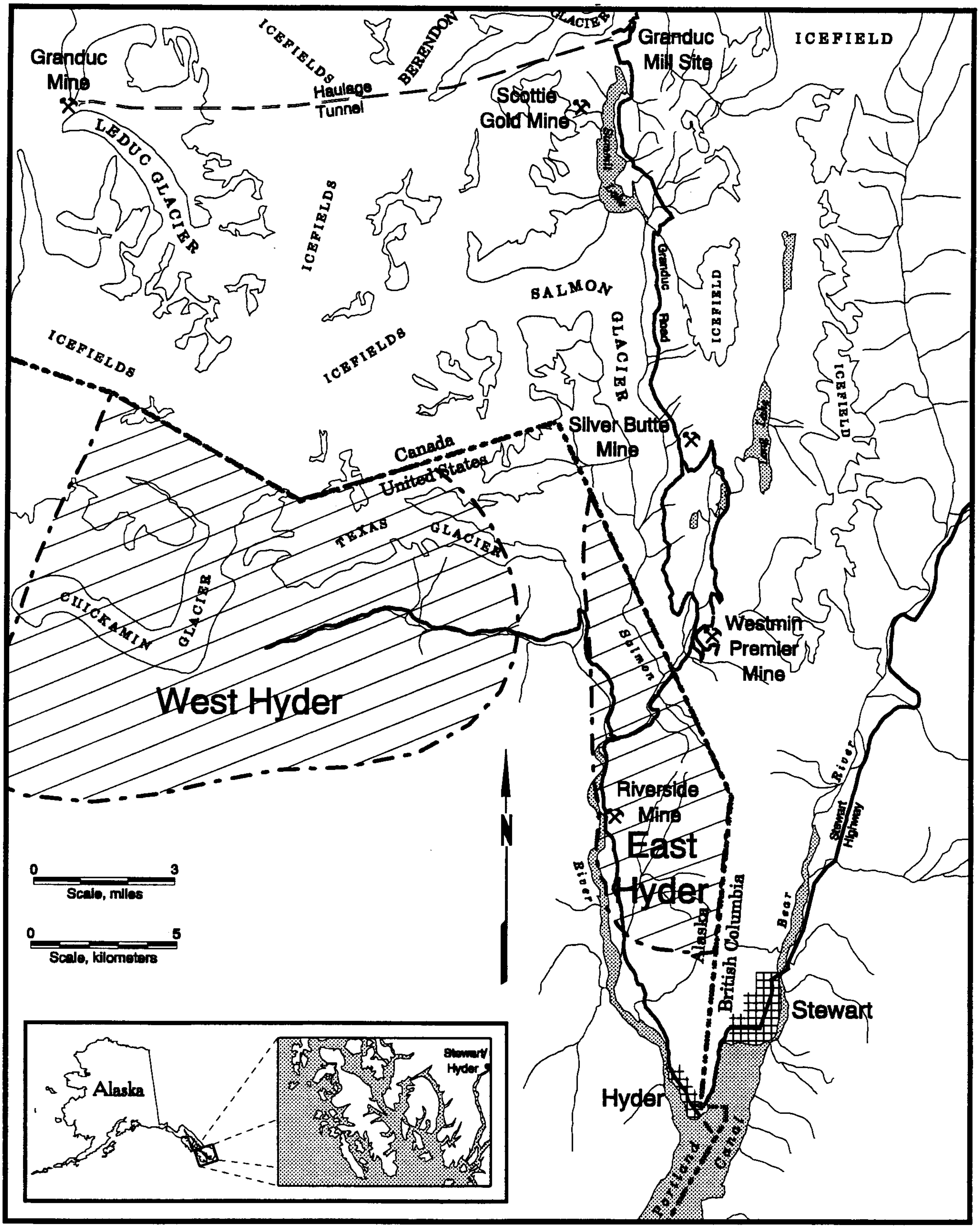

Figure 5. - East and West Hyder known mineral deposit areas.

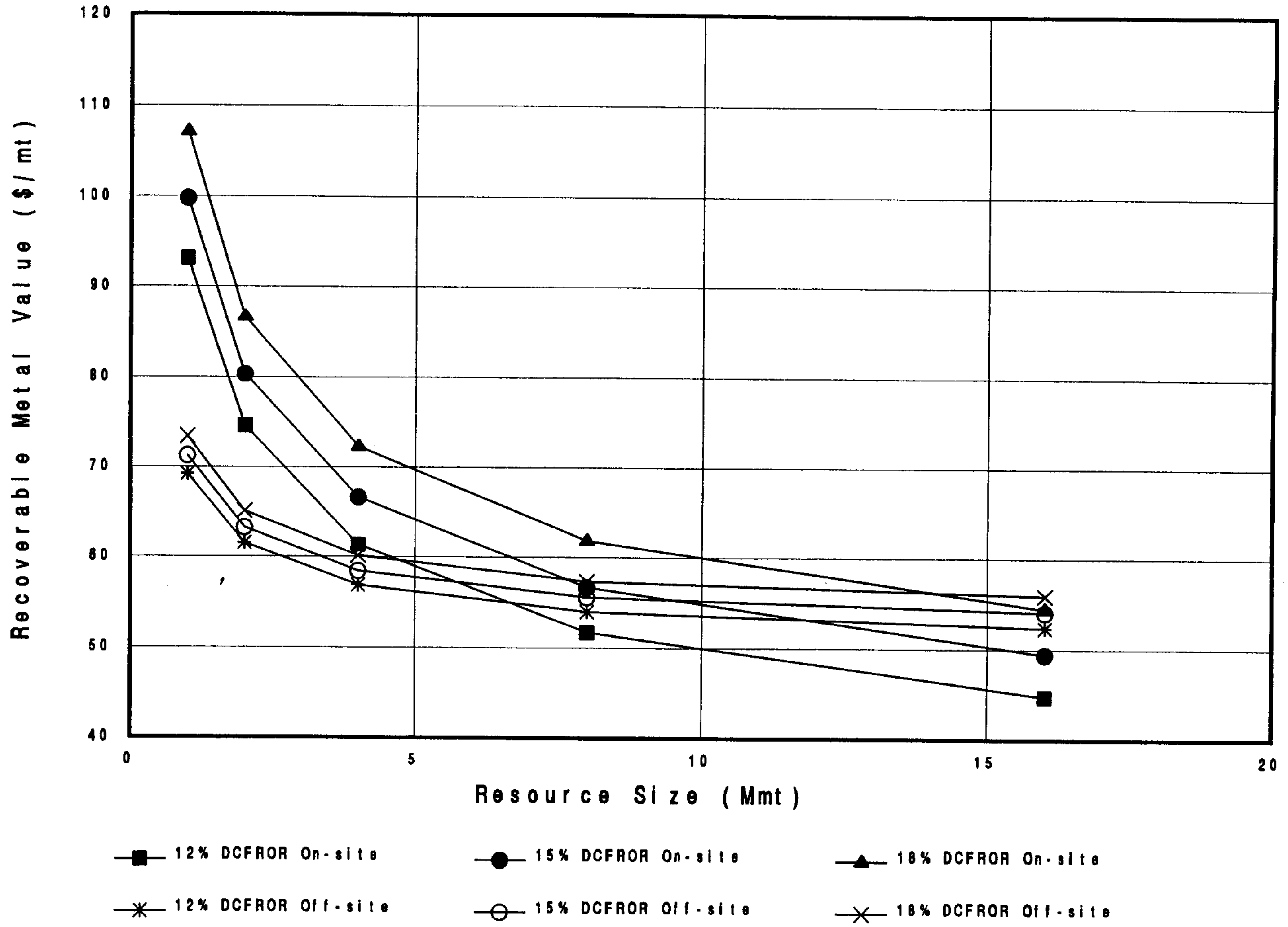

Figure 6. - RMV vs. resource size, open-pit gold models

SUMMARY AND CONCLUSIONS

Mining prefeasibility investigations were conducted for volcanogenic massive sulfide copper-zinc and low sulfide vein gold deposit types that may be found in the KMD. Mine models were developed for application to the mineral deposit models. Capital and operating costs for the models were determined using simplified cost models for prefeasibility minerals evaluations. These models were supplemented with additional cost estimates from the USBM's Cost Estimation System (CES 2.3) to customize the models for Alaska. Published cost information drawn from industry publications, permitting documents, and environmental impact statements were also used. All costs were escalated by factors which reflect the higher cost of labor, transportation, and electricity in Alaska.

The cost data for each mine model were used to perform a cash flow analysis for each mine model, and the DCFROR was calculated. The goal of the prefeasibility study was to determine the RMV per metric ton of minable ore that would cause the simulated cash flow of each of the mine models to achieve a 15% DCFROR economic threshold. The 15% DCFROR threshold is an industry standard and was selected as the minimum return on investment that would be considered acceptable.

The economic modeling indicated RMV required to achieve a 15% DCFROR for an underground cut-and-fill, massive sulfide mine range from $137/mt for a 6,100 mtpd (32 Mmt) operation using on-site milling to $526/mt for a 450 mtpd (1 Mmt) operation using off-site toll milling. On-site milling was less costly than off-site milling.

Economic modeling for low sulfide vein gold deposits indicated the RMV necessary for a 15% DCFROR for an open-pit mine, off-site mining operation ranged from $54/mt at 2,900 mtpd to $71/mt at 360 mtpd, and from $49/mt at 2,900 mtpd to $100/mt at 360 mtpd for an on-site milling operation. Off-site milling was less costly than on-site milling until production exceeded approximately 1,700 mtpd. Then, economies of scale reduced operating costs enough to offset the higher capital costs required for on-site milling.

Deposit grades required to achieve the necessary RMV for a 15% DCFROR with the development scenarios modeled in this report can be calculated based on information found in Appendix B.

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APPENDIX A. - CAPITAL AND OPERATING COSTS FOR KMD MINE MODELS

The tables in this appendix give the mineral deposit type and mine model descriptions; and capital and operating costs for the KMD mine models. Capital costs are categorized into six groups which include acquisition, exploration, infrastructure, mine, mill, and working capital costs for each model. Operating costs are categorized into six groups which include general and administrative, infrastructure, mine, mill, smelting, and transportation.

Table A-1. - Mineral deposit and mine model descriptions

Deposit type	Deposit size (Mmt)	Mine model	Mining rate (mtpd)	Mine life (yrs)[4]	Mill type
Massive sulfide	1	Cut and fill	450	6	Flotation
Massive sulfide	2	Cut and fill	760	8	Flotation
Massive sulfide	4	Cut and fill	1,300	9	Flotation
Massive sulfide	8	Cut and fill	2,100	11	Flotation
Massive sulfide	16	Cut and fill	3,600	13	Flotation
Massive sulfide	32	Cut and fill	6,100	15	Flotation
Low sulfide vein gold	1	Surface	360	8	CIL Plant
Low sulfide vein gold	2	Surface	610	9	CIL Plant
Low sulfide vein gold	4	Surface	1,000	11	CIL Plant
Low sulfide vein gold	8	Surface	1,700	13	CIL Plant
Low sulfide vein gold	16	Surface	2,900	16	CIL Plant

[4] Mine life estimate is based on 350 days per year.

TABLE A-2. - Capital and operating costs - massive sulfide on site mill models

Model Description						
Resource size (Mmt)	1	2	4	8	16	32
Mining rate (mtpd)	450	760	1,300	2,100	3,600	6,100
Capital Costs ($ millions)						
Acquisition	$5.31	$6.33	$7.61	$9.40	$11.70	$14.90
Exploration	35.20	37.60	41.70	48.70	60.30	80.00
Infrastructure	23.20	27.40	31.60	39.10	46.70	58.80
Mine	59.60	67.60	77.70	90.40	106.00	124.00
Mill	13.50	18.10	24.80	34.30	49.10	70.80
Reclamation	9.20	9.20	9.20	9.20	9.20	9.20
Working Capital	5.48	7.59	10.70	15.20	22.00	32.00
TOTAL[5]	$151.00	$174.00	$203.00	$246.00	$350.00	$390.00
Operating costs ($/mt)						
Infrastructure	$13.00	$9.82	$7.56	$5.95	$4.80	$3.99
Mine	73.80	63.10	54.20	46.70	40.40	35.10
Mill	35.60	26.80	20.60	16.30	13.20	11.00
Smelting[6]	43.00	43.00	43.00	43.00	43.00	43.00
Transportation	12.30	11.20	10.40	9.76	9.25	8.84
TOTAL[5]	$178.00	$154.00	$136.00	$122.00	$111.00	$102.00

TABLE A-3. - Capital and operating costs - massive sulfide off site mill models

Model Description						
Resource Size (Mmt)	1	2	4	8	16	32
Mining rate (mtpd)	450	760	1,300	2,100	3,600	6,100
Capital Costs ($ millions)						
Acquisition	$6.01	$6.80	$7.86	$9.10	$10.70	$12.50
Exploration	35.20	37.60	41.70	48.70	60.30	80.00
Infrastructure	47.60	53.20	60.30	67.90	79.10	88.60
Mine	60.00	68.00	77.80	90.30	106.00	126.00
Mill	0.00	0.00	0.00	0.00	0.00	0.00
Reclamation	9.20	9.20	9.20	9.20	9.20	9.20
Working Capital	5.90	8.90	13.80	21.60	34.10	54.50
TOTAL[5]	$164.00	$184.00	$211.00	$247.00	$299.00	$371.00
Operating costs ($/mt)						
Infrastructure	$11.50	$9.65	$8.43	$7.71	$7.56	$7.83
Mine	73.80	63.10	54.20	46.70	40.40	35.10
Custom Mill Fee	48.00	48.00	48.00	48.00	48.00	48.00
Smelting[6]	43.00	43.00	43.00	43.00	43.00	43.00
Transportation	17.50	17.00	16.50	16.10	15.80	15.50
TOTAL[5]	$194.00	$181.00	$170.00	$162.00	$155.00	$149.00

[5] Figures may not sum due to independent rounding.

[6] Includes base smelter charges of $209/mt zinc concentrate, and $196/mt lead concentrate. RMV includes smelter recovery and all price and assay adjustments which reduce the smelter payment (23).

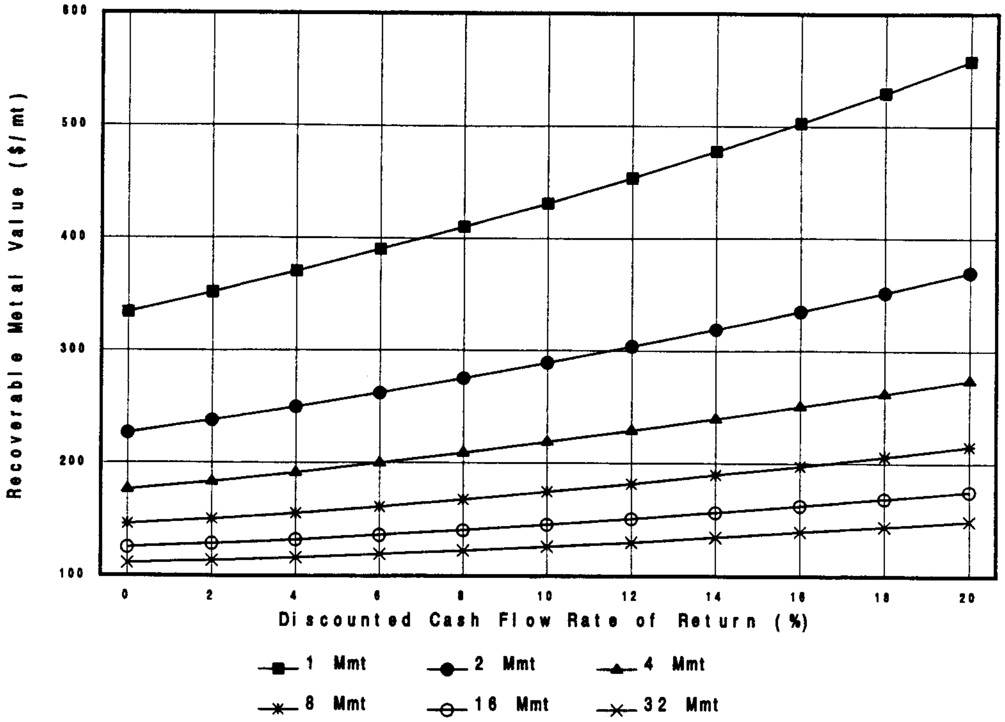

Figure A-1. - RMV vs. DCFROR massive sulfide models - on site mill

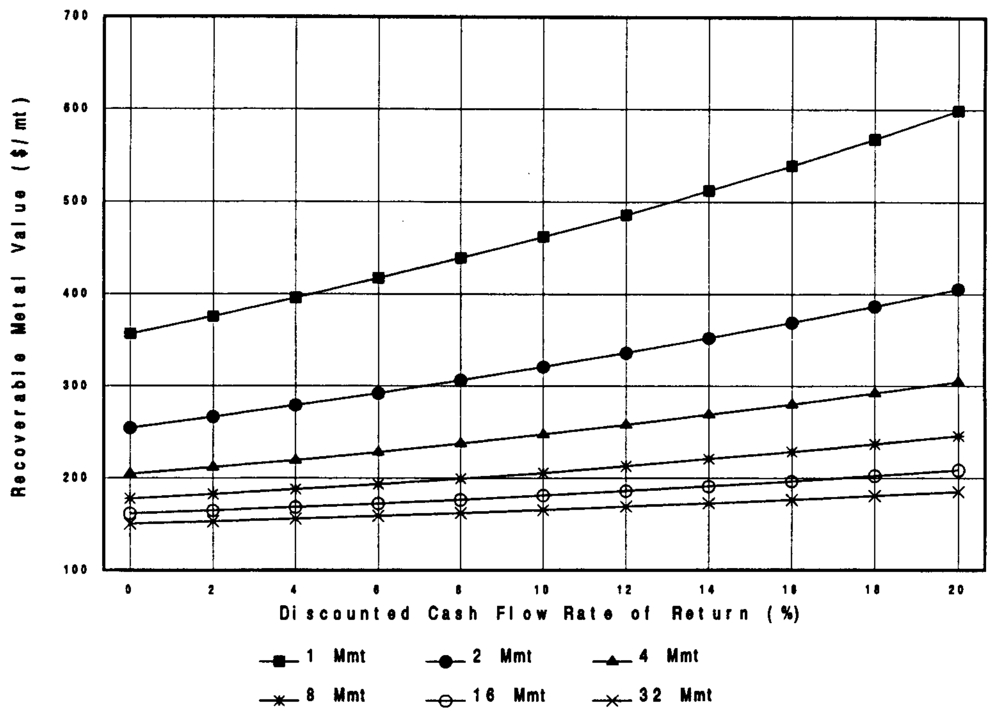

Figure A-2. - RMV vs. DCFROR massive sulfide models - off site mill

TABLE A-4. - Capital and Operating costs - gold on site mill models

Model description					
Resource Size (Mmt)	1	2	4	8	16
Mining rate (mtpd)	360	610	1,000	1,700	2,900
Capital Costs ($ millions)					
Acquisition	$1.03	$1.48	$2.17	$3.26	$5.02
Exploration	2.00	4.00	8.00	16.00	32.00
Infrastructure	4.16	4.53	5.01	5.63	6.44
Mine	5.66	7.53	10.05	13.40	17.50
Mill	13.90	20.80	31.10	46.50	69.50
Working Capital	1.68	2.29	3.19	4.53	6.56
TOTAL[7]	$28.50	$40.70	$59.50	$89.30	$137.00
Operating costs ($/mt)					
Infrastructure	$0.81	$0.48	$0.28	$0.17	$0.10
Mine	10.48	7.89	5.98	4.59	3.56
Mill	35.24	30.40	26.49	23.31	20.73
Refining	0.21	0.21	0.21	0.21	0.21
Transportation	4.86	2.89	1.72	1.02	0.61
TOTAL[7]	$51.60	$41.90	$34.70	$29.30	$25.20

TABLE A-5. - Capital and Operating costs - gold off site mill models

Capital Costs ($ millions)					
Resource size (Mmt)	1	2	4	8	16
Mining rate (mtpd)	360	610	1,000	1,700	2,900
Capital Costs ($ millions)					
Acquisition	$0.41	$0.56	$0.81	$1.25	$2.06
Exploration	2.00	4.00	8.00	16.00	32.00
Infrastructure	3.42	3.56	3.76	4.00	4.33
Mine	4.88	6.38	8.41	11.20	15.10
Mill	0.00	0.00	0.00	0.00	0.00
Working Capital	1.83	2.82	4.44	7.12	11.60
TOTAL[7]	$12.50	$17.30	$25.40	$39.60	$65.10
Operating costs ($/mt)					
Infrastructure	$0.81	$0.48	$0.28	$0.17	$0.10
Mine	10.48	7.89	5.98	4.59	3.56
Custom Mill Fee	38.58	38.58	38.58	38.58	38.58
Refining	0.21	0.21	0.21	0.21	0.21
Transportation	6.32	4.35	3.18	2.48	2.07
TOTAL[7]	$56.40	$51.50	$48.20	$46.00	$44.50

[7] Figures may not sum due to independent rounding.

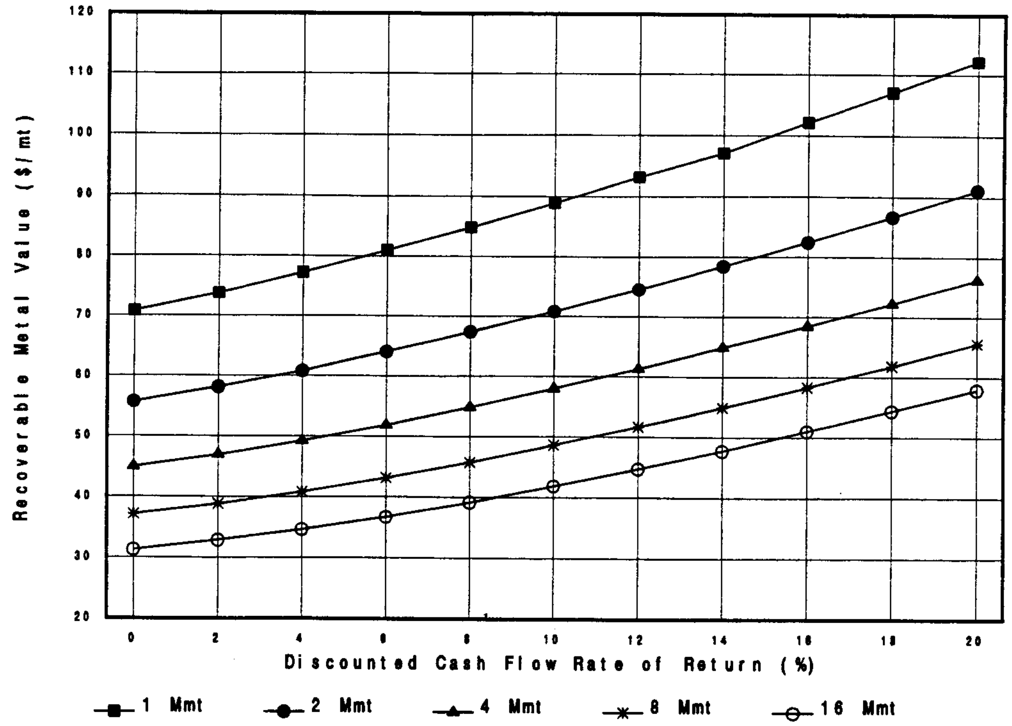

Figure A-3. - RMV vs. DCFROR gold models - on site mill

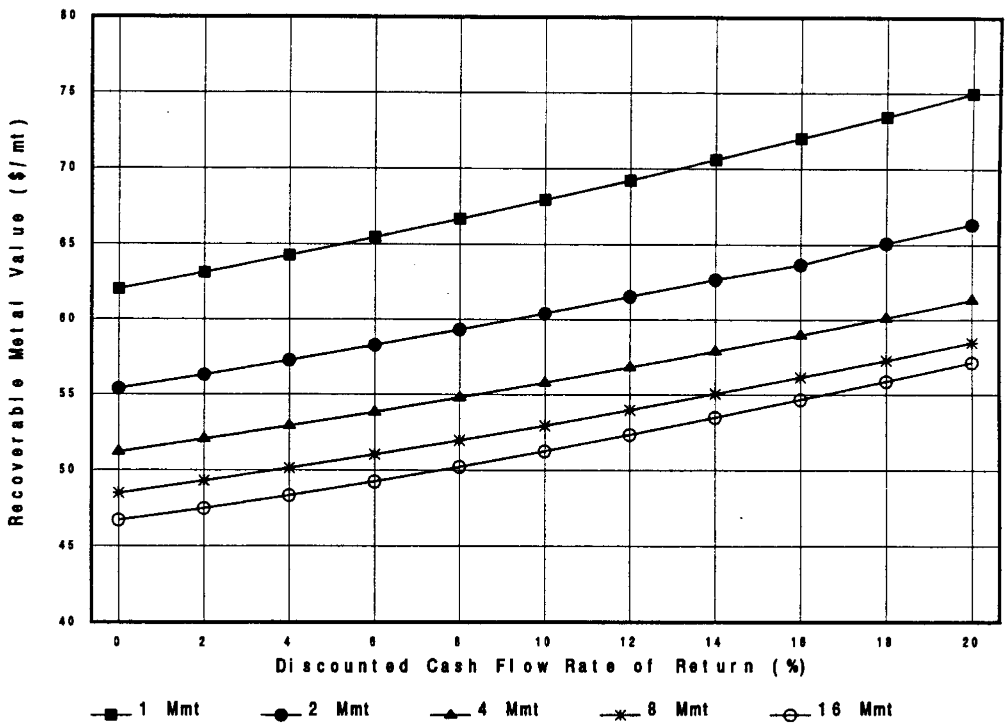

Figure A-4. - RMV vs. DCFROR gold models - off site mill

APPENDIX B. - ECONOMIC ASSUMPTIONS

This appendix includes information regarding the development of the economic models. It notes all major assumptions for income tax rates, depletion, depreciation, commodity prices, exploration and permitting costs, working capital, salvage value, and reclamation expense.

Economic Factors

It is important to emphasize that the mine models described in this report are based on hypothetical mining and milling scenarios. The models are not meant to represent a feasibility analysis of specific deposits. This would be inappropriate since such an analysis requires more precise data than that available for this report.

The models do not include proprietary company data which, if available, would probably change the outcome of the evaluation. When applicable, cost information from developing or producing mines in Alaska was used in constructing the models. Alaska Mineral Industry Cost Escalation Factors (AMICEF) of 1.51 for operating labor, 1.58 for capital labor, 1.08 for capital costs, and 1.73 for electricity were used to reflect higher costs in the KMD (7).

A number of factors control the feasibility of mineral development, including physical attributes of the deposit, metallurgical attributes of the minerals, metal markets, infrastructure availability, political climate, environmental constraints, and corporate policy. Any forecast of the development potential should weigh all of these factors. Results and the conclusions presented here should be considered preliminary.

Cash Flow Assumptions

All RMV ($/mt) are equal to the amount of revenues required before all expenses including royalties, mining and milling operating costs, off-site transportation costs, base smelting charges, and taxes are deducted. Base smelter charges are estimated at $209/mt zinc concentrate and $196/mt lead concentrate. RMV includes smelter recovery and all price and assay adjustments which reduce the smelter payment (23). The massive sulfide model assumes all concentrates would be sent to Japan.

Federal, Alaska corporate income, and mining license tax rates are simulated with a 41% tax rate during the first 3 years of production, 43% in the 4th year, and 45% thereafter. All projects were assumed to be equity financed by a single corporate producer that expensed tax due against other income. Modified Accelerated Cost Recovery System (ACRS) depreciation and Percentage Depletion were utilized.

Exploration costs were considered for all models. Acquisition capital cost represents the direct cost of permitting, and was estimated at 4% of the total project cost (21). Additional reclamation costs were included in the massive sulfide models to supplement the salvage value recovered at the end of the mine life.

For the gold models, salvage value was assumed to equal reclamation cost. Mine and mill reinvestment was considered for the massive sulfide models, but was not considered for the gold models. Working capital for both models equals 90 days of operating costs less smelting costs and was recovered in the last year of the project.

Calculation of RMV

Assume mill feed with grades of 11% zinc, 396.5 g/mt silver, 3% lead, and 3.6 g/mt gold was mined from a deposit. Mill recoveries were estimated at 90% for zinc, 85% for silver, 81% for lead, and 71% for gold. Smelter recoveries were estimated at 75% for zinc, 87% for silver, 80% for lead, and 55% for gold. Using the 30 year average prices shown on Table B-1, the RMV ($/mt) equals $237.

The equation used in calculating RMV for a deposit is:

$$\sum_{i=1}^{n} G_iR_iS_iV_i,$$

where

G_i = mill feed grade of commodity i,
R_i = mill recovery of commodity i,
S_i = smelter recovery of commodity i,
V_i = $/unit of commodity i,
and n = total number of commodities.

The calculations are shown in the worksheet below.

CALCULATION OF RECOVERABLE METAL VALUE						
Commodity	Grade (decimal)	Mill Recovery (decimal)	Smelter Recovery (decimal)	Unit	Price	RMV
	Gi	Ri	Si		Vi	(GiRiSiVi)
Zinc	0.11	0.90	0.75	mt	$1,420	$107
Silver	396.5	0.85	0.87	g	$0.30	88
Lead	0.03	0.81	0.80	mt	$1,120	25
Gold	3.6	0.71	0.55	g	$12.18	17
TOTAL						$237

How To Use Worksheet

1. Estimate minable resource size, and resource commodity grades to be evaluated.

2. Refer to Figure A-1, or A-3, select appropriate graph line representing nearest estimated minable resource size. Read RMV ($/mt) from y-axis. This is the minimum value per metric ton of minable resource adjusted for mining recovery, dilution, mill and smelter recovery required to yield a 15% DCFROR using the mining and milling scenario described in the report.

3. To translate this value into a gross in place value (GIPV), back calculate value using assumed mill recoveries or pilot testing results if available, and appropriate smelter recoveries. Suggested commodity prices shown in Table B-1 may be used or other prices as desired.

Transportation costs

Mineral locations in Southeast Alaska mining operations are often located off the road system. Most potential mines will have to arrange for barge or ship transport of incoming supplies and outgoing ore or concentrate. For small operations requiring only periodic shipments, the use of a barge with a porta-ramp is usually less costly than the construction of a dock.

Barges and tugs are available in Juneau and Wrangell with 900-3,200 mt capacities. A barge in this size range will cost $200-300 per day to charter. The tug will cost $3,000-4,600 per day depending on size and who supplies the fuel. The charges start when the tug and barges leave their home port (5,37).

For larger mines requiring more frequent shipments a small dock becomes a necessity. A minimum length of 30.5 m along with dolphins located 15 m off the ends of the dock is required to load 61 m long barges. If the dock will only be used for barges, a minimum water depth of 3 m is required, but safe use by small cargo ships will require a depth of 6.1 m. A typical dock is assumed to be located about 30.5 m from shore to be in the recommended 6.1 m depth.

A simple small dock would be "T" shaped, having a 6.1 m wide by 30.5 m long section connecting the dock to the shore. The dock itself would be 30.5 m long by 15 m wide to safely handle loading equipment. A similar dock was recently constructed at a cost of $840,000 (18).

Access road costs can be quite variable, depending primarily on the ruggedness of the terrain and the remoteness of the site. A typical 4.25 m wide road with rock overlay designed to handle 72.5 mt gross vehicle weight (GVW) vehicles can be expected to cost about $300,000 to 600,000/km in much of the rugged terrain common in Southeast Alaska (39).

Commodity Prices

Commodity prices provided for comparison purposes were determined by using an inflation adjusted thirty-year average for the years 1964-93. Prices for 1964-93 from various Bureau publications were escalated to 1993 dollars using U.S. Department of Commerce Gross National Product implicit price deflators and then averaged (25-31).

Thirty year average prices are recommended for all commodities except silver and gold. The twenty year average price for silver and gold offsets the effects of government policies on these metals prior to 1973. All prices shown in Table B-1 are given in 1993 dollars.

Table B-1. - Ten, Twenty, and Thirty year Average Commodity Prices (1964-1993)

	English Units				Metric Units			
Commodity	30 YR AVG	20 YR AVG	10 YR AVG		30 YR AVG	20 YR AVG	10 YR AVG	
Copper	$1.42	$1.30	$1.11	lb	$3.13	$2.87	$2.45	kg
Gold	378.70	486.05	441.36	tr oz	12.18	15.63	14.19	g
Lead	0.51	0.49	0.38	lb	1.12	1.07	0.83	kg
Silver	9.44	11.06	6.68	tr oz	0.30	0.36	0.21	g
Zinc	$0.64	$0.68	$0.63	lb	$1.42	$1.50	$1.39	kg