Report # 9
061478

PRELIMINARY EVALUATION

YUKON - N.W.T. IRON ORE

For

CREST EXPLORATION LIMITED

Canadian Bechtel Limited

January 1963

CANADIAN BECHTEL LIMITED

TWENTY-FIVE KING STREET WEST
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TORONTO, ONTARIO

S. M. BLAIR
PRESIDENT

January 15, 1963

Mr. G. L. Knox
President
Crest Exploration Limited
Medical Arts Building
329A - 6th Avenue S. W.
Calgary, Alberta

Dear Mr. Knox:

We are pleased to submit our preliminary evaluation report on your Yukon-N. W. T. iron ore deposit. With your guidance the emphasis in the study has been laid on what appears to be the most realistic size of development and the most realistic quality of material to produce at this time. Thus the report gives primary attention to a development that will produce 10 million long tons per year of granular concentrate. Supporting information, in the way of alternates in quantity ranging from 5 to 20 million long tons per year, and in quality of output, including a pelletized product, are also recorded.

These estimates are entirely based on conventional methods of operation and on equipment of established reliability, so that the conclusions reached may be considered as proven. We agree with you that this approach is essential in obtaining a realistic picture of the feasibility of the deposit at this time.

When considering the overall aspects of the development in future years, however, recognition should be given to such factors as: improvements in ore beneficiation and the feasibility of developing, both methods and equipment, particularly suited to this project. In view of these factors we believe there is a very strong likelihood of materially reducing costs below those currently prevailing. To be specific, costs might be reduced by any of the following means:

1. Utilization of larger equipment.

2. Adoption of more sophisticated metallurgical techniques.

3. Arrangement of mining in the first few years of operation to reduce stripping or to exploit the best ore.

4. Utilization of some of the newer techniques in pipeline and other transport, particularly for lower capacities.

5. Higher degrees of mechanization or automation in mining, beneficiation and transport.

6. Application of other improved, but untried, techniques.

7. Use of gas or oil for which that area would be an economically attractive market.

As an example of the above, the 12-yard shovels and 45-ton trucks adopted in our study for the primary haul from the mine benches to the railroad loading pockets might be replaced with larger units. 100-ton semitrailer units have recently been placed in service at a large Canadian open pit mine. They were not included in this study because these units only have a very limited experience record at this time. Nevertheless the trend over the years has consistently been towards larger equipment. In this connection, it is interesting to note that the economics obtained through the use of larger equipment has, in general, made it possible to maintain almost constant low cost mining, despite the substantial increase that has taken place in the cost of labour, supplies, and equipment.

We are intensely interested in this assignment. We are confident that, with the proof of this vast resource and the advances being made in almost every phase of the industry, the project will become of immense value to your company and of major importance to our country. We look forward to serving and assisting you in any way in the attainment of this objective.

Yours sincerely,

S. M. Blair

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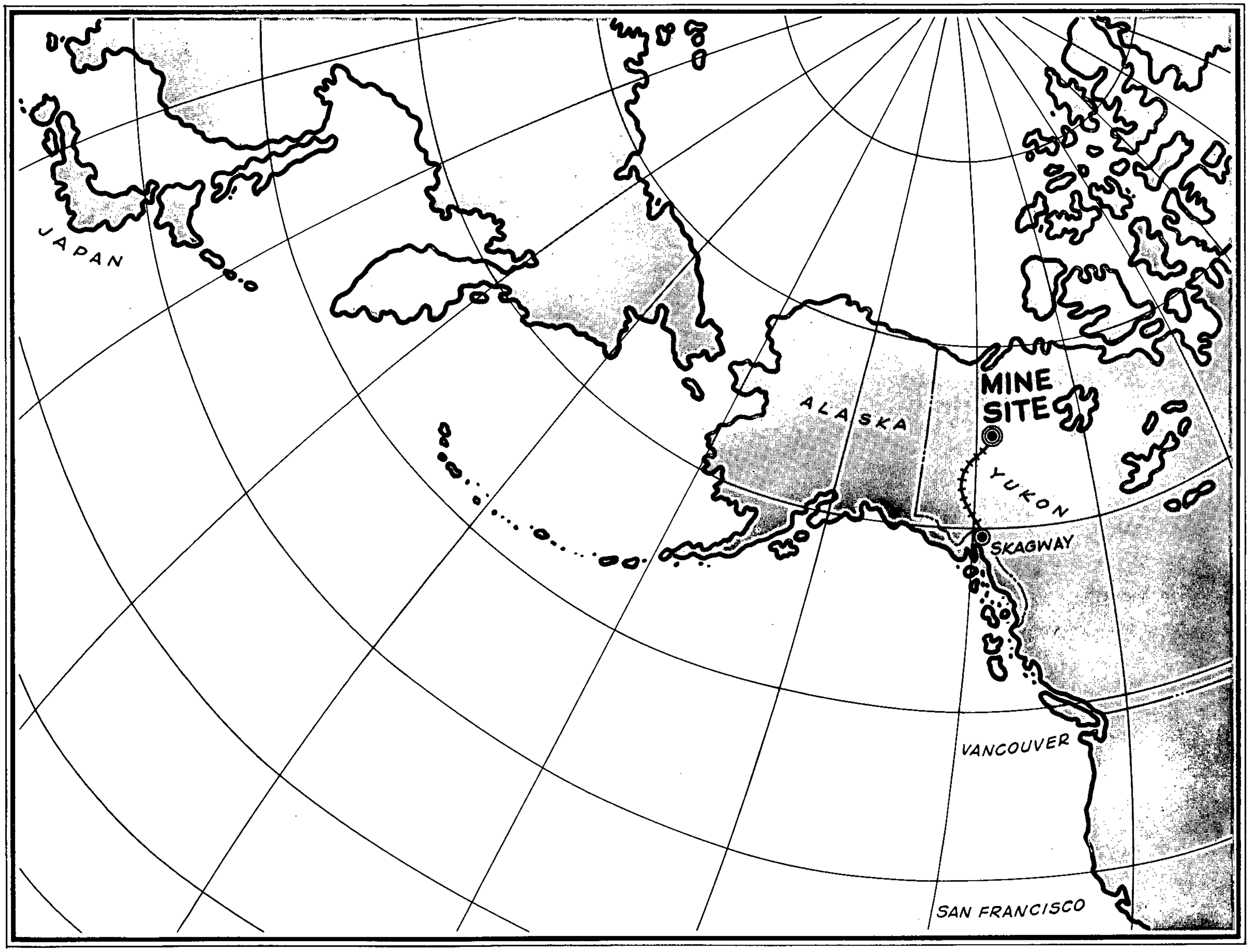

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1. INTRODUCTION AND SUMMARY

1.1 Scope of Work

Crest Exploration Limited has requested Canadian Bechtel Limited to undertake a preliminary evaluation of a large iron ore body located approximately on the border between Yukon Territory and Northwest Territory, Canada, some 360 air miles north of Whitehorse. The evaluation is to include preliminary estimates of the initial investment and annual operating costs of facilities to mine, process and haul to Japan iron ore concentrate at each of the three delivery rates of 5, 10 and 20 million tons per year. Adjusted costs are shown which would apply in event the concentrate were pelletized. Estimates of ocean transport costs from the port to other important world markets also are included as well as transport costs from existing or potential competing sources of ore.

The study is in the nature of a preliminary scrutiny of the project which will give guidance for the planning of further exploration and development work. It is based on geological and metallurgical information furnished by Crest and makes use of conventional, reliable and proven means of mining, ore processing and transportation. As associated work, Canadian Bechtel has participated in a market study for iron ore which Crest is carrying on.

1.2 Background Information

The ore body being investigated by Crest Exploration Limited is a new discovery in a remote area. Limited geological and metallurgical information has been collected and aerial plus limited ground reconnaissance has been made of only one potential route for a railroad to the coast and potential harbour sites. With the assumptions that such data are representative and that the ore will behave in a manner similar to other iron ores with known characteristics, Bechtel on the basis of experience has selected the facilities required to develop the ore body and prepare order-of-magnitude cost estimates. While the development plans and cost estimates in this report thus are subject to considerable adjustment, they are suitable for use in assessing the probable competitive position of the Yukon ore body relative to other important world supplies and to show the critical factors which should receive first attention in further investigations.

1.3 Summary and Discussion

A consolidated summary of the estimates of initial and operating costs is shown in the following table. These estimates represent our best judgment as to costs for the project described in this report rather than a probable cost ceiling. However, experience has shown that economies often appear during development studies of a major project and as a matter of business judgment it is expected that areas will be found where savings can be effected in the Yukon ore project.

Costs are shown CIF Japan as well as FOB vessel at Skagway, the outloading port, since Japan is an important potential market for the Yukon ore. Shipping costs to Japan have been added on the basis of a company owned fleet which gives the lowest unit costs although capital requirements are increased. Detailed information contained in the body of the report shows the competitive position of the Yukon ore body with regard to ocean freight costs to Japan and U.S. West Coast ports is quite favourable.

The effect of the remote location is clearly illustrated in that the cost of moving ore by railroad the 600 miles to tidewater is a substantial part of the full delivered costs. The sharp reduction in the unit costs of rail shipments as annual tonnage increases show the benefit of operating the railroad near capacity.

The desirability of further delineating the ore body and determining the character of the ore is accepted. Even so a number of factors have been noted throughout the report where it is particularly important to confirm the assumptions we have used to estimate the costs of mining and beneficiation. Additional field exploration including core drilling should receive primary attention and equally important are ore dressing tests on 10 to 20 ton samples to determine the beneficiation process best suited for the Yukon ore and the quality of concentrate which will be obtained.

Further design studies may show the way to sizeable reductions in the railroad costs although it is improbable that improvements in these costs will alter the unit costs of ore to any marked degree. Also, the railroad will open a vast, highly mineralised area and the degree to which other users might share the high fixed costs of the railroad remains to be explored. Similarly, the cost of pipeline transport of concentrate in a water slurry has not been determined. Preliminary studies for other projects have shown pipeline transport would compare very favourably with rail shipments in amounts of the order of 10 million tons per year.

CREST EXPLORATION LIMITED

YUKON IRON ORE PRELIMINARY EVALUATION

CONSOLIDATED SUMMARY OF ESTIMATED COSTS

	GRANULAR CONCENTRATES			PELLETS		
	5 MM LT/YR	10 MM LT/YR	20 MM LT/YR	5 MM LT/YR	10 MM LT/YR	20 MM LT/YR
CAPITAL COSTS - MILLIONS DOLLARS (1)						
Mining and Hauling to Concentrator	17.1	28.3	42.0	17.1	28.3	42.0
Ore Processing and Loading	50.2	82.0	138.6	103.6	181.7	328.6
Railroad Transportation to Port	333.0	357.2	417.2	334.3	361.9	422.4
Port Handling and Shiploading	23.2	26.3	32.5	23.2	26.3	32.5
Utilities	17.7	20.3	27.8	22.6	34.2	47.0
Indirect, Administration and Overhead	25.1	37.9	59.5	28.3	44.3	70.4
Interest During Construction (2)	57.9	61.6	70.9	69.9	75.1	90.5
Subtotal F.O.B. Vessel-Skagway	524.2	613.6	788.5	599.0	751.8	1,033.4
Vessels - Skagway to Japan (3)	47.4	94.7	190.0	47.4	94.7	190.0
Total C.I.F. Japan (1963)	571.6	708.3	978.5	646.4	846.5	1,223.4
OPERATING COSTS - DOLLARS PER LONG TON (4)						
Mining and Hauling to Concentrator	.98	.92	.86	.98	.92	.86
Ore Processing and Loading	1.46	1.42	1.34	3.16	3.12	3.09
Railroad Transportation to Port	3.07	2.27	1.86	3.07	2.27	1.86
Port Handling and Shiploading	.11	.08	.07	.11	.08	.07
Indirect, Administration and Overhead	.61	.45	.33	.74	.59	.42
Subtotal F.O.B. Vessel-Skagway	6.23	5.14	4.46	8.06	6.98	6.30
Freight - Skagway to Japan (3)	1.61	1.61	1.61	1.61	1.61	1.61
Total C.I.F. Japan (1963)	7.84	6.75	6.07	9.67	8.59	7.91
TOTAL OPERATING AND CAPITAL COSTS - DOLLARS PER LONG TON						
Capital Charges-F.O.B. Vessel-Skagway (5)	9.33	5.55	3.67	10.59	6.73	4.71
TOTAL-F.O.B. Vessel-Skagway	15.56	10.69	8.13	18.65	13.71	11.01
Capital Charges-C.I.F. Japan (5)	10.12	6.34	4.46	11.38	7.52	5.50
TOTAL-C.I.F. Japan	17.96	13.09	10.53	21.05	16.11	13.41
TOTAL - C.I.F. Japan Escalated to Date of Full Production (6)	19.90	14.78	12.66	23.32	18.21	16.20

NOTES:

(1) Not included are the following:

- Operating Cash and Startup Costs
- Exploration
- Ore Processing Pilot Plant
- Owner's Overhead During Construction

(2) Computed at 5-1/2% interest.

(3) Based on foreign flag, 69,000 DWT vessels. Capital cost includes one year's interest during construction.

(4) Operating costs are for plant at full production.

(5) Based on actual life with 20-year maximum and interest at 5-1/2%.

(6) Operating costs escalated at 2-1/2% per year to date of full production, as follows:

For 5 MMLT/YR - July 1968
For 10 MMLT/YR - July 1969
For 20 MMLT/YR - July 1973

Costs shown do not include taxes other than payroll taxes.

2. CONSULTANTS AND REFERENCES

2. CONSULTANTS AND REFERENCES

2.1 Consultants and Special Services

In carrying out the present studies, Canadian Bechtel has arranged for consultant services and other special services from a number of eminent authorities.

Major J.H. Charles of Winnipeg, consultant on railroad construction with broad experience in the West, has handled much of the railroad location and has assisted in preparing the construction cost estimates for the roadbed. His work is incorporated in the basic report.

Mr. B.G. Gallacher of the Southern Pacific Company has been made available as a consultant on railroad operations and his assistance is reflected in the basic report. Mr. Gallacher has had many years experience with the Southern Pacific on their runs through the mountains of western United States.

Mr. Victor Dolmage, Consulting Geologist of Vancouver, has prepared a preliminary analysis of tunnelling conditions through the Coast Range from Whitehorse to Skagway, Alaska. His summary is included as Appendix A to this report.

Dean R.M. Hardy, Consulting Civil Engineer of Edmonton, has reviewed the probable effects of permafrost on the project, particularly the railroad, and his comments are included as Appendix B to this report.

Joshua Hendy Corporation, a United States shipping company active in moving bulk cargoes, prepared the estimates of ocean shipping costs. Their work is included as Appendix C to this report.

V. Zay Smith Associates Ltd. of Calgary prepared the topographic maps for the northerly 163 miles of the railroad route. Maps issued by the Government were used for the remainder of the route.

2.2 References

Information concerning the ore body has been furnished by Crest Exploration Limited in the following documents:

1. Geophoto Contour Map - showing outline of the iron formation outcrops.

2. Two Stratigraphic Cross-sections - showing locations where samples were taken.

3. Iron Formation Sample Sections - showing the vertical height of each channel and indicating the volumetric percentage of hematite and waste bands, etc.

4. Ontario Research Foundation Report of Investigation No. 0-62341, dated December 12, 1962.

5. Crest Exploration Limited letter of December 24, 1962.

3. DESCRIPTION OF ORE BODY

3. ORE BODY

The ore body being investigated by Crest is a new discovery and there has been time to date for only limited field investigations. These limited data have been projected by Crest geologists for a preliminary estimate of the extent and nature of the ore deposit, summarized in references 1, 2 and 3. Bechtel engineers have utilised the Crest estimate and further estimates of their own concerning overburden and other factors to assess the ore body in a preliminary way.

3.1 Location and Topography

The ore body lies over an extensive area not fully delineated as yet. The exploratory work to date has been carried out in the vicinity of Iron Creek approximately 10 miles above its confluence with the Snake River at latitude 65^{o} 15 ft. north longitude 133^{o} west, as is shown on Plate II. The area is one of bold relief with elevations ranging from 2500 to 5000 feet. The Iron Creek valley and its tributary side valleys are steep-walled and narrow with little or no soil mantle. At the Snake River confluence, there are sizeable areas where gravel beds of somewhat more moderate slope will provide locations for the beneficiation plant, townsite and other facilities.

3.2 Geology

The ore body is a thick, relatively uniform sedimentary deposit of hematite and jasper. The beds dip approximately 10^{o} to the south and show distinct banding from differential deposition. The region shows little structural deformation or metamorphism. The young erosion pattern has exposed the iron formation over a distance of some 32 miles in thicknesses up to 500 feet.

The potential pit sites given primary attention for the present study lie in two general areas. Pits D and E on Plate IV lie in the bottom of the Iron Creek valley at elevations 2700 to 3700 feet. The ore in these pits is covered by only moderate amounts of overburden and the pits are favourably situated for development of benches and hauling of ore. Other potential pits are A, B, C, F, G and H, at elevations 4,000 to 5,100 feet in the upland areas north of Iron Creek. These pits would be more costly to exploit than D or E because of their more difficult access and the need for considerably more extensive premining development.

A summary of the ore reserves assumed for this study is given in the following table. No attempt has been made to develop a complete ore reserve picture with the information at hand and the estimates may require adjustment since they are based on maps with 100 foot contour intervals where the position of the formation has been located to an estimated accuracy of one half the contour interval. The areas selected are considered to be those most readily mineable either from the relative ease of access or the nominal stripping requirement. Tonnage estimates have been derived from cross sections at 500 and 1000 foot intervals and pit limits have been taken as the point where the volumetric ratio of waste to ore rises to 1:1 as shown by the maps and cross sections developed therefrom. Reserves so developed are considered to be more than adequate for the undertaking of a mining venture at the production levels envisaged and represent only a fraction of the area's total potential.

Approximately 12% by weight of interbedded waste will be mined with the main hematite beds. Specific gravity of the hematite has been estimated by Crest geologists to be 4.3 and for calculation purposes a weighted specific gravity of 4.1 has been used.

SUMMARY OF RESERVES

Area	Ore Millions of Long Tons	Waste Millions Of Cubic Yards	Waste: Ore Ratio Cubic Yards: Long Tons
A	230	15	0.065
B	50	-	0.000
C	800	98	0.1225
D	730	42	0.058
E	115	9	0.078
F	230	23	0.100
G	120	17	0.142
Total	2,275	204	0.090

3.3 Metallurgy

The ore of the Iron Creek formation shows distinct bands containing varied proportions of iron and silica. Petrographic studies of a number of samples of apparently pure hematite have shown that jasper also is disseminated quite generally throughout the hematite on a microcrystalline scale. Minor amounts of accessory minerals are present, the most important of which are calcite and apatite. The calcite appears in small lenses distributed haphazardly through the mineralized areas. Ore dressing testwork revealed that roughly two-thirds of the apatite is associated with the hematite.

3.3.1 Sampling and Assays

Sampling of the mineral deposit by Crest Exploration geologists involved cutting vertical channels across the exposed horizontal beds with each channel being further subdivided into a number of subsamples each covering a separate bed or layer. Beds that clearly were waste were not sampled. Because of the apparent uniformity of the deposit bulk samples from only two channel locations were selected by Crest for beneficiation tests; one going to the Ontario Research Foundation in Toronto, and the other to the Canadian Department of Mines and Technical Surveys in Ottawa. The test data cited in this report are those obtained by the Ontario Research Foundation and reported in reference (4).

Assays of channel samples have been made by Coast Eldridge, a commercial laboratory. A summary of their results on 6 channels as summarized in reference (5) is shown below:

Channel Sample Averages from Crest Exploration Limited

Channel No.	Footage Sampled	% Fe Wt. Ave.	% SiO_2 Wt. Ave.	% P Wt. Ave.	%S Wt. Ave.
13	135	46.5	24.46	0.53	0.02
6	150	48.2	24.32	0.32	0.02
9	206	46.8	24.66	0.36	0.01
19	218	46.4	23.68	0.33	0.01
37	160	46.2	25.86	0.30	0.01
44	132	45.9	24.59	0.41	0.01
Weighted Average of Above Channels	1001	46.7	24.5	0.36	0.01

The results of head assays obtained by Ontario Research Foundation on the bulk samples used for beneficiation tests are shown in the following table. The bulk samples were not taken in a manner to make them representative of the entire channels.

Bulk Sample Averages by Ontario Research

High % Fe	56.3
Low % Fe	36.6
Average % Fe	46.3
High % SiO_2	35.3
Low % SiO_2	14.6
Average % SiO_2	24.8
High % P	1.40
Low % P	0.18
Average % P	0.55

3.3.2 Heavy Liquid and Heavy Media Tests

Because of the large differences in specific gravity between hematite (4.9 to 5.3) and quartz (2.7), the problems of determining liberation size, probable concentrate grade, and iron recovery were approached by heavy media and heavy liquid techniques. It was found that progressive improvement in recovery and grade was obtained with finer grinds down to 10 mesh size where the following results were obtained:

	Average Fe Grade	Average Fe Recovery
Concentrates from 4.2 Specific Gravity	64.1	67.4
Concentrates from 3.7 Specific Gravity	61.8	75.8
Concentrates from 3.5 Specific Gravity	60.2	81.0
Concentrates from 3.3 Specific Gravity	58.5	85.8

While it was found that important grade improvements would be obtained by grinding to approximately 10 mesh, screen analysis of the concentrates and assays of the screen fractions revealed that no further significant increase in grade of concentrates would be obtained by grinding the ore as fine as 200 mesh.

Confirmation of these data was obtained by photomicrographs taken at 500 diameters which clearly showed microcrystalline quartz in ore particles that were, to the eye, apparently pure hematite.

3.3.3 Deister Table Tests

The data obtained by heavy liquid tests distinctly illustrate the problems involved in the treatment of an ore containing middling particles which have specific gravities covering the entire range between the gravities of the ore mineral and gangue. Tests on a Deister Table, results of which on Sample No. 4 are presented below as typical, clearly showed the presence of these middlings and their effect on beneficiation:

	Wt. %	% Fe	% Fe Distribution
Concentrate	28.7	63.6	37.9
1st Middlings	27.5	57.7	33.0
2nd Middlings	24.9	31.0	16.0
Tails	18.9	33.1	13.1
	100.0		100.0

3.3.4 Humphreys Spiral Tests

The necessity for grinding to approximately 10 mesh and the preference for a simple gravity concentration procedure pointed towards the use of Humphreys spirals in the beneficiation plant. Three composite samples, ground to 28 mesh and screened at 200 mesh, were processed through two stages of spiral concentration; after preliminary tests indicated the high specific gravities of the concentrate and middling particles would necessitate grinding the feed to approximately 20 mesh for the best spiral performance. The results of these tests were disappointing, with Fe recoveries averaging 54.2% and iron content averaging 57.7% fe. However, the tests were not performed under optimum conditions. It has been recommended that a comprehensive series of spiral tests be performed using representative samples of adequate size. The tests should cover a range of feed sizes, produced by closed circuit grinding such that the size consists of the feeds will be comparable to those obtained in an operating plant. Up to three stages of concentration should be investigated. Pending the receipt of data from such a test series, it has been assumed that the performance of spirals under production conditions adapted to the characteristics of the Yukon ore will more nearly approach the results of the heavy liquid laboratory results than the results of the limited spiral tests.

3.3.5 Summary of Metallurgy

For the purposes of this study, it has been assumed that concentration by spirals will be suitable for the beneficiation of the Yukon ore. It has been estimated that the best spiral concentrates obtainable in commercial operation would be no higher in grade than those obtained by heavy liquid at 3.7 specific gravity and, because of the high proportion of middling particles present, the iron recovery would be less than that obtained in the same heavy liquid tests. For sizing the mine and mill facilities it has been assumed that the average Fe content for all ore mined will be 46%; that the waste unavoidably mined with the ore will amount to 12% by weight of the ore; that the Fe concentration in the beneficiated product will average 62% and that the Fe recovery factor will be 72%. The resultant over-all concentration ratio is 2:1. In regard to comminution, accepted practice involving conventional crushing and grinding by rod and ball mills has been adopted for this study. With no data available concerning the grinding characteristics and the power required to grind the ore, autogenous grinding was not considered. The behaviour of any ore in an autogenous grinding mill is extremely sensitive to its hardness and other characteristics, such that the behaviour of one ore can not be estimated from that of another ore of quite similar properties.

3.3.6 Future Metallurgical Work

Exploration of the Iron Creek deposit in the future will depend to a great extent upon the outcome of the ore dressing tests now being conducted by Humphreys Engineering Company. If these tests show there is good prospect of obtaining satisfactory grade concentrates through the use of spirals, future ore dressing tests should lead to large-scale pilot plant testing to obtain complete information as to grinding requirements and other process factors. It is suggested that assistance be obtained from manufacturers of grinding and other ore processing equipment with regard to preliminary bulk sample tests to obtain data for the pilot plant design.

In the event the spiral concentrating tests at Humphreys Engineering do not result in acceptable grades of concentrates, further exploration work should include petrographic examination of samples on the site. If a section of the ore body is found that contains hematite which appears through petrographic study to be more amenable to beneficiation, a sampling and testing program would be initiated for this material.

In event results with the spiral concentrators prove marginal, heavy media cyclones may prove to be attractive since these units have a high efficiency in the rejection of heavy middling particles. Where spirals give satisfactory results, they are preferred over heavy media cyclones since cyclones have high capital, operating and maintenance costs in comparision to spirals as well as being unable to handle minus 65 mesh particles.

4. MINE/AREA/FACILITIES

4. MINE AREA FACILITIES

4.1 General

The facilities described in this section are those in the mine area for mining, beneficiating and rail loading the ore along with auxiliary and townsite facilities to support the operations. Primary attention is given to a plant to produce granular concentrate but, as an alternate, facilities to produce iron ore pellets also are described.

Mine area facilities to produce pellets would include additional housing in the town and a far larger electric generating plant to provide power for regrinding and pelletizing the ore, along with additions to the mill. Fuel storage requirements would be increased to serve the larger electric plant and to handle the increased fuel requirements at the mill for induration.

The project in either case will be a long-term development and all construction will be of permanent type. Mill and shop buildings will be of steel frame construction with insulating panel siding and roofing. Miscellaneous structures will be of comparable quality and housing will be of frame construction.

4.1.1 Production Rates

The facilities to be considered are for three production capacities: 5, 10 and 20 million long tons per year. Data summarised in Section 3.2 and 3.3 indicate the concentration ratio will be 2:1, between mined material entering processing and beneficiated product. Based on this factor, and estimated stripping ratios for each production level, the mine and mill annual throughputs will be:

	5 MMT/Yr.	10 MMT/Yr.	20 MMT/Yr.
Mine Waste	0.65 MMCY	1.5 MMCY	3.6 MMCY
Mill Feed	10.0 MMT	20.0 MMT	40.0 MMT
Product	5.0 MMT	10.0 MMT	20.0 MMT
Tailings	5.0 MMT	10.0 MMT	20.0 MMT

4.1.2 Plant Sites

Plate II shows a possible arrangement of major facilities in the mine area. Visual inspection of the area has indicated there are adequate areas suited to development and a suitable final arrangement will be developed readily in the design phase.

4.1.3 Weather Conditions

The mine area is located in a region of sub-Arctic climate where temperature extremes of +90°F to -70°F occur. Average weather conditions for Carmacks, Elsa and Mayo Landing which are shown in Section 5.2 are typical for this region. The climate is quite dry and mean annual snowfall is approximately 40 inches, although the regional averages may be altered by local topography.

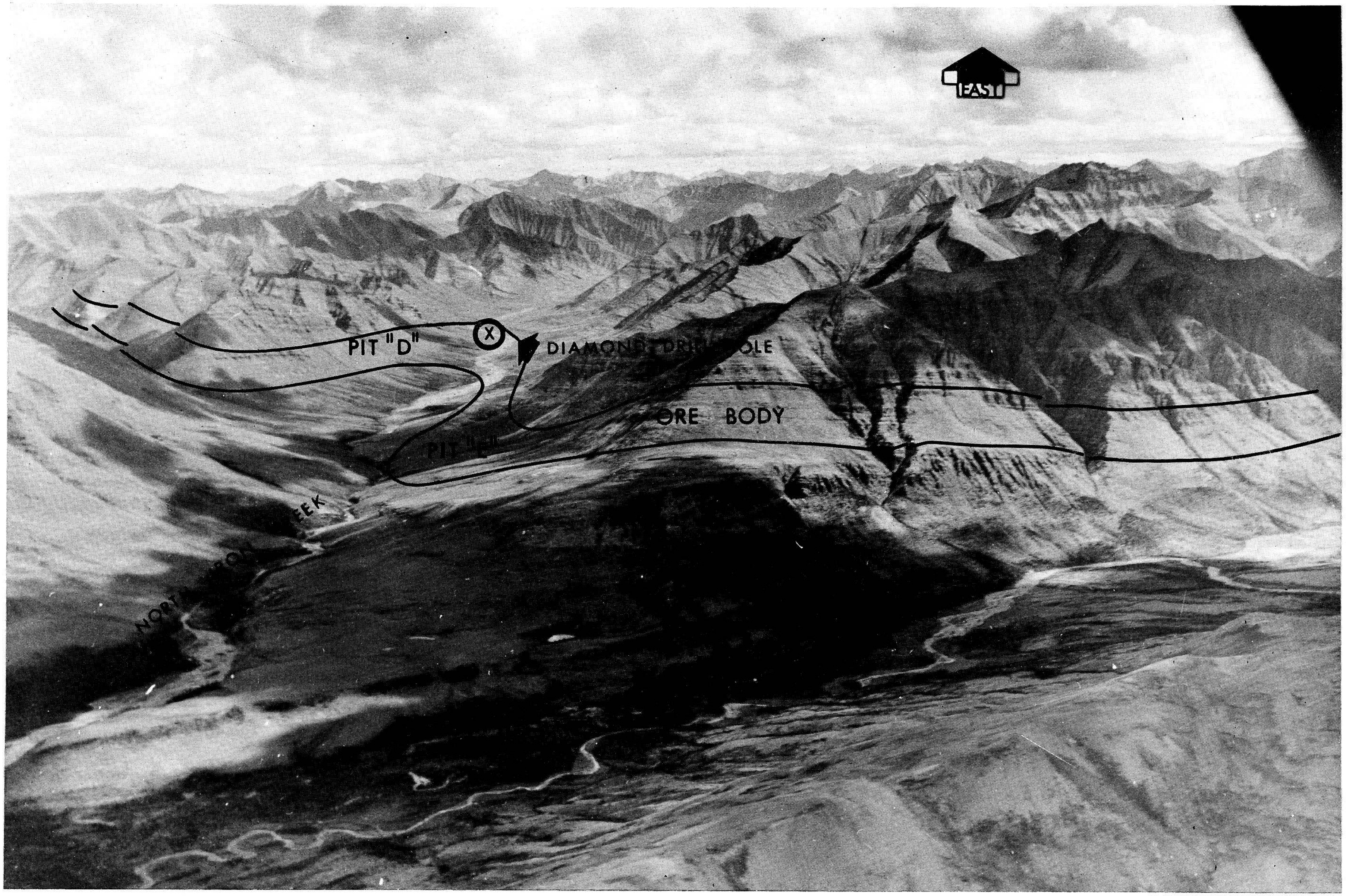
In general, winter conditions can be expected to interfere with operations to some degree but not to prevent year-round operation or make such operation unduly costly.

4.2 Mining - 10 Million Tons per Year

Of the potential mine pits described in Section 3.2, only the lower pits, D and E, have been considered for development in the 10 million tons per year project. Adequate benches can be developed in pits D and E to maintain the desired production rate while the 845 million tons, more or less, of reserves estimated to be recoverable without exceeding a 1:1 stripping ratio will allow development of the upper pits to be postponed 30 to 40 years.

Approximately half of the estimated ore reserve tonnage of pit D lies south of and below Iron Creek. It has been assumed that the indicated structure will be confirmed by drilling and that the tonnage below the creek can be made accessible at a reasonable cost by diverting the creek, first to one side of the valley and then the other.

Studies conducted on the Carol operation where circumstances are similar, showed that truck haul to railroad loading stations resulted in the lowest capital and operating costs compared with direct train-loading or ramp-loading from trucks. Due to the grades encountered only a limited tonnage could be moved by



MINE AREA LOOKING EASTERLY SHOWING IRON ORE OUTCROPS direct train loading at the Crest iron ore property. Moreover, the length of working face required for direct train loading usually is about twice that required for truck haulage. Truck loading of trains from ramps appears to offer no advantage at least until mining reaches the eastern extremities of the pits. Direct truck haul to the beneficiation plant is not practical with the presently considered plant site. For the above reasons, truck haul of the ore to railroad loading points with rail haul to the beneficiation plant has been adopted for the study.

4.2.1 Mine Development

Along with development of the mine benches and necessary stripping preproduction development will include construction of approximately 5 miles of railroad and construction of twin truck dumps at each pit. From the truck dumps, the ore will be delivered through short ore passes to high capacity apron feeders loading rail cars. Service facilities and utilities are described in other sections of the report.

Development of the necessary benches will require considerable excavation because of the steep terrain. However, there will be no unusual problems. In general, with the terrain encountered in the lower mining areas, it would be most desirable to operate the pits from the top down, establishing long, wide benches rather than a multiplicity of narrow benches. Under this system the bench area is increased as each 'lift' is mined. This method would, however, require the maximum amount of preproduction stripping and a compromise method has been adopted for both pits whereby commencement of mining will be at an intermediate elevation in each pit. Stripping of the waste capping then will progress concurrently with the mining. This procedure also will permit an earlier establishment of the Iron Creek by-pass while mining of the upper section of pit D is being completed. It is estimated 1.5 million cubic yards of waste stripping will be required to open the two pits plus 1.0 million tons of ore mined and stockpiled. All the preproduction stripping of waste will be in pit E.

4.2.2 Mine Operation

Limited experience in exploratory diamond drilling has indicated that difficulty may be experienced with mechanical drilling of the ore. Preliminary tests on small samples indicate that the ore is amenable to jet piercing and that reasonable penetration rates may be obtained. In consequence jet piercing drilling techniques have been assumed for this study but considerably more full scale test work is required to confirm this selection. For a production rate of 20 million tons per year of ore (10 million tons of concentrate) 3 drill rigs will be required. To establish benches suitable for the operation of the drill rigs, shovels, and other equipment, it will be necessary initially to use down-the-hole rigs. Also, on the sloping hillsides, bench trimming using auxiliary rigs will be required. Drilling costs with this equipment will be higher but the proportion of such drilling small.

For the purposes of this report a powder factor of 1.5 lb/cu.yd. has been assumed using 50% ammonium nitrate and fuel oil, and 50% hydromex. With 45 foot benches and partial chambering of the holes, a yield of 3830 long tons per hole is calculated.

Calculations show that the combination of 45 ton rear dump trucks with 12 cu.yd. shovels offer a highly efficient loading and hauling combination in this heavy ore. Electric shovels, such as the Marion 191-M, with 12 cubic yard buckets have been adopted. Assuming no ore blending and properly established benches, 3 shovels operating can meet production requirements in well fragmented ore. A fourth 12-yard shovel is included to assure that three will be maintained in primary production. This unit and spare stripping shovels allowed for in the estimate will provide necessary standby capacity plus take care of new bench initiation and clean-up.

For this estimate 45 ton rear dump trucks, such as Euclid Series R-45 Model 10 LD, equipped for Arctic operation, have been selected. These units offer the high degree of manoeuvrability particularly desirable in the early phases of the mining operation and operating costs are estimated to be equal to those of larger rear dump units which would lack flexibility. The use of large tractor trailer units may be considered in the longer, easier gradient haulage situations. Such units are in use but they are a new development and their effectiveness and operating costs have not yet been defined. An average haul of 7000 feet has been assumed, with 22 trucks operating per day on the average, although a large variation in haulage distances occurs over a period of time and between the respective pits.

It is estimated that an average of 1.5 MM cu. yds. per year of stripping will be required on a continuing basis to extend the pits ahead of mining. Drilling and blasting of the waste has been assumed, with down-the-hole drills which will correspond with bench preparation and trimming equipment. An explosive factor of 0.6 lb/cu. yd., using ammonium nitrate, has been assumed for stripping. 4-1/2 cu. yd. diesel electric shovels in combination with 30 ton trucks have been selected to contend with the road grades and general topographic conditions. Haul distances will be fairly long but may be reduced as mining progresses by dumping waste to refill depleted pit areas.

Mine offices, warehouse, dry and maintenance shops will be established close to the pits. Explosives will be stored in magazines suitably located to service each principal mining area. The oxygen plant will be located in the industrial complex near the mill and gaseous oxygen will be delivered by pipeline to the pits and drills. Diesel fuel will be delivered by trucks to a storage tank in the pit service area and further distributed by smaller trucks to the drills and dispensing stations at the truck dumps. Power at 13.8 KV will be transmitted on overhead lines to the pit service area and the pits. Portable substations will be provided for powering the shovels and drills. Potable and service water will be pumped in insulated twin pipelines, such as Ric-Wil type, to the pit service area. Distribution to the drills will be by truck. Direct line telephone communication between the pit service area and the Concentrator Plant will be provided. Service and supervisors' vehicles will be fitted with 2-way radios for communication with the service area.

4.3 Ore Processing: 10 Million Tons per Year

Based on the assumptions of criteria listed under Section 3.3, the ore will be crushed in three stages to rod mill feed size. For maximum crusher capacity and efficiency, the ore will be screened between each crushing stage and the tertiary crushers will operate with a closed circuit. Rod mills will be in a closed circuit with 20 mesh D.S.M. screens for spiral feed preparation. Spiraling will be done in three stages with middlings from the first two stages recirculated to the same stages and tailings from the last two stages each recirculated to the previous stages. Final tailings will be removed only from the first spiral stage and final concentrates will be removed only from the third spiral stage.

The primary arrangement comprises facilities to produce granular concentrate. For this case, the spiral concentrates will be processed directly through drum filters and dryers to obtain a final moisture content of approximately 1%. As an alternate, facilities to produce a pelletized product also are included. To produce pellets, the spiral concentrates will be reground in ball mills, thickened, filtered, balled with bentonite and indurated.

4.3.2 Crushing and Screening

In more detail, mine run ore from pits E and D will be delivered in 80-ton gondolas to the plant site. This ore will be dumped directly into the crushers with the products falling into below grade hoppers. Eighty-four inch apron feeders below the crusher hoppers will feed parallel inclined conveyors for transfer to elevated stockpile belts equipped with trippers. The stockpile will have 200,000 tons of live storage. Two parallel reclaim conveyors in tunnels running lengthwise of the stockpile will be fed by apron feeders. The reclaimed ore will be delivered to a tripper gallery above the secondary crusher feed bins. Each of the above feeding and conveying systems will have sufficient capacity to handle the entire plant production. All conveyors will be 72-inches wide.

Apron feeders under each of the four secondary crusher feed bins will feed 6-foot by 14-foot double deck vibrating screens which will in turn feed their plus-3/4-inch products to four 7-foot standard cone crushers having 2-1/4-inch closed side settings. The crusher products will be routed through rock boxes to 8-foot by 14-foot vibrating screens equipped with 3/4-inch cloth. Oversize from each secondary crusher discharge screen will be collected and conveyed to a tripper gallery over the tertiary crusher bins.

Vibrating feeders under the tertiary crusher feed bins will feed ore to eight 7-foot shorthead cone crushers having closed side settings of 1/2-inch and the crusher products will be screened at 3/4-inch on 8-foot by 16-foot vibrating screens. Screen oversize will be returned to the tertiary crusher feed bins by collecting conveyors. Undersize from each screen will be collected and conveyed to the tripper gallery about the eight fine ore bins.

4.3.3 Concentration

The concentrating plant will be divided into 8 parallel sections each of which will include one rod mill. Fine ore will be withdrawn from the ore bins by belt feeders which will discharge onto the mill feed belts. Each of the eight rod mills will be 13-feet in diameter inside the shell and have a length between the head liner and grate suitable for 18-foot rods. Each rod mill will be pipe fed and will discharge into a D.S.M. screen feed sump equipped with a level control for dilution water addition. A density meter on the pump discharge will control the speed of the rod mill feeder. Ten 4-foot D.S.M. screens will be used for each rod mill to handle its 100% circulating load. Screen oversize will be returned to the mill by gravity and the minus 20 mesh undersize will be pumped to a distributor for feeding to the rougher spirals. It has been estimated that the rod mills will draw 1500 H.P. each.

Each of the eight spiral sections will contain 250 - 5 turn roughers, 200 - 5 turn cleaners and 150 - 3 turn recleaners. The roughers will produce a final tailing, a middling which will be returned to the rougher feed and a concentrate which will be pumped to the cleaner spirals. The cleaner spirals will produce a tailing for recirculating to the roughers, a middling for recirculating to the cleaner feed and a concentrate which will be pumped to the recleaner spirals. The recleaners will produce a tailing for recirculating to the cleaner spirals and a final concentrate.

4.3.4. Tailings Disposal

Tailings from the concentrator will be pumped to a 50-foot diameter hydroseparator, which will overflow to one 250-foot thickener. The coarse hydroseparator underflow and the fines thickener underflow will be combined and pumped at 50% solids to the tailings disposal area. The thickener overflow will be returned to the millwater circuit. Total makeup water requirements will be of the order of 9000 GPM for the 10 MM TPY plant. Each additional 10 MM TPY of production will require an additional hydroseparator and thickener for handling tailings.

It has been assumed that tailings disposal will be by conventional methods of ponding, with the disposal area in the Snake River valley below the water supply reservoir.

4.3.5 Drying Granular Concentrate

For the production of granular concentrate as an end product the spiral concentrates will be collected and filtered directly without thickening. Filtering will be done in eight 10-foot diameter by 10-foot top feed drum filters, to a moisture content of about 7%.

Drying of the concentrates will be done in four 16-foot diameter fluo-solid dryers, each drawing 1000 H.P. Heat for the dryers will be furnished by oil firing at the rate of 1700 BTU per pound of water evaporated and the dried concentrates will contain 1% moisture. Dried concentrates, of approximately -28, +200 mesh particle size, will be collected by conveyor and delivered to the loadout or the emergency stockpile.

4.3.6 Pelletizing

For the alternate case to produce pellets, concentrates from the eight spiral sections will be pumped without thickening to the sixteen regrind ball mill sumps. It is assumed for this study that two 13-foot diameter by 17 foot, 1500 H.P. ball mills will be required to regrind the concentrate from each of the eight spiral sections to an estimated 80% minus 325-mesh grind although an extensive agglomeration testing programme on the particular ore under consideration is essential for the selection of optimum regrind and induration equipment and indurating cycle. Regrinding will be done in closed circuit with cyclones and the cyclone overflows from each two regrind mills will be thickened in one 75-foot thickener. Each thickener underflow will be pumped to three 6 foot - 9 inch by 10 disc filters. Provisions will be made to divert the thickener underflows to storage pits during pelletizing machine down times. Reclaimation of this temporarily stored material will be by hydraulic methods.

The filtered concentrate from each filter will be blended with approximately 1/2% by weight of bentonite as a binder and balled in a 10-foot diameter by 22-foot balling drum equipped with a 5-foot distributing scroll. The green balls will discharge to a 5-foot by 14-foot vibrating screen which will remove undersized balls for return to the balling drum. Three balling drums will feed each of the eight induration machines.

The induration section of the plant will consist of eight straight grate pelletizing machines. Each grate will have downdraft drying, heating, firing and soaking sections and an updraft cooling section to produce pellets having an average temperature of 250°F. Heat in the firing section will be supplied by oil fired burners and heat will be recovered from the firing and soaking sections by recirculating the hot gases. A chunk breaker will be installed at the discharge end of each grate to break up any fused masses of pellets that may be produced.

A screen installed between each chunk breaker and the pellet collection conveyor will remove pellet chips and a portion of the final product will be conveyed to a storage bin to provide pellets for hearth and side layers for protecting the grates from extreme heat. Chips will be reground wet in a ball mill and returned to the grate via the reground concentrate thickener.

4.4 Product Stockpile and Loading - 10 Million Tons per Year

4.4.1 General Plan and Criteria

The facilities at the mine site for handling finished product provide for direct rail loading, stockpiling and stock reclaiming. Also included is the marshalling yard required for the pellet loading operations and for handling mine site supplies.

For granular concentrate, 25,000 tons of covered storage, the equivalent of two train loads, are provided as minimum surge capacity for normal operations. 500,000 tons of outside storage also are provided for emergency use. Plate VI shows a tentative layout of stocking and loading facilities and the marshalling yard.

For pellets, 500,000 tons of outside storage will be provided, approximately 17 days' normal production, with no covered storage since freezing within the pile would be less of a problem in the case of pellets. Conveyor transfer points and other details of the handling systems will require modification as compared to granular concentrate but such changes will have nominal effect on costs.

4.4.2 Stockpile and Reclaim Facilities

A conveyor from the mill will deliver finished product to a transfer tower where a suitable gate and chute arrangement will divert the ore either to the stockpile conveyor or the car loader conveyor. For granular concentrate, the stocking out conveyors with tripper unloaders will pass overhead through the covered storage building and continue in a gallery over the open storage pile. Similarly, a single reclaim tunnel under the piles will service both the open and covered storage areas. There will be 22 vibrator feeders to load the reclaim belt, with bulldozers for clean-up of the dead storage volumes.

4.4.3 Car Loading Facilities

For either granular concentrate or pellets, a chute type loader will be used, capable of loading twenty 100-ton cars per hour. Cars in full train strings will be moved through the loader by switching engine. A 1000-ton surge hopper above the chute will be filled by a belt conveyor from the transfer tower. When loading direct from the mill, makeup tonnage will be reclaimed from the stockpile as required.

4.4.4 Railroad Marshalling Yard

Sufficient trackage is provided in the mine area to hold three extra trains in emergencies in addition to the three trains which may be at the mine during normal operations. Suitable cross-switching is provided to funnel trains to the loading track, to bypass the loading station and to effect locomotive turn arounds and efficient switching. In addition to ore loading trackage, a 4000-foot spur is required for fuel oil; one 4000-foot spur for general supplies; and several sidings to the plant site for explosives, grinding mill rods and balls, bentonite and miscellaneous supplies.

Yard facilities for servicing the railroad rolling stock are covered in the section on railroad facilities.

4.5 Mine Area Service Facilities - 10 Million Tons per Year

4.5.1 Maintenance Shops

Heavy maintenance shops for mine and mill equipment will be provided at the mill site, with facilities at the mine pits for servicing and minor maintenance.

It is planned to provide a General Shops Building that will include the machine shop, welding shop, electric shop for maintenance and repair of miscellaneous small equipment and shops for maintenance and repair of locomotives and ore cars used in the mining operations as well as emergency repair of rolling equipment for the main line. A heavy parts warehouse will be incorporated in this building, where crane service will be available. These shops are combined to improve co-ordination of the work and obtain better use of facilities.

At the mine proper, it is planned to provide the necessary facilities for servicing the mine equipment, i.e.: shovels, tractors, trucks, cranes, drills and miscellaneous small equipment. Miscellaneous shops such as paint, tyre and carpenter shops also will be provided near the mill. The sizes of these shops will be:

General Shops	140,000 sq.ft.
Mine Shop	20,000 sq.ft.
Miscellaneous Shops	8,000 sq.ft.

4.5.2 Warehouse Facilities

Inclement weather and remote location of the project will result in warehousing requirements in excess of those for projects in more accessible regions.

It is planned to provide a warehouse at the mine pits for mine supplies and minor parts for the mine equipment. Storage for tyres will be provided at the tyre shop. Fenced areas also will be provided for the storing of cable and of other materials not affected by the weather.

For service in the mill area, it is planned to provide two adjacent parts warehouses, one heated and one unheated, both serviced by railroad spur. In addition, fenced areas will be provided to store parts and equipment not affected by the severe weather. For the alternate facilities to produce pellets, another warehouse will be included close to the pelletizing plant for the storage of refractories, plus silos for storing bentonite.

The sizes of the warehouse facilities will be:

Mine Warehouse	8,000 sq.ft.
General Warehouse - heated	10,000 sq.ft.
General Warehouse - unheated	20,000 sq.ft.
Open Storage (Total for Area)	8 acres
Refractory Storage	1,500 sq.ft.
Bentonite Storage	150,000 cu.ft.

4.5.3 Change Houses

Change houses, provided with showers and lockers, will be provided at the mine and in the mill area for a total of 950 men in the case of granular concentrate production, working in 3 shifts. For the alternate to produce pellets, 1100 men will be cared for.

4.5.4 Office and Laboratories

There will be a main office and administration building as well as mine office and small offices in the plant buildings, general shops, laboratory, and warehouse.

The main office building will accommodate the executive and supervisory personnel, engineering, geology, accounting, research, payroll and systems personnel. The mine office building will accommodate the mine superintendents, supervisory personnel and the mine engineering force. An assay and geological laboratory building will be provided at a location convenient to both the mine and the plant.

The sizes of these buildings will be:

Main Offices	10,000 sq.ft.
Mine Offices	3,000 sq.ft.
Laboratory	3,000 sq.ft.

In addition, the plant buildings will have small offices for the superintendents and shift bosses. A section of the main warehouse will be used for office space where inventory and purchasing functions will be concentrated.

4.5.5 Fuel Storage Facilities

Fuel storage capacity for approximately 30 days requirements will be divided into three installations: at the mill site, the power plant site and the mine. Unloading stations for incoming rail shipments will be at the mill and power plant sites with truck deliveries to the mine storage tanks. Unloading stations will have circulating hot water supplies to heat incoming cars of fuel oil and the fuel oil lines and storage tanks. Storage tanks will be of conventional design with revetments in accordance with the API code. Tanks and lines to handle fuel oil will be insulated.

The total storage capacities will be:

	To Produce Granular Concentrate	To Produce Pellets
Fuel Oil	120,000 bbl	250,000 bbl
Diesel Fuel	25,000 bbl	25,000 bbl
Gasoline	1,000 bbl	1,000 bbl

4.5.6 Oxygen Plant

To supply oxygen for the jet piercing drills, it will be necessary to build an oxygen plant with a capacity of 50 tons per day. Waste heat from this plant will be used in cold weather to heat the water being recirculated through the distribution system.

4.5.7 Airfield

A 100 by 5,000 ft. unpaved runway will be located in the Snake River valley near to the townsite. A 1,000 sq.ft. terminal building will be constructed and 30,000 gallons of buried tankage for aviation grade gasoline. There will be no hangars or other service facilities.

4.6 Mine Site Utilities - 10 Million Tons per Year

4.6.1 Electricity - Generation and Transmission

The steam electric generating plant will be of 44,000 K.W. installed capacity for the project to produce granular concentrate or 132,000 K.W. for the alternate to produce pellets. In either case, the plant will consist of two identical boiler - turbine generator units. The plant will be located near the water supply dam on the Snake River and condenser cooling water will be used for mill process water to take advantage of the waste heat. A 4,000 foot railroad spur will provide for fuel oil deliveries. Electric power transmission to substations at the important load centres will be at 138 kv.

4.6.2 Central Heating System

A central heating plant for the mill and associated shop buildings is planned, utilising high pressure, high temperature water which presents definite advantages over a similar steam heating system. The heating plant will consist of two boilers operating and one spare, each of 60,000 lb. per hour capacity, and the necessary circulating pumps. Distribution lines will be buried, insulated pipe.

4.6.3 Water Supply System

Water supply for the area will require an average of 10,000 gallons per minute for process and domestic requirements.

To satisfy this demand and provide sufficient storage during the winter months, it will be necessary to impound water.

This can be done by a dam on the Snake River, upstream of the confluence with Iron Creek. A 100 foot high dam to impound 20,000 acre feet has been selected arbitrarily since there are no run-off data available for the Snake.

A pumping station would be built, close to the condenser discharge, feeding a buried and insulated pipeline to the plant, mine and townsite. A smaller recirculating line will parallel the primary main and recirculation will be provided for the distribution systems through the town and industrial areas with provisions included for additional heating of the water at the central heating station for the mill and shops and at the oxygen plant.

Filtration and chlorination plants will be located at the townsite and the mine to treat process water for domestic use.

4.6.4 Sewage Disposal System

Sanitary sewage will be collected and given primary treatment before discharge into Iron Creek downstream of the developed areas.

4.6.5. Communications Facilities

It is planned to build a despatcher's tower at the rim of each pit for control of mining operations. There will be telephone ties between the towers and the mine area telephone system. In addition, there will be two-way F.M. radio systems between the towers and mine service vehicles and mine supervisors vehicles. On other frequencies, there will be two-way F.M. radio communications between the towers and the mine area locomotives.

There will be several high frequency radio channels to interconnect the mine area telephone system, the railroad headquarters at Whitehorse and the port at Skagway. The station at Whitehorse will tie into the established telephone company for communications to the outside.

4.7 Mine Area Town - 10 Million Tons per Year

There is a marked trend toward higher quality of personal amenities at remote developments and for the Yukon iron ore project housing and personal services of high quality level are planned. Such provisions will be in keeping with this long term development requiring a large permanent staff. For the 10 million ton per year project to produce granular concentrate, the estimated number of Crest employees will be 1500 and there will be an estimated 375 persons employed in addition by other enterprises in the town such as stores, theatre and the like. Corresponding numbers for the alternate to produce pellets are 1750 and 400. While community facilities will be sized for the total population, it is assumed that the independent enterprises will provide housing for their employees and Crest will provide housing only for its own employees. The estimated town population and housing to be constructed by Crest are:

	To Produce Granular Concentrate	To Produce Pellets
Total employed, including town support	1500	1750
Total residents	7100	8300
School Children	2600	3100
Family housing, single units	800	925
Apartments, family and single housing	250	300
Single housing, dormitories	450	525

In addition, company-owned town facilities will include:

- Schools
- Recreation Centre
- Town Hall
- Hospital
- Hotel
- Mess Hall
- Town Maintenance and Warehouse Building

It is assumed that independent enterprise will finance a shopping centre, theatre, churches, laundry and other miscellaneous services as well as housing for the personnel operating such services.

All town buildings will be of frame construction with oil fired central heating. All quarters will be furnished except for linen and personal items in the family housing.

4.8 Facilities to Produce 5 Million Tons per Year

Facilities to produce 5 million tons per year of either granular concentrate or pellets will be similar in type to those required to produce 10 million tons per year. The reduced number of major components are shown in the equipment lists. Other changes are described hereinafter.

4.8.1 Mining

At the 10 million ton per year mining level, to obtain 5 million annual tons of product, pit E only will be developed initially with pit D development deferred for 10 to 15 years. Pre-production development will be similar to that described in Section 4.2 except that approximately 3 miles of railroad will be constructed initially with a two-mile extension to pit D to be completed at the later date. Bench preparation will be in pit E rather than pit D. Haul distances will be shorter and sizeable benches more readily developed in pit E.

For this estimate the equipment selected corresponds to that described in Section 4.2, with the required number of units of each type reduced as shown in the equipment lists. Sound cost estimates are derived on this basis; however, more detailed study may indicate the desirability of using smaller production units at this production level for increased flexibility in operation.

Mine services will be similar to those described in Section 4.2 except that diesel fuel and water will be trucked to the pit service area and to the pits.

4.8.2 Ore Processing, Product Stockpile and Loading Facilities

Ore processing and product handling for the 5 million ton per year projects will use the same equipment components as are proposed for the 10 million tons per year projects, either for granular concentrate or pellets. The reduced numbers of units is indicated in the equipment lists.

The covered storage for granular concentrate will be retained at 25,000 tons capacity while the open storage will be reduced to 250,000 tons. In the alternate for pellets, 250,000 tons of outside storage will be provided.

The capacity of the stock-out and reclaim conveyors will be reduced as shown in the equipment lists.

4.8.3 Mine Area Service Facilities and Utilities

Service facilities and utilities required to support a 5 million tons per year production level will be reduced in size to the following:

General Shops Building	90,000 sq. ft.
Mine Shop	12,000 sq. ft.
Miscellaneous Shops	5,000 sq. ft.
Mine Warehouse	5,000 sq. ft.
Mill Area Warehouse	18,000 sq. ft.
Change House	
To produce granular concentrate	500 men
To produce pellets	600 men
Main Office	7,000 sq. ft.
Mine Offices	2,500 sq. ft.
Laboratory	2,500 sq. ft.
Electric Power Plant	
To produce granular concentrate	33,000 kw
To produce pellets	66,000 kw

Central Heating Plant	100,000 lb. per hr., installed
Water Supply System	5,000 gpm
Water Storage	10,000 acre ft.
Fuel Oil Storage	
To produce granular concentrate	70,000 bbl.
To produce pellets	125,000 bbl.
Diesel Fuel Storage	15,000 bbl.
Gasoline Storage	1,000 bbl.
Oxygen Plant	25 T/day

4.8.4 Mine Area Town

The total employed personnel will be 920 to produce 5 million tons per year of granular concentrate or 1100 to produce pellets. In either case housing and services will be comparable to those described for the 10 million ton projects.

4.9 Facilities to Produce 20 Million Tons per Year

Facilities to produce 20 million tons per year of either granular concentrate or pellets will be similar in type to those required to produce 10 million tons per year. The increased amounts of equipment are shown in the equipment lists and other changes are described hereinafter.

4.9.1 Mining

Mine development and plant construction will follow the same procedure outlined in Section 4.2 to bring the mine operation to a production level of 10 million tons per year of product.

Thereafter stripping and bench preparation will continue, first to open up new benches in the upper area of pit D and second to expand available bench areas in pit E. Bench preparation in the build-up period will be at a high rate to establish adequate working faces.

Based on the information available, it is considered practical to maintain production at the rate of 20 million tons per year of product from the lower pits for a period of twenty years, more or less, and that the high cost of developing the upper level pits may be deferred. In making this assessment, it is noted that the position of the iron formation in the lower pit areas is critical and further confirmation is needed of the depth of the ore beds and the depths of waste overburden.

Mine operation would be as described to obtain 10 million tons of product with equipment and crews increased to meet the requirements of the higher production level. At this higher production level, where stripping requirements cannot be well defined, an average stripping ratio of .09 cubic yards of waste per long ton of ore mined has been assumed.

Mine service facilities appropriately extended, would be as described for the smaller project except that diesel fuel would be piped and pumped to a storage tank in the pit service area and trucked from the service area to the drills and pit dispensing facilities.

At some stage in the life of the operation, development of the upper level pits will become necessary. It is estimated that the capital cost of the upper pit development would be approximately $28 million based on present day prices, without escalation. This development work, when required, would consist of the construction of an access road to and service facilities in the pit F area and the extension of the railroad haulage system underground as shown on Plate IV.

Extensive pre-production stripping of the pit F capping would be undertaken and primary gyratory crushers installed at approximately the 4,900 foot level. Ore passes would be driven from the haulage way to connect the crushers with underground loading stations. To facilitate the handling of men and materials for the upper pit areas a service shaft would be sunk to the haulage way. Crosscuts from the shaft would be driven for inspection and maintenance of the ore passes. Power, water, fuel and oxygen lines would be extended to the upper service area and pits.

The initial upper level crusher location would service the mining areas A, F and a small part of C. Haulage distances would be increased by this procedure compared with the 'ore-pass and crusher per pit' arrangement originally considered, but pre-production stripping and tunnel costs would be substantially reduced. The crushers would be relocated and the underground haulage system extended as mining areas within economic trucking grades and distances are depleted.

4.9.2 Ore Processing, Product Stockpile and Loading Facilities

Ore processing and product handling for the 20 million ton per year project will follow the same pattern as for the 10 million.

For either the mill to produce a granular concentrate or that for pellets, the equipment components will be the same as for the 10 million ton mills. The reduced numbers of units is indicated in the equipment lists.

The covered storage for granular concentrate will be retained at 25,000 tons capacity while the open storage will be increased to 1.0 million tons. In the alternate for pellets, 1.0 million tons of outside storage will be provided.

The single car loader described for the 10 million ton per year facilities will not be able to handle 20 million tons per year. A second loader will be added and the capacities of the stock-out and reclaim conveyors increased as shown in the equipment lists.

4.9.3 Mine Area Service Facilities and Utilities

Service facilities and utilities to support the 20 million tons per year production level will be increased in size to the following:

General Shops Building	220,000 sq. ft.
Mine Shop	40,000 sq. ft.
Miscellaneous Shops	12,000 sq. ft.
Mine Warehouse	12,000 sq. ft.
Mill Area Warehouse	60,000 sq. ft.
Change House	
To produce granular concentrates	1,700 men
To produce pellets	2,000 men
Main Office	15,000 sq. ft.
Mine Offices	5,000 sq. ft.
Laboratory	4,000 sq. ft.

Electric Power Plant	
To produce granular concentrates	88,000 kw
To produce pellets	220,000 kw
Central Heating Plant	320,000 lb. per hr., installed
Water Supply System	20,000 gpm
Water Storage	40,000 acre ft.
Fuel Oil Storage	
To produce granular concentrates	260,000 bbl.
To produce pellets	500,000 bbl.
Diesel Fuel Storage	50,000 bbl.
Gasoline Storage	2,000 bbl.
Oxygen Plant	100 T/day

4.8.4 Mine Area Town

The total employed personnel will be 2,470 to produce 20 million tons per year of granular concentrate and 2,900 to produce pellets. In either case, housing and services will be comparable to those described for the 10 million ton projects.

5. RAILROAD

The railroad will be a single track line, extending north and east from Taiya Inlet, adjacent to Skagway, for approximately 600 route miles to the mine, as is shown on Plate I. Particularly difficult terrain will be traversed through the Coast Range and across the Selwyn Mountains near the mine. The central portion of the road will run along the broad river valleys of the interior plateaus where conditions are easier. Headquarters offices and the centre for heavy maintenance and repair of rolling stock will be at Whitehorse, the largest Canadian town along the right of way.

The railroad will be suited specifically for heavy ore hauls from one terminal to the other with virtually no intermediate traffic and only a small fraction of the total freight in the form of fuel oil and general supplies for the mine area. All equipment will be captive which will allow increased efficiency from standardisation and special adaptations. Diesel electric locomotives have been adopted and gondola type ore cars with swivel couplings for rotary dumping without complete breakdown of the trains.

It has been assumed that 3-man train crews will be used; engineer, brakeman and conductor. The planned high level of remote control will make such operation safe and it is essential that haul costs be reduced to a minimum if the Yukon ore is to be competitive with ore from other developments closer to tidewater. It has been assumed that the road will be operative 340 days per year. Equipment maintenance has been taken as a year-round operation. Maintenance of way also has been taken as a year-round operation but with a sharp summer peak.

5.1 Weather Conditions

Weather conditions along the route fall into two, sharply divided categories.

On the ocean side of the Coast Range, the railroad and port will be exposed to the moderately cold, wet weather typical of the North Pacific. The weather data for Skagway in the following table are characteristic for this region. Freezing will not last more than a few days at a time. Annual precipitation will vary from approximately 30 inches at the immediate port area to several times that amount in the mountains. Total snowfall is extremely heavy in the higher levels, as much as 50 to 60 feet per year, which has been one factor leading to the adoption of a long tunnel through the Coast Range.

Inland of the Coast Range, there are periods of intense cold in the winter, down to -70° F., even though the Rocky Mountains act as a barrier against the extremely cold polar air from the Northwest Territories. Total annual precipitation is light, from 10 to 15 inches, with a total of 40 to 60 inches of snowfall in the winter. Summer precipitation is heaviest in July and August and much of the rain falls in thunder showers. Winter winds are not strong so that drifting snow is not a serious problem.

Weather Station Summaries

Station	Lat. N.	Long. W.	Altitude Feet	Record Period Years	Annual Averages: Air Temperature - Degrees F: July: Mean Maximum	July: Daily Mean	January: Daily Mean	January: Mean Minimum	Precipitation Total Rain & Snow Inches	Surface Wind M.P.H.
Carmacks	62° 06'	136° 18'	1,718	2	73.5	60.5	-26	-35.7	Not Rptd	Not Rptd
Elsa	63° 55'	135° 29'	3,000	7	67.0	56.9	-10.6	-15.7	15.27	Not Rptd
Mayo Landing	63° 36'	135° 53'	1,625	30+	68	59	- 7.8	-10	10.86	Jan 8.3 Jul 8.7
Skagway	59° 27'	135° 18'	23	30+	66.4	56.4	24.5	19.4	29.86	Jan 10 Jul 10
Whitehorse	60° 43'	135° 04'	2,289	18	67.2	56.2	5.2	- 2.7	10.05	8.7

Notes:

1. Mean maximum and/or minimum for any given month is defined as the summation of all maximum and/or minimum readings divided by the number of days. The daily mean for any given month is the sum of the mean maximum and mean minimum temperatures for that month divided by 2.

2. Approximate mean monthly temperatures at Goz Pass (elevation 4,025), Mile 524 may be estimated by deducting 3° F (1° F for each 330 feet) from available means at Elsa (Elevations 3,000), Mile 397. Monthly means at Iron Creek, Mile 598, would approximate those at Elsa.

5.2 Description of Roadway

A number of possible routes were considered in selecting the route used for the study and a route has been adopted which will show costs and operating characteristics representative of a suitable final choice. However, a final route selection has not been attempted in the present limited studies.

5.2.1 Selection of Ocean Terminal

The head of Taiya Inlet at the mouth of the Taiya River has been selected for the ocean terminal, as is shown on Plates I and IX. The railroad route up the Taiya River and thence by tunnel through the coast range to the vicinity of Bennet Lake is the favoured route to the interior. There is good access from the ocean, sheltered water for the pier area and an adequate area of level land suitable for development. Skagway is only five miles distant over an existing road which will allow the port personnel to live in an existing community.

5.2.2 Topography of Selected Route

The route selected for the study traverses the Coast Range immediately upon leaving the port. The steep, irregular mountain slopes and passes, reaching 3740 feet in elevation with 14 miles, make this extremely difficult terrain; requiring costly side-hill construction and a tunnel approximately 10.6 miles long. The tunnel will extend from the east fork of the Taiya River to the south end of Lindeman Lake, under Chilkoot Pass, through granitic rock assessed as offering very good tunnelling conditions. A report on the geological aspects of the region important to tunnelling is included as Appendix A to this report.

From the north portal of the tunnel, the projected line follows the east shore of Lindeman Lake and the irregular, precipitous shore of Bennett Lake to Carcross at milepost 59. The new roadway will be in close proximity to the White Pass and Yukon Railroad through most of this reach and some extra cost will be required to avoid interference.

North from Carcross, the line runs along the broad river valleys of the interior plateaus. At M.P. 100, the line passes Whitehorse and for the next 300 miles parallels in

BENNETT LAKE LOOKING NORTH FROM BENNETT.
WHITE PASS AND YUKON RAILWAY IN FOREGROUND

WHITE HORSE, YUKON TERRITORY. YUKON RIVER IN FOREGROUND general the existing all-weather highway to Stewart Crossing, Mayo Landing and Elsa.

The valley floors are generally covered by a heavy mantle of gracial till: sand, gravel, and boulders. Effects of glaciation, such as eskers, kettle holes and terraces, render the ground surface extremely choppy in sections but, in general, the route runs with the mountain valleys and construction will not be overly difficult. Some reaches of permafrost will be encountered but they will not be extensive. Four major river crossings; the Yukon, Pelly, Takhini and Stewart Rivers, are characterised by steep, deeply eroded banks dropping 500 feet, more or less, below the surrounding country.

Approaching Scougale Lakes at M. P. 430, the valleys become narrower, the streams braided and the maintain slopes more precipitous. The line now will run in an easterly direction, crossing the Selwyn Mountains, where it will traverse extremely difficult mountain terrain for most of the remaining distance to the mine. The railroad summit is reached crossing the Bonnet Plume Range through Goz Pass, where elevation 4,045 feet is attained at M. P. 524. Through this region, the underlying rock is almost devoid of overburden. From Goz Pass, the route descents the steep mountain slopes to the floor of the Snake River Valley and from M. P. 545 runs along the alluvial fans which border the braided river bottom to the confluence of the Snake and Iron Creek. The terminal at M. P. 598 is approximately 10 miles above the mouth of Iron Creek, at elevation 2,380 feet.

5.2.3 Alternate Routes

The more important alternates reviewed in adopting a route for the study are described below. These and other alternates should receive more attention in further development studies.

An alternate egress from Taiya Inlet is shown as Route "B" on Plate I. This alternate utilises a 23.3 mile tunnel to reach Partridge Lake from where it progresses around the west side of Bennett Lake and joins the selected route at Whitehorse. This alternate will suffer less operating interference with snow and rock slides in the Coast Range and allow somewhat easier running grades for loaded trains: 1.5% as compared to 1.9%. However, the cost of excavating a 23 mile tunnel

YUKON RIVER NEAR MINTO

SNAKE RIVER LOOKING NORTHWESTERLY FROM THE VICINITY OF GOZ PASS would be very high and the cost of ventilation equipment adequate to prevent overheating of the diesel locomotives would represent a further substantial increase.

Another alternate, designated "C" on Plate I, runs from Haines, Alaska, up the Klehini River to Chilkat Summit and thence via Klukshu, Champagne and Hatshi Lake to Emerald Lake where it joins the selected route at M.P. 196. A suitable port could be developed at Haines and the terrain north of Klukshu is favourable. However, the 120 miles from Haines to Klukshu traverses very difficult terrain and the rock in this section is described in Appendix A as less favourable for tunnelling. Grades up to 2.25% would be required between Haines and Chilkat Summit, although these would be running grades for the loaded ore trains, and this route is approximately 60 miles longer than the adopted route.

A line down the Tatshenski or Alsek Rivers to a port on the Alsek in Canadian territory was considered but found to be impracticable. Either route would traverse extremely rugged terrain with several obstructing glaciers. Moreover, the lower Alsek River and the ocean at the river mouth are too shallow for navigation.

There are several alternates available for the northerly portion of the line. One of the more attractive of these, designated Alternate "D" on Plate I, runs east of the selected route from M.P. 170 to Goz Pass. This route would be 12 to 15 miles shorter than the selected route but there are adverse factors which appear to more than offset this advantage. Support from 230 miles of existing highway between M.P. 170 and Elsa would be lost, resulting in increased construction costs. Also the 80 mile section of the alternate from the Stewart River to the Bonnet Plume River appears on the map to traverse particularly difficult terrain where construction costs will be very high.

5.2.4 <u>Criteria for Line and Grade</u>

A maximum adverse grade of 0.6%, or approximately 0.75% compensated for curvature, has been judged to offer a good balance between construction and operating costs over the line from M.P. 0 to 497. This has been increased to 0.8%, or 1.0% compensated, for the section over Goz Pass from

M.P. 497 to the mine. Helper engines are planned for this run. Maximum running grade is 1.5% except for the section under Chilkoot Pass from the port to M.P. 26, where the grade becomes 1.9%.

Curvatures do not exceed 10 degrees at any point and there are only a few scattered curves where the curvature exceeds 6 degrees.

As indicated above, these criteria were adopted as a matter of judgment, giving consideration to the terrain and operating requirements for very heavy hauls but without attempting to make extensive comparative analyses. As further topographic data become available, analysis may show that modifications are desirable to achieve a best balance between construction and operating costs.

5.2.5 Location of Major Facilities

The railroad headquarters and centre for heavy maintenance and repairs will be at Whitehorse, as noted previously. Centres for minor servicing of rolling stock will be placed at the mine and the port. The railroad has been divided into five divisions so the normal shift for train crews will not exceed 8-hours and full advantage can be taken of mechanised equipment for maintenance of way. Division headquarters will be at the port, Whitehorse, Milepost 275, Milepost 475 and the mine. Wayside maintenance stations will be located at 26 mile intervals, more or less, between division headquarters. Twenty-three passing sidings will be at intermediate division headquarters and the wayside maintenance stations.

5.2.6 Right-of-Way Considerations

A right-of-way 100 feet wide is contemplated. Although no title searches have been made, it can be assumed with safety that ownership in general will be by the Crown and accordingly the purchase price relatively low. It can be expected that the right-of-way costs in the immediate vicinity of Whitehorse and Carcross will be considerably higher.

It will be necessary to negotiate with the White Pass and Yukon Railroad for any encroachments on their right-of-way between

Bennett and Carcross, a distance of some 25 miles. In general, the new line will occupy a position above that of the WP&YRR on steep, rocky slopes and costs to alleviate encroachments may be quite high although no allowance for such costs has been included in the estimates. Legal survey costs will be relatively low as the low ownership density will result in few property ties.

5.3 Roadbed

Soil conditions along the route fall in three general categories: rock, glacial till and muskeg. The occurrence and design treatment of each type is discussed in Appendix B and is summarised below.

Soil conditions are generally good over the length of the route although there are sections, particularly those involving muskeg, where construction will be difficult. It is anticipated that glaciation will present a problem with railroad embankments along sidehills where the cuts intersect water bearing strata.

5.3.1 Rock

In general, at either end of the line where mountainous conditions occur, the railroad will occupy a position along steep rock sidehills. Full cut sections will be designed for a subgrade width of 26 feet, including ditches, with a back slope of 1/4:1. Sidehill cuts will have a subgrade width of 24 feet. Adequate rock and snow sheds will be provided where conditions dictate their necessity.

5.3.2 Glacial Till

In the plateau country, the soils along the broad valley floors are glacial tills for the most part. A 22 foot wide subgrade for embankments is planned. In cuts in the glacial soils, subgrade widths will be 26 feet wide with 1-1/2:1 back slopes being the general rule.

5.3.3 Muskeg and Permafrost

To obtain satisfactory grades and alignment at reasonable cost, it will be necessary to build the roadbed on muskeg for some portions of the route although this material is undesirable for foundations. The behaviour of muskeg is markedly affected by the presence of permafrost and the occurrence of permafrost conditions must be considered in planning construction across muskeg.

Permafrost generally is found where the mean annual temperature is below 25° F. Mean annual Whitehorse and Mayo Landing temperatures for the period 1951-1960 were 25.0° F and 20.7° F respectively. In general, permafrost condition is found to exist north of a point roughly 75 miles north of Whitehorse. South of this point to the western slope of the coast range, except for an area near the summit, fringe area occurs in which the permafrost is sporadic in occurrence and in a delicate state of equilibrium between the frozen and thawed conditions.

In the permafrost area, muskeg will present little problem, although it is essential to avoid open water and the route should be located on the more stable muskeg: areas supporting black spruce growth. Throughout this region, embankments should be built so as to permanently retain the permafrost below the roadbed and cuts should be avoided. In the fringe area, muskeg underlain by permafrost should be avoided and special consideration will be required in each locality as construction progresses.

5.4 Structures

5.4.1 Tunnels

The rock penetrated by the long tunnel on the approach to the sea consists of granitic materials (quartz, diorite or granodiorite) of the Coast Intrusive, or older rocks of equal competence. The rocks of this complex afford better than average tunnelling conditions as described in Appendix A. It is estimated that not more than 20% of the entire tunnel length will require lining. The tunnel cross section is to be of conventional design: 15 ft. - 0-7/8 in. between top of rail and spring line with arched roof of 8 ft. - 6 in. radius. Clear width is 17 ft. - 0 in. on tangents. A ventilation system similar to that of the 9 mile tunnel of the Great Northern Railroad in the Cascade Range is included. This system has two 850 hp blowers at the upper end of the tunnel to blow cooling air past locomotives climbing the grade. Doors at the upper portal prevent back-loss of the air and these doors are interconnected with the train signal system.

Other short tunnels are assumed to penetrate weathered rock where lining is required, with the same cross section as for the long tunnel.

5.4.2 Bridges and Culverts

Corrugated metal pipe will be used for all culverts. Trestles will be of timber, creosote treated near grade and for horizontal members. Bridges will be of steel construction for the main span, generally with timber trestle approaches. Bridges rather than large culverts will be used for the steep mountain-side ravines and chutes, to prevent clogging with debris.

5.4.3 Miscellaneous

Snow fence, cattle guards, mileposts, warnings and other miscellaneous structures will be of conventional design.

5.5 Track, Ties and Ballast

136 pound rail will be used on the mainline, with 110 pound relay rail on sidings. Ties will be 7" x 6" x 8-1/2' hemlock or fir treated to 8 pounds per cubic foot retention of equal parts of creosote and oil. Ballast will be crushed rock or crushed gravel from the glacial and alluvial deposits along the route. 12 inches of ballast under the ties is planned.

5.6 Signal and Communications Systems - 10 Million Tons per Year

5.6.1 Signal System

The signal system will consist of automatic block signals with battery power. Passing sidings will have spring switches which will automatically route traffic travelling toward the mine into the siding. Trains will operate "under order" from the despatcher. Electric detectors for slides will be provided in critical areas which will activate the automatic signals.

5.6.2 Communications System

The prime communications link will be by microwave with repeater stations at forty mile intervals. Sufficient channels are proposed for despatcher phone, future CTC control and indication, wayside station phone and long distance phone circuits.

At each microwave repeater location, (way station) there is to be a despatcher-to-train VHF radio base station, controlled by the despatcher or called into service by a train wishing to talk to the despatcher. Way stations also are to be linked to the despatcher's office by carrier telephone.

5.7 Service and Maintenance Facilities - 10 Million Tons per Year

5.7.1 General

Railroad service and maintenance facilities will include the components shown on Plate VIII. Construction will be of permanent type, except for portable housing units for seasonal maintenance personnel. Larger buildings will have steel frames with insulated roof and wall panels, on concrete foundations. Smaller structures, particularly at the wayside maintenance stations, will be of wood frame construction. Portable housing will be similar to that commonly used for remote construction projects and will be adapted to crane pickup for movement from place to place via rail car. Utility units will connect to permanent utility services installed at each station.

Personnel facilities are included at the mine, the division stations at mile posts 275 and 475 and the wayside maintenance stations. At Whitehorse and the port, it has been assumed that local enterprise will provide housing.

5.7.2 Terminal Facilities at the Mine and Port - 10 Million Tons per Year

Railroad facilities in the port area will include a locomotive service station, a shop for minor repairs and facilities for a division headquarters. Marshalling yards and car loading and unloading facilities are described with other components of the port. The locomotive service station will provide for simultaneous fuelling, sanding and turnaround inspection of four locomotives with four-service points spotted along a concrete inspection pit 250 feet long. The pit also will be equipped with radiant heating panels. The four sanding towers will be supplied by one unloading, storage and drying unit.

There will be a one-spot car repair shop 40 ft. by 110 ft.; a 50 ft. by 120 ft. garage for maintenance vehicles and equipment; approximately 3000 sq. ft. of warehouse space; 1500 sq. ft. of division office space; a train crew dormitory and mess hall totalling 5000 sq. ft.; and space and utility connections for portable housing for seasonal personnel.

Railroad facilities at the mine area will duplicate those at the port, with the mine area marshalling yards and car loader included with the ore handling facilities.

5.7.3 Railroad Headquarters and Shops at Whitehorse - 10 Million Tons per Year

Facilities at Whitehorse will include the railroad headquarters and heavy maintenance shops as well as a division headquarters. A site of approximately 40 acres will be developed with roads and utility services. Electric power will be obtained from the utility company serving Whitehorse. Approximately 10,000 sq. ft. of office space will be furnished for headquarters and division offices, communications centre and dispensary. Repair shops will include a 120 ft. by 260 ft. locomotive shop with spots for six units and equipment for major overhaul and repairs; a car maintenance shop 75 ft. by 240 ft.; a paint shop 40 ft. by 80 ft. and a heated storage shed 40 ft. by 200 ft. for locomotives. There will be 8000 sq. ft. of warehouse space along with a garage and maintenance facilities for automotive and division maintenance equipment approximately 50 ft. by 160 ft. A locomotive service station will be able to supply fuel, lubricating oil, water and sand to four locomotives simultaneously. Space for all the 150 portable housing units will be provided so these structures can be assembled for maintenance and repair during the winter season. It has been assumed that local enterprise will provide room and board for the train crews lying over.

5.7.4 Division Stations at Mileposts 275 and 475

The two isolated division stations each will include a locomotive service station to supply fuel, lubricating oil, water and sand to four units simultaneously; 1500 sq. ft. of office space; a 50 ft. by 100 ft. garage for maintenance vehicles and equipment; 1000 sq. ft. of warehouse space; a 5000 sq. ft. dormitory and mess hall for train crews; family housing for 9 permanent employees and space and services for portable housing for seasonal maintenance personnel. A 250 kw diesel electric generating station will provide power and all other utilities will have to be provided for a developed site of approximately 15 acres.

5.7.5 Wayside Maintenance Stations

The 19 wayside maintenance stations each will include family housing for two permanent employees, mess hall and gallery of 1200 sq. ft., a tool house 20 ft. by 40 ft., space and services for portable housing, and utilities including a 30 kw diesel electric generator.

5.8 Rolling Stock - 10 Million Tons per Year

Estimates of rolling stock requirements are based on calculated running times and other operating factors developed from operating criteria consistent with other experience in heavy bulk railroad hauls. Train size has been limited to approximately that of the largest train which has been proved satisfactory in service.

5.8.1 Operating Criteria

The basic operating criteria adopted for this study are:

Ore trains will consist of 15,000 trailing tons, or 12,000 short tons of ore.

Speed limits will be 40 mph maximum, 25 mph on major bridges, 30 mph on down grades between 1.0% and 1.5% and 20 mph on down grades exceeding 1.5%.

Northbound trains will delay for meets and a 1-hour delay allowance has been included for each meet. Other delay allowances are 45 minutes for each crew change, 3 hours for locomotive servicing and train makeup at each terminus and a miscellaneous allowance of 15% of total calculated trip time.

Turn-around time for ore cars is 6 hours, for general freight cars 2 days and for tank cars 2 days to allow for heating the contents.

5.8.2 Train Operations

Based on the above general criteria, an operating plan has been developed which provides for maximum practicable utilisation of equipment. To accomplish this, the ore cars of 6 loaded trains are made up into 5 empty trains for the return run and the locomotives from the sixth train assist in hauling the loaded supply trains north. The operations are:

Ore Trains - Southbound:

An average of 2.75 trains per day, each consisting of 8 locomotive units and 120 ore cars. Two locomotive units cut off at Milepost 125 and deadhead back to mine on next returning train.

Ore Trains - Northbound:

An average of 2.3 trains, each consisting of six locomotive units and 144 ore cars.

Supply Trains - Southbound:

An average of one train every other day, each consisting of one locomotive unit and approximately 57 empty cars.

Supply Trains - Northbound:

One train every other day, each consisting of eight locomotive units and 57 loaded supply cars. Two locomotive units cut off at Whitehorse and deadhead back to port with the next southbound train.

A summary of the operations is:

Operative days per year	340
Short tons per day	33,000
Short tons per ore train	12,000
Cycle time - hours	59
Average speed for complete cycle	20.4 mph
Train departures per day	
Loaded ore trains	2.75 @ 120 cars
Empty ore trains	2.3 @ 144 cars
Loaded supply trains (alternate days)	1 @ 57 cars
Empty supply trains (alternate days)	1 @ 57 cars

Number of ore trains = 59/24 x 2.75 = 7

To maintain these operations, the rolling stock shown in the railroad equipment list will be required.

5.8.3 Locomotives

General Electric Model U25B, 4 axle road locomotives of 2500 hp were adopted for this study after comparative studies showed they are well suited to the estimated service conditions.

For switching, 1800 hp switching locomotives were adopted and 1200 hp units have been included for maintenance service.

All units are equipped with oversized fuel tanks, dynamic braking, multiple unit control, integral train control, microwave radio transceivers and pressurised cabs with bottled air supply for the run through the long tunnel.

5.8.4 Ore Cars

The ore cars used in the study are 100 short ton capacity open gondola cars, with roller bearings and swivel couplings. Cars weigh approximately 52,000 pounds. For hauling granular concentrate, it has been assumed arbitrarily that raising the car sides 2 feet will prevent excessive wind loss. Experience has shown that high freeboard on open gondola cars hauling iron ore of moderately fine grind will hold windblown losses to nominal amounts. It is calculated that moisture pickup while in the open railroad cars normally will not exceed 1.8% and for extreme storms will not exceed 4.6%. Comparable figures for the stockpile at the port, with 2 months exposure assumed, will be less than 1.5% normally and not more than 2.0% as an extreme. The total moisture pickup after drying thus will not be excessive and the considerable added cost for covered cars and covered stockpiles is not warranted.

5.8.5 Miscellaneous Cars

20,000 gallon tank cars with heater coils and roller bearing trucks have been adopted for the study. For other requirements, standard box cars, flat cars and refrigerator cars are proposed, all with roller bearing trucks. For the alternate to produce pellets, the number of tank cars is increased substantially to haul additional fuel oil and added box cars to haul bentonite are provided.

5.8.6 Service Equipment

Service equipment for maintenance and other specialised operations is shown in the railroad equipment list.

5.9 Railroad Facilities for 5 Million Tons per Year

Railroad facilities to handle 5 million tons per year of ore will be essentially the same as for 10 million tons except that rolling stock requirements will be reduced and there will be a corresponding reduction in other items, principally the maintenance facilities. The modified rolling stock and equipment requirements are shown in the equipment list. Other modified items are described below.

The dormitory and mess hall facilities for train crews will be reduced to 4,000 sq. ft. of space at all five division stations. Office space for the division headquarters will be reduced to 1000 sq. ft. and for the railroad headquarters to 7500 sq. ft. Locomotive service points will have their facilities reduced to allow for servicing two locomotives at a time and the fuel and sand storage will be similarly reduced. The locomotive shop at Whitehorse will be 100 by 260 feet, the car shop 75 by 200 feet and the equipment shop 50 by 140 feet.

Family housing for 7 employees at the two remote division stations will be provided. Portable housing units for 130 men will be provided.

5.10 Railroad Facilities for 20 Million Tons per Year

Railroad facilities to handle 20 million tons per year of ore will be very similar in character to those for 10 million tons. However, there will be several changes to handle the increased traffic in addition to the increase in rolling stock and maintenance equipment shown in the equipment list.

The number of passing sidings will be increased to 48, which will give an average spacing of 12 miles. A centralised traffic control system with the despatcher at Whitehorse will be installed. Switches will be remote controlled and power operated, which will require a power line along the length of the railroad. There will be a link between the microwave communications system and the CTC system for transmitting control signals.

The dormitory and mess hall facilities for train crews will be increased to 7500 sq. ft. at each division headquarters and office space at each increased to 1800 sq. ft. The sidings at the maintenance shops in Whitehorse will be increased to 34,000 feet of trackage, the locomotive shop will be 140 by 260 feet, the car shop 75 by 300 ft. and the automotive shop 50 by 200 ft.

Family housing for 11 employees will be provided at the two remote division headquarters. Portable housing for 220 men will be provided.

6. PORT

6.1 Site Characteristics

It has been noted in Section 5.2.1 that the head of Taiya Inlet is an attractive location for the port with respect to construction conditions, availability of level land for on-shore facilities and favourable conditions for ships. Taiya Inlet, Chilkoot Inlet and the Lynn Canal offer a sheltered passage to the ocean which is ice-free the year round except for scattered icebergs from Taku Glacier. The flood plain at the mouth of the Taiya River is only 5 miles from the town of Skagway over an existing road. Not only are site conditions favourable, but most, if not all, of the land is State-owned so that it will be available at an equitable price.

6.1.1 Topography

The level flood plain at the lower end of the Taiya River Valley is approximately 1/2 mile wide by 3 miles long, formed primarily of sands and gravel. The main channel of the Taiya River runs along the easterly side of the valley so that the entire plot can be developed as one parcel by minor improvement work to cut off and fill small secondary channels which interlace the flood plain. The bordering mountainsides are bare rock eroded to approximately a 40% slope.

6.1.2 Hydrography

The steep rock slopes of the mountains continue under water along the westerly side of Taiya Inlet to three hundred feet or more of depth while the coarse sediments washed down by the Taiya River also have a sharp drop-off along the northerly end of the inlet. A sheltered location for the pier is available with good ships' access, a natural water depth of 50 feet along the pier face so that dredging will not be required and where bottom sediments appear to be present so that piling can be driven readily. The extreme tidal range is approximately 25 feet, but there is little or no tidal current at the head of the inlet.

LOOKING NORTHWARD UP TAIYA VALLEY

PORT OF SKAGWAY, ALASKA

6.1.3 Weather

Weather conditions at Skagway are summarised in Section 5.2 of this report. Zero days are rare although -40° has been recorded. Prevailing winds are from the North and follow the natural topography of the North-South Taiya Valley leading from tidewater to Chilkoot Pass.

6.1.4 Outside Support Facilities

The port is five miles by existing road from Skagway, although a highway bridge over the Taiya River will have to be constructed. Skagway is the southern terminal of the White Pass and Yukon Railroad and transportation is the principal local industry. Population is 750 and the town has a hospital, accredited high school, hotels and social facilities.

6.2 General Arrangement

To accommodate ore carriers up to 100,000 ton capacity, a 50-foot minimum water depth is proposed. This can be obtained by placing a marginal pier with the face approximately 500 feet off the north and west shores of Taiya Inlet and parallel to the west shore, as is shown in Plate IX. A 500-foot trestle will connect the pier to the area proposed for on-shore facilities. The ore stockpiles and car unloading facilities have been placed adjacent to the pier head for convenience and to minimise the conveyor system. The port offices, service building and transit warehouse also are adjacent to the pierhead for convenience. The oil storage farm can be placed up to several thousand feet from the pierhead and still receive products via the ship's pumps and at the same time be convenient for refuelling the railroad locomotives, one of the important fuel deliveries. The permanently assigned railroad and port employees, numbering approximately 210, will be cared for in Skagway, and it has been assumed their housing and service needs will be provided at no cost to the project.

6.3 Ships' Piers

The ships' piers will be of the marginal type to take advantage of the natural water depth,although tugs and other small craft will be accommodated on the shore side. A 1200 by 140-foot pier with minimum water depth of 50 feet is planned for ore loading. This pier also will handle general cargo and fuel coming in. With mooring dolphins off the ends, the pier will accommodate one 100,000 ton ore carrier or two smaller vessels. The pier and trestle are to be of steel construction with concrete deck.

6.4 Ore Handling Facilities - 10 Million Tons per Year

Plate IX shows the proposed lay-out of the port facilities for handling ore at the port. The stock-out and reclaim systems have been separated such that all out-loaded material will pass through the stockpile. Handling facilities are simplified and their cost reduced by this arrangement. The handling rate suitable for ship loading far exceeds the rate required to unload ore cars so that a portion of the outloaded material would come from stockpile in any event. Facilities are essentially the same for handling either granular concentrate or pellets. Conveyor belts will operate at somewhat higher speeds for pellets to compensate for the lesser bulk density of pelletized ore as compared to granular concentrate. For either product, stockpiles will be open. As described in Section 5.9.4, the moisture buildup in stockpile will not be excessive and the added cost of covered storage is not warranted.

6.4.1 Stockout and Stockpile Facilities

The planned method of operation for unloading is:
The 120 - car trains will be received in the marshalling yard. Cars to be dumped will be switched to the unloading track and engaged with the cable-operated car pusher which will feed the car string through a rotary car dumper on an automatic cycle at a rate of 30 cars per hour. Empty cars will be switched back to the marshalling yard for inspection and make-up into returning trains.

A radiant heating shed ahead of the dumper will thaw the car sides in winter to facilitate dumping. Moisture content of either granular concentrate or pellets will be sufficiently low to prevent the frozen ore from adhering tightly so that the material will break up readily on grizzlies beneath the car dumper. Ore passing the grizzly will be collected in a 250 ton hopper under the dumpers and fed by vibrating feeders onto a 54-inch belt conveyor system for delivery to the 2 million ton stockpile at a rate of 3500 tons per hour.

6.4.2 Ore Reclaiming Facilities

Ore will be reclaimed through twin reclaim tunnels equipped with vibratory feeders discharging onto 60-inch reclaim belts. A transfer belt will rise to 50 feet above grade and deliver onto a belt running the length of the pier. A travelling shiploader with retractable and raising conveyor boom will load ships at a rated capacity of 6000 LT/hr.

6.5 Other Cargo Facilities - 10 Million Tons per Year

6.5.1 General & Refrigerated Cargo

General cargo including refrigerated foods will be handled over the ore pier and there will be railroad tracks onto the pier for this service. Provisions will be made for handling containerised bulk shipments of bentonite and other cargo, but there also will be a transit warehouse for general cargo including perishables. The warehouse will have a track scale and space for customs inspection.

6.5.2 Fuel Handling and Storage

Pipelines will be provided to carry petroleum products from the pier to the tank farm, utilising the ship's pumps for incoming deliveries. The storage tanks will be of conventional design, insulated and heated where used for heavy fuel oil. A pump house will load out to tank cars spotted on sidings or directly to the fuel tanks of the railroad locomotives. There will be 110,000 bbl of storage for fuel oil in the case of facilities to produce granular concentrate and 225,000 bbl for the alternate to produce pellets. In either case, there will be 80,000 bbl of storage for diesel fuel and 2,000 bbl for gasoline.

6.6 Railroad Marshalling Yard - 10 Million Tons per Year

Sufficient trackage is provided in the marshalling yard to clear the right-of-way of southbound trains and at the same time hold three additional trains of ore cars. This will allow capacity for inspection, special train make-up and other normal operations. There will be 9 sidings totalling 58,500 feet of track.

6.7 Administration and Service Facilities

A general administration building will accommodate the port director, clerical employees and facilities for Immigration and Customs service.

Service buildings will include a heating plant, emergency power plant, water supply and miscellaneous maintenance shops. Railroad service shops are discussed in Section 5. 8. 2.

6.8 Port Facilities for 5 Million Tons per Year Project

Port facilities to handle 5 million tons per year of ore will be essentially the same as for 10 million tons. The railroad marshalling yard, the ore unloading and stock-out system and fuel storage will be increased in capacity. Other components already are of minimum size for reasonably prompt ship turn-arounds.

6.8.1 Ore Unloading and Stock-out

The car pusher will be sized to handle 30-car strings rather than 120 car, and the cycling rate reduced to 20 cars per hour. The stocking out conveyor system will be reduced to a 48 inch belt to handle 2400 long tons per hour. The size of the stockpile will be 1 million tons.

6.8.2 Fuel Storage

The capacity of the tank farm for fuel storage will be 55, 000 bbl of fuel oil in the case of facilities to produce granular concentrate and 115, 000 bbl for the alternate to produce pellets. In either case, there will be 40, 000 bbl of diesel fuel and 2, 000 bbl of gasoline. The transfer rates will remain unchanged.

6.8.3 Railroad Marshalling Yard

With the reduced traffic, the number of sidings will be reduced to 5 and the amount of trackage to 32, 500 feet.

6.9 Port Facilities for 20 Million Tons per Year

Port facilities to handle 20 million tons per year will be similar to those for 10 million tons per year with additions as described below:

6.9.1 Ships' Piers

The 1200 foot ore loading pier will be supplemented by a 600 foot by 100 foot extension to the south which will provide one berth for general cargo vessels and tankers.

6.9.2 Ore Handling Facilities

The stockout system will have an increased capacity of 7,000 tons per hour, requiring 60 inch belt conveyors. There will be a double car dumper with a design operating rate of 80 cars per hour. The double dumper will discharge into two 250-ton hoppers. The reclaim and loading system will be rated at 8000 LT/hr. The size of the stockpile will be 3 million tons.

6.9.3 Fuel Handling and Storage

Storage capacities for petroleum products will be 160,000 bbl of fuel oil in the case of facilities to produce granular concentrate and 450,000 bbl for the alternate to produce pellets. In either case, there will be 155,000 bbl for diesel fuel and 2,000 bbl for gasoline. There will be no change in the transfer rates.

6.9.4 Railroad Marshalling Yard

Using the same basic criteria as for the 10 million ton per year project, there will be 15 spurs in the marshalling yard totaling 97,500 feet of track.

7. CONSTRUCTION COST ESTIMATES

This section of the report includes order-of-magnitude estimates of construction costs for the facilities described in Sections 3 through 6 of this report. The estimated costs are contractor's all-inclusive costs including an allowance for detailed design. Also included are the purchase costs of land for the railroad and land for the port and procurement cost of mobile equipment and spare parts. No allowances are included for the Owner's administrative costs during construction or planning of work prior to the detailed design.

The estimates are developed from experience on other projects involving similar facilities with adjustment made on a judgment basis to reflect conditions for the Yukon project. When preliminary designs are prepared, considerable adjustment to the present estimates may become necessary but these estimates are believed sufficiently accurate for a general evaluation of the project as well as to show the relative magnitude of major cost elements.

Certain cost elements were obtained from U.S. sources. In such cases, the costs were converted to Canadian funds on the basis of the October, 1962 midrate of 7-1/8% premium on the U.S. dollar.

The cost of a construction road from Elsa to the mine area has been included as a part of the distributed indirect costs. It has been assumed that the existing road from Whitehorse will provide access to the railroad right-of-way as far as Elsa. The cost of a construction camp independent of the operators townsite also is included as a distributed indirect construction cost.

Costs shown in the following tables are based on January, 1963 prices. A suitable escalation allowance is added in the tabulations of Section 9. Start-up of the initial production increment has been taken as April 1968 for all schemes with future build-up to each final production level as is shown in Section 9. No allowance has been included for expedited construction although the April 1968 start-up date requires a very tight construction schedule. At the same time considerable risk will have to be assumed to meet that date, in that major construction will have to start on the railroad and mine area facilities prior to completion of the exploration work and metallurgical tests necessary to prove out the ore body.

At the present stage of the development studies, there is not a sound basis for rational assessment of the project uncertainties. In consequence, no contingency allowance is shown in the estimated costs.

SUMMARY
ORDER OF MAGNITUDE ESTIMATE
OF CONSTRUCTION COSTS

Facilities to Produce Granular Concentrate

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Mine Development and Mining Facilities	$ 17,100	$ 28,300	$ 42,000
Ore Processing and Car Loading Facilities	50,200	82,000	138,600
Railroad Facilities	333,000	357,200	417,200
Port Handling and Shiploading Facilities	23,200	26,300	32,500
Mine Area Utilities	17,700	20,300	27,800
Indirect, Administration and Overhead Facilities	25,100	37,900	59,500
Total Construction Costs with Additions Listed Below	466,300	552,000	717,600

a) Land purchase for railroad right-of-way and for port
b) Mobile equipment
c) Spare parts

ORDER OF MAGNITUDE ESTIMATE

To Produce Granular Concentrate

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Mine Area Facilities			
Mine Development and Haul to Crusher			
Haulage System (Incl. R.R., Bridge, Tunnels and Controls)	$ 2,800	$ 5,700	$ 5,800
Dumps and Loading Stations	800	1,600	1,600
Service Roads Fills, Service Areas, Service Bldgs. and Explosives Stor.	1,500	2,100	2,600
Oxygen Plant and Distr. Piping	1,100	1,700	2,400
Utilities (Fuel, Water, Power, Communications and Heat. and Vent.)	400	1,200	1,800
Mine Stripping and Pre-Production	3,200	3,300	4,700
Mobil Equipment (Incl. Spare Parts)	7,300	12,700	23,100
Subtotal	17,100	28,300	42,000
Ore Processing Facilities and Carloading			
Site Improvements and Earthwork	4,900	7,000	9,200
Primary Crushing and Handling Facility to Secondary Crusher Plant	7,700	11,500	18,300
Sec. and Tert. Crushing Handling Facility to Fine Ore Storage at Mill	4,300	7,700	14,000
Concentrator Incl. Fine Ore Storage, Mill Building and Tailings Disposal	21,500	38,700	71,000
Filtering and Drying Facilities	2,100	3,700	7,000
Concentrate Stockpile and Loadout Facility	6,600	8,800	11,800
Maintenance Shops and Equipment	3,100	4,600	7,300
Subtotal	50,200	82,000	138,600
Mine Area Utilities			
Electric Generation and Transmission	9,800	11,900	18,700
Water Supply (Incl. Dam and Transmis.)	6,700	6,800	6,900
Misc. Utilities (Incl. Heating System, Sewage, Domestic Water, Fire and Communications)	1,200	1,600	2,200
Subtotal	17,700	20,300	27,800

ORDER OF MAGNITUDE ESTIMATE

To Produce Granular Concentrate

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Mine Area Facilities (cont'd)			
Indirect, Administration and Overhead			
Service Buildings (Warehouses, Change house, Offices and Labs)	$ 1,100	$ 1,700	$ 2,900
Fuel Oil Storage and Holding	400	600	1,000
Mine Area Town	22,000	34,000	54,000
Airfield	800	800	800
Misc. Vehicles	800	800	800
Subtotal	25,100	37,900	59,500

ORDER OF MAGNITUDE ESTIMATE

To Produce Granular Concentrate

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Railroads and Shops (Plant to Port)			
Clear and Grade	120,000.	120,000.	121,500.
Bridges and Culverts	59,000.	59,000.	59,000.
Short Tunnels, Rock and Snow Sheds	12,000.	12,000.	12,000.
Track Lay and Ballast	20,000.	20,000.	20,200.
Tunnel (Excavate and Line Only)	20,000.	20,000.	20,000.
Track Materials Mainline (598 mi.)	46,000.	46,000.	46,000.
Track Materials Siding	3,300.	3,300.	5,500.
Crossings, Fences, Miscellaneous	200.	200.	200.
Signal and Control System	5,000.	5,000.	15,000.
Communications (Microwave)	1,800.	1,800.	1,800.
Shop	8,500.	9,500.	11,000.
Rights of Way	500.	500.	500.
Rolling Stock and Spare Parts	36,700.	59,900.	104,500.
Total	333,000.	357,200.	417,200.

ORDER OF MAGNITUDE ESTIMATE

To Produce Granular Concentrate

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Port Facilities			
1. Site Improvements, Incl. Grading, Roads, Utilities and F.O. Stor. Hdlg. & Land Purchase	$ 6,000	$ 6,700	$ 7,600
2. Service Buildings and Shop Equipment	2,200	2,500	3,000
3. Unloading and Stockpile Facilities	3,900	4,600	6,700
4. Reclaim and Shiploading Facilities	4,900	6,300	7,800
5. Pier	4,300	4,300	5,500
6. Railroad Marshalling Yard	1,900	1,900	1,900
Total Port Facility	23,200	26,300	32,500

ORDER OF MAGNITUDE ESTIMATE

To Produce Granular Concentrate

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Mobile Equipment and Rolling Stock at Mine			
Mining	$ 4,600	$ 8,800	$ 15,400
Stripping	1,000	1,300	3,000
Service	1,000	1,500	2,600
10% Spares and Miscellaneous	700	1,100	2,000
Total	$ 7,300	$ 12,700	$ 23,000
Railroad Rolling Stock (Plant to Port)			
Locomotives	10,000	17,500	32,200
Ore Cars	11,900	23,800	47,600
Supply Cars	4,300	5,700	8,600
Service Equipment	8,700	10,000	11,100
Spare Parts	1,800	2,900	5,000
Total	$ 36,700	$ 59,900	$ 104,500

SUMMARY
ORDER OF MAGNITUDE ESTIMATE
OF CONSTRUCTION COSTS

Facilities to Produce Pellets

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Mine Development and Mining Facilities	$ 17,100	$ 28,300	$ 42,000
Ore Processing and Car Loading Facilities	103,600	181,700	328,600
Railroad Facilities	334,300	361,900	422,400
Port Handling and Shiploading Facilities	23,200	26,300	32,500
Mine Area Utilities	22,600	34,200	47,000
Indirect, Administration and Overhead Facilities	28,300	44,300	70,400
Total Construction Costs with Additions Listed Below	529,100	676,700	942,900

a) Land purchase for railroad right-of-way and for port
b) Mobile equipment
c) Spare parts

ORDER OF MAGNITUDE ESTIMATE

To Produce Pellets

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Mine Area Facilities			
Mine Development and Haul to Crusher			
(Same as for granular concentrate)	$ 17,100	$ 28,300	$ 42,000
Ore Processing Facilities and Carloading			
Site Improvements and Earthwork	4,600	6,700	8,800
Primary Crushing to Secondary Crusher	7,300	11,000	17,700
Sec. and Tert. Crushing to Fine Ore Storage	4,000	7,400	13,500
Concentrator	20,200	37,000	68,700
Pellet Plant (Incl. Regrind, Thickening, Filtering, Balling, Indurating and Additives)	58,700	107,800	201,900
Pellet Stockpile and Loadout Incl. Marshalling Yard	5,900	7,400	10,900
Maintenance Shops and Equipment	2,900	4,400	7,100
Subtotal	103,600	181,700	328,600
Mine Area Utilities			
Electrical Generation and Transmission	14,600	25,700	37,800
Water Supply	6,700	6,700	6,700
Miscellaneous Utilities	1,300	1,800	2,500
	22,600	34,200	47,000
Indirect, Administration and Overhead			
Service Buildings	1,100	1,700	2,900
Fuel Oil Storage	600	1,000	1,800
Mine Area Town	25,000	40,000	64,000
Airfield	800	800	800
Miscellaneous Vehicles	800	800	900
Subtotal	28,300	44,300	70,400

ORDER OF MAGNITUDE ESTIMATE

To Produce Pellets

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Railroad and Shops (Plant to Port)			
Clear and Grade	120,000.	120,000.	121,500.
Bridges and Culverts	59,000.	59,000.	59,000.
Short Tunnels, Rock and Snow Sheds	12,000.	12,000.	12,000.
Track Lay and Ballast	20,000.	20,000.	20,000.
Tunnel (Excavate and Line Only)	20,000.	20,000.	20,000.
Track Materials Mainline (598 mi)	46,000.	46,000.	46,000.
Track Materials Siding	3,300.	3,300.	5,500.
Crossings, Fences, Miscellaneous	200.	200.	200.
Signal and Control System	5,000.	5,000.	15,000.
Communications (Microwave)	1,800.	1,800.	1,800.
Shops	8,500.	9,500.	11,000.
Right of Way	500.	500.	500.
Rolling Stock and Spare Parts	38,000.	64,600.	109,700.
Total	334,300.	361,900.	422,400.

ORDER OF MAGNITUDE ESTIMATE

To Produce Pellets

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Port Facilities			
1. Site Improvements, Incl. Grading, Roads, Utilities and F.O. Stor. Bldg.	$ 6,000	$ 6,700	$ 7,600
2. Service Buildings and Shop Equipment	2,200	2,500	3,000
3. Unloading and Stockpile Facilities	3,900	4,600	6,700
4. Reclaim and Shiploading Facilities	4,900	6,300	7,800
5. Pier	4,300	4,300	5,500
6. Railroad Marshalling Yard	1,900	1,900	1,900
Total Port Facility	$ 23,200	$ 26,300	$ 32,500

ORDER OF MAGNITUDE ESTIMATE

To Produce Pellets

	Output Capacity		
	5 MM LTPY	10 MM LTPY	20 MM LTPY
	(Costs in $1,000)		
Mobile Equipment and Rolling Stock at Mine			
Mining	$ 4,600	$ 8,800	$ 15,400
Stripping	1,000	1,300	3,000
Service	1,000	1,500	2,600
10% Spares and Miscellaneous	700	1,100	2,000
Total	$ 7,300	$ 12,700	$ 23,000
Railroad Rolling Stock (Plant to Port)			
Locomotives	10,000	18,300	32,500
Ore Cars	11,900	23,800	47,600
Supply Cars	5,600	9,400	13,300
Service Equipment	8,700	10,000	11,100
Spare Parts and Miscellaneous	1,800	3,100	5,200
Total	$ 38,000	$ 64,600	$109,700

8. OCEAN TRANSPORT COST ESTIMATES

8. COST OF OCEAN TRANSPORT

This section of the report presents the results of a comparative study of ocean shipping costs for Yukon iron ore and potentially competitive ores to selected world markets. These costs are summarised in Tables 1 through 9. The cost data for this study was prepared by the Joshua Hendy Company, a Los Angeles shipping concern, and their detail cost breakdowns are included as Appendix C. Costs include present day operating expenses, amortisation of capital and interest on investment, port charges, fuel, and insurance. In the summary tables an over-head charge of $100 per vessel day has been added in accordance with the recommendations of Joshua Hendy Company as transmitted in their letter of November 5, 1962 which also appears in Appendix C. Escalation of shipping costs has not been included in these summary tables but is added in the project summaries where escalation of all costs is covered. No allowance has been made for profit in either the summary tables or cost breakdowns. The cost breakdowns in Appendix C have been prepared in U.S. dollars since U.S. currency is widely used in international trade but all costs shown in this section of the main report are in Canadian funds. Conversions may be made on the basis of the October, 1962 midrate of 7-1/8% premium on the U.S. dollar.

Operating and capital costs from Haines to foreign markets are based on using ships of foreign flag and construction. Cost for shipments from Haines to the United States ports are based on using ships of U.S. flag and construction.

Shipping costs were determined for several vessel classes and for capital write-off periods of 10, 15 and 20 years. The summary cost tables show that an increase in the write-off period from 10 to 20 years decreases the shipping costs approximately 18% irrespective of vessel class or length of voyage.

Of the four classes of vessels considered, the 35,400-ton Rio and 50,343-ton Neptune classes, are currently in service as ocean ore carriers. The two larger classes, 69,000 and 100,000 tons, would constitute new building. Construction of 69,000-ton ore carriers presently is under way and the shipping industry anticipates the use of 100,000-ton vessels by 1970. For the purpose of this study, however, the maximum size vessel has been taken as 69,000-tons, the largest of assured availability. Where full utilisation of the cargo capacity is not restricted by draught limits, shipping costs with the 100,000 DWT vessels are approximately

40% less than with the 35,400 DWT vessels. In several instances, however, particularly those involving Canal Zone transit, lower unit shipping costs are obtained with the 50,343 class than with larger vessels. Draught limitations in many ports also limit the potential use of 100,000 DWT vessels although they could enter the port of Tabata, Japan.

Analysis of the shipping costs from Haines and other potential sources of iron ore shows Japan and the U.S. West Coast to be more favourable markets for Yukon ore. From Haines to Tabata, Japan, shipping costs range from $1.99 to $3.98 per long ton depending on vessel class and write-off rate. This compares advantageously to the equivalent range of $3.73 to $7.77 for shipments from San Juan, Peru, the nearest major import source presently in operation. With estimated unit costs of $1.70 to $3.39 per long ton, shipping costs from Port Hedland, Australia to Tabata will be very competitive as Port Hedland ore shipments develop. The lower costs, however, are based on the use of large vessels which will not be able to leave Port Hedland fully loaded as the port now is being built. Because of draught limitations, Port Hedland will not be able to handle vessels larger than approximately 40,000 deadweight tons. Plans for increasing the harbour depth are not known but it is understood that this would constitute a major undertaking.

The geographic proximity of Haines to U.S. West Coast ports gives Yukon ore a slight advantage in ocean shipping costs over most other import sources despite the higher operating and capital costs for ships of U.S. flag and construction. Costs from Haines are $1.53 to $2.72 to San Francisco and $1.74 to $3.15 to Los Angeles. This gives Yukon ore a $.52 to $.97 advantage in San Francisco and $.16 to $.24 advantage in Los Angeles over shipments from San Juan, Peru, the most competitive alternate import source.

For shipments to the U.S. South and East Coast ports, the greater distances from Haines and the higher costs of U.S. flag ships results in a severe disadvantage for Yukon ore as compared to ore from several other sources. Shipping costs of Yukon ore will be $7.00 to $10.50 per ton, compared to costs of $1.50 to $3.50 for ore from South America, Canada, and Africa.

Utilising foreign flag ships, costs from Haines to European ports are $6.75 to $9.25. Costs of $1.75 to $4.00 from several other possible sources give these competing producers a substantial shipping cost advantage.

Backhaul of oil offers potential savings in the shipping cost of ore from Haines to Tabat if large vessels are used with a long capital write-off period. The per cent savings with larger class vessels are considerably greater with oil backhaul as compared to straight ore service. This is because of the cumulative effect of increasing unit oil revenue and decreasing unit ore charges with the larger and more efficient carriers. Backhauling Bahrein oil with 100,000-ton vessels and a 20-year capital write-off results in shipping costs of $.25 per ton of ore from Haines to Tabata as compared to $1.99 per ton when only ore is handled. Not explicit in the cost figures, however, is the effect of backhaul on the total capital or shipping capacity commitments required to effect these savings. Round trip time for this run is increased by a factor of 2.6. Capital requirements are increased by an even greater amount because of a 10% additional expense for equipping vessels for dual service. Backhauling Sumatran oil, which has less value but is more conveniently located, increases capital requirements by a lesser factor of 2.1 but results in less of a unit cost savings. A similar analysis of shipping costs from San Juan with an oil backhaul show a cost reduction, using 100,000-ton vessels and a 20-year write-off, from $3.73 to $1.63 per ton of ore. This leaves the competitive advantage with Yukon ore under similar conditions by a margin of $1.38.

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SHIPPING COSTS TO TABATA, JAPAN
(Dollars Per Long Ton)

TABLE 1

Port of Origin	Years Payout	35,400 DWT Rio Class	50,343 DWT Neptune Class	69,000 DWT New Building	100,000 DWT New Building
Haines, Alaska	10	3.98	3.22	2.76	2.46
	15	3.52	2.85	2.45	2.15
	20	3.29	2.67	2.30	1.99
San Juan, Peru	10	7.77	6.26	5.25	4.58
	15	6.88	5.54	4.65	4.01
	20	6.38	5.19	4.36	3.73
Vitoria, Brazil	10	11.55	9.32	7.77	6.72
	15	10.22	8.25	6.89	5.90
	20	9.54	7.71	6.45	5.48
Port Hedland, Australia	10	3.39	2.73	2.33	2.09
	15	3.00	2.42	2.07	1.83
	20	2.82	2.27	1.94	1.70
Haines with Oil Backhaul: Sumatra to San Francisco:					
	10	--	3.06	2.10	1.49
	15	--	2.29	1.46	.86
	20	--	1.92	1.13	.54

SHIPPING COSTS TO TABATA, JAPAN - TABLE 1

Port of Origin	Years Payout	35,400 DWT Rio Class	50,343 DWT Neptune Class	69,000 DWT New Building	100,000 DWT New Building
Haines with Oil Backhaul: Bahrein to San Francisco:					
	10	--	4.10	2.34	1.52
	15	--	3.07	1.47	.68
	20	--	2.55	1.04	.25
San Juan with Oil Backhaul: Sumatra to San Francisco:					
	10	--	5.48	4.28	3.20
	15	--	4.41	3.19	2.33
	20	--	3.88	2.74	1.90
San Juan with Oil Backhaul: Bahrein to San Francisco:					
	10	--	6.15	4.32	3.24
	15	--	4.82	3.20	2.17
	20	--	4.15	2.64	1.63

CREST EXPLORATION LIMITED

SHIPPING COSTS TO SAN FRANCISCO
(Dollars Per Long Ton)

TABLE 2

Port of Origin	Years Payout	35,400 DWT Rio Class	50,343 DWT Neptune Class	69,000 DWT New Building
Haines, Alaska	10	2.72	2.16	1.91
	15	2.37	1.88	1.65
	20	2.19	1.74	1.53
San Juan, Peru	10	3.69	2.96	2.51
	15	3.23	2.60	2.21
	20	3.01	2.42	2.05

SHIPPING COSTS TO LOST ANGELES
(Dollars Per Long Ton)

TABLE 3

Port of Origin	Years Payout	35,400 DWT Rio Class	50,343 DWT Neptune Class	69,000 DWT New Building
Haines, Alaska	10	3.15	2.50	2.18
	15	2.75	2.17	1.89
	20	2.55	2.01	1.74
San Juan, Peru	10	3.39	2.73	2.32
	15	2.98	2.40	2.04
	20	2.78	2.24	1.90

CREST EXPLORATION LIMITED

SHIPPING COSTS TO MOBILE, ALABAMA
(Dollars Per Long Ton)

TABLE 4

Port of Origin	Years Payout	35,400 DWT Rio Class	50,343 DWT Neptune Class	69,000 DWT New Building
Haines, Alaska	10	9.83	8.39	8.51
	15	8.64	7.35	7.43
	20	8.02	6.83	6.92
San Juan, Peru	10	3.38	3.15	3.36
	15	3.03	2.82	3.01
	20	2.84	2.66	2.84
Seven Islands,	10	2.56	2.29	2.26
Quebec	15	2.26	2.01	1.99
	20	2.04	1.87	1.86
Puerto Ordaz,	10	2.42	2.15	2.17
Venezuela	15	2.12	1.89	1.91
	20	1.97	1.77	1.77
Port Etienne,	10	3.81	3.44	3.38
French West	15	3.35	3.03	2.97
Africa	20	3.13	2.83	2.77
Vitoria, Brazil	10	4.55	4.11	4.02
	15	4.01	3.62	3.55
	20	3.73	3.38	3.32

CREST EXPLORATION LIMITED

SHIPPING COSTS TO BALTIMORE, MARYLAND
(Dollars Per Long Ton)

TABLE 5

Port of Origin	Years Payout	35,400 DWT Rio Class	50,343 DWT Neptune Class	69,000 DWT New Building
Haines, Alaska	10	10.48	8.95	9.05
	15	9.18	7.83	7.90
	20	8.52	7.26	7.32
San Juan, Peru	10	3.75	3.47	3.68
	15	3.35	3.11	3.30
	20	3.15	2.77	3.10
Seven Islands, Quebec	10	1.60	1.41	1.40
	15	1.41	1.24	1.23
	20	1.31	1.15	1.14
Puerto Ordaz, Venezuela	10	2.25	2.04	2.01
	15	1.98	1.80	1.75
	20	1.85	1.67	1.63
Port Etienne, French West Africa	10	3.15	2.75	2.71
	15	2.76	2.43	2.40
	20	2.58	2.26	2.23
Vitoria, Brazil	10	4.09	3.60	3.50
	15	3.58	3.17	3.09
	20	3.34	2.96	2.88

CREST EXPLORATION LIMITED

SHIPPING COSTS TO ROTTERDAM, NETHERLANDS
(Dollars Per Long Ton)

TABLE 6

Port of Origin	Years Payout	35,400 DWT Rio Class	50,343 DWT Neptune Class	69,000 DWT New Building
Haines, Alaska	10	8.94	7.87	8.06
	15	7.92	7.00	7.17
	20	7.42	6.56	6.73
San Juan, Peru	10	6.36	5.69	5.87
	15	5.66	5.06	5.25
	20	5.30	4.75	4.93
Seven Islands, Quebec	10	3.11	2.52	2.24
	15	2.74	2.23	1.99
	20	2.57	2.09	1.86
Puerto Ordaz, Venezuela	10	3.96	3.52	3.53
	15	3.47	3.11	3.11
	20	3.26	2.90	2.91
Port Etienne, French West Africa	10	2.36	1.93	2.09
	15	2.10	1.71	1.85
	20	1.97	1.60	1.73
Vitoria, Brazil	10	4.70	3.81	3.39
	15	4.16	3.39	3.00
	20	3.89	3.16	2.82

CREST EXPLORATION LIMITED

SHIPPING COSTS TO PIOMBINO, ITALY
(Dollars Per Long Ton)

TABLE 7

Port of Origin	Years Payout	35,400 DWT Rio Class	50,343 DWT Neptune Class	69,000 DWT New Building
Haines, Alaska	10	9.26	8.17	8.35
	15	8.20	7.28	7.44
	20	7.69	6.81	6.97
San Juan, Peru	10	6.67	5.96	6.14
	15	5.91	5.30	5.48
	20	5.56	4.98	5.15
Seven Islands, Quebec	10	3.67	2.98	3.26
	15	3.25	2.63	2.89
	20	3.04	2.58	2.70
Puerto Ordaz, Venezuela	10	4.82	3.72	3.72
	15	4.34	6.28	3.29
	20	4.09	3.07	3.07
Port Etienne, French West Africa	10	2.15	1.91	1.66
	15	1.91	1.69	1.47
	20	1.80	1.59	1.38
Vitoria, Brazil	10	4.56	3.99	2.53
	15	4.00	3.55	2.33
	20	3.78	3.33	2.23

CREST EXPLORATION LIMITED

SHIPPING COSTS TO PHILADELPHIA, PENNSYLVANIA
(Dollars Per Long Ton)

TABLE 8

Port of Origin	Years Payout	35,400 DWT Rio Class	50,343 DWT Neptune Class	69,000 DWT New Building
San Juan, Peru	10	3.76	3.50	3.62
	15	3.35	3.14	3.25
	20	3.15	2.96	3.06
Seven Islands, Quebec	10	1.48	1.19	1.24
	15	1.31	1.05	1.09
	20	1.22	.98	1.01
Puerto Ordaz, Venezuela	10	2.27	2.02	2.02
	15	2.00	1.76	1.76
	20	1.86	1.65	1.65
Port Etienne, French West Africa	10	3.09	2.49	2.47
	15	2.71	2.19	2.17
	20	2.53	2.04	2.02
Vitoria, Brazil	10	4.06	3.29	3.20
	15	3.57	2.90	2.83
	20	3.33	2.70	2.62

CREST EXPLORATION LIMITED

SHIPPING COSTS TO PHILADELPHIA - MORRISVILLE
(Dollars Per Long Ton)

TABLE 9

Port of Origin	Years Payout	35,400 DWT Rio Class	50,343 DWT Neptune Class	69,000 DWT New Building
San Juan, Peru	10	3.91	3.62	3.75
	15	3.49	3.24	3.36
	20	3.28	3.05	3.17
Seven Islands, Quebec	10	1.61	1.31	1.35
	15	1.42	1.14	1.18
	20	1.33	1.06	1.10
Puerto Ordaz, Venezuela	10	2.42	2.13	2.14
	15	2.12	1.87	1.89
	20	1.98	1.74	1.75
Port Etienne, French West Africa	10	3.21	2.60	2.58
	15	2.84	2.28	2.26
	20	2.63	2.13	2.11
Vitoria, Brazil	10	4.19	3.41	3.32
	15	3.69	2.99	2.92
	20	3.44	2.78	2.72

9. INITIAL AND OPERATING COST ESTIMATES

9. INITIAL AND OPERATING COST ESTIMATES

This section of the report includes order-of-magnitude estimates of initial costs and anticipated operating costs after full production is realised. These estimates are based on the estimated construction costs shown in Section 7 and experience on other projects insofar as operating costs are concerned. It is believed the present estimates are sufficiently accurate for a general evaluation of the project as well as to show the relative magnitude of major cost elements although future planning may show adjustments are desirable.

Certain cost elements were obtained from U.S. sources. In such cases, the costs were converted to Canadian funds on the basis of the October, 1962 midrate of 7-1/8% premium on the U.S. dollar.

The initial costs include construction costs and interest during construction. Start-up costs and operating cash are not included; nor are allowances for exploration of the ore body, metallurgical studies and pilot plant tests nor Owner's administrative costs during exploration and construction. On other similar projects with which we are familiar, Owner's administrative costs have been in the order of 3% of the total project costs. Exploration and metallurgical studies including pilot plant tests have ranged in cost between 10 and 20 million dollars, some 20% of which has been for the metallurgical work. Typically, development work has been spread over 4 to 10 years and the moderate initial expenditures increased as a project took on a more and more favourable aspect.

It has been assumed that the initial production increment of 5 MLTPY capacity will start-up in 1968 as shown on the Production Start-Up Schedule. For the alternates with larger total capacity: the second 5 MLTPY increment has been assumed to start up in 1969, the 3rd increment in 1971 and the 4th increment in 1973. The rate at which these successive increments are assumed to go into operation has been dictated primarily by marketing factors. To meet the start-up dates, it is estimated that construction will have to proceed as shown in the Schedule of Capital Investment and the accompanying graphs titled Schedule of Cumulative Investment.

The build-up of interest during construction is shown for each alternate on the Investment Interest Schedule. In preparing this build-up, allowance for interest during construction has been terminated for each production increment as that increment starts operating.

In calculating the capital charges shown in the tables, it has been assumed that the initial investment will be written off completely in 20 years from the start-up of the last production increment for each alternate, with interest at 5-1/2%. Shorter life equipment such as mobile units and railroad rolling stock has been amortised over its estimated useful life.

Escalation of capital costs has been calculated on the basis of a 2-1/2% per year increase from January, 1963 to the time of expenditure as shown in the Schedule of Capital Investment. Escalation of operating costs has been calculated on the basis of a 2-1/2% per year increase from January, 1963 to the date upon which full production is attained as shown in the Production Start-Up Schedule.

The breakdown sheets of Operating and Maintenance Labor Costs show the estimated number of employees in each major production operation and the total annual wage costs. Estimated labor costs reflect the labor rates shown in the Summary of Payroll Costs. Facility requirements and operating costs are based on 18 shifts per week throughout the year for mining and 21 shifts per week for beneficiation and rail haul. A 6 day, 48 hour week has been assumed for all personnel. Current practice at remote mining developments in the Northwest is to work a 48 hour week with 40 or 44 hours on a straight-time basis.

The Operating and Maintenance Supply Costs; Indirect, Administration and Overhead Costs; and Power Requirements and Operating Costs are based on experience of other projects adjusted to reflect conditions at the Yukon ore project. No allowance has been included for taxes other than payroll taxes.

Capital costs and operating costs for ocean shipping to Japan are based on use of 69,000 DWT vessels. Vessels of this size retain flexibility in that they can enter most major ports, whereas vessels of 100,000 DWT are quite restricted in the ports they can utilise.

There is as yet no sound basis for rational assessment of the project uncertainties. In consequence, no contingency allowance is shown in the estimated costs.

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

SUMMARY OF ESTIMATED COSTS

10 MILLION LONG TONS OF GRANULAR CONCENTRATES PER YEAR

	OPERATING & MAINTENANCE COSTS					CAPITAL COSTS				TOTAL COSTS		
	Annual Cost (Millions Dollars)											
	Labor	Supplies & Utilities	Total	Per L Ton	Percent	Initial Capital Investment (Millions	Annual[1] Fixed Cost Dollars)	Per L Ton	Percent	Annual (Millions Dollars	Per L Ton	Percent
Mining & Hauling to Concentrator	4.70	4.50	9.20	0.92	17.9	28.3	3.50	0.35	7.0	12.70	1.27	12.5
Ore Processing & Loading	2.61	11.58	14.19	1.42	27.6	82.0	6.86	0.69	13.6	21.05	2.11	20.7
Railroad Transportation to Port	8.56	14.19	22.75	2.28	44.3	357.2	32.83	3.28	65.2	55.58	5.56	54.7
Port-Handling & Shiploading	0.55	0.25	0.80	0.08	1.6	26.3	2.20	0.22	4.4	3.00	0.30	2.9
Subtotal - Direct Costs	16.42	30.52	46.94	4.70	91.4	493.8	45.39	4.54	90.2	92.33	9.24	90.8
Utilities	(Distributed to other accounts)					20.3	1.70	0.17	3.4	1.70	0.17	1.7
Indirect, Admin. & Overhead	1.45	2.99	4.44	0.44	8.6	37.9	3.25	0.32	6.4	7.69	0.76	7.5
Subtotal - F.O.B. Vessel	17.87	33.51	51.38	5.14	100.0%	552.0	50.34	5.03	100.0%	101.72	10.17	100.0%
Interest During Construction[2]						61.6	5.15	0.52		5.15	0.52	
Total Estimated Cost F.O.B. Vessel			51.38	5.14		613.6	55.49	5.55		106.87	10.69	
Freight - Skagway to Japan[3]			16.08	1.61		94.7[5]	7.92	0.79		24.00	2.40	
Total - C.I.F. Japan - January 1963			67.46	6.75		708.3	63.41	6.34		130.87	13.09	
Total - C.I.F. Japan - July 1969[4]			78.42	7.84		774.9	69.37	6.94		147.79	14.78	

1 Annual Fixed Cost based on actual life with 20 year maximum and interest at 5-1/2%.
2 Based on 5-1/2% on invested capital to July 1969.
3 Based on foreign flag 69,000 DWT class vessels.
4 Operating costs escalated to July 1969 at 2-1/2% per year. Capital costs escalated to date of expenditure.
5 Includes interest during construction (one year at 5-1/2%).

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

SUMMARY OF ESTIMATED COSTS

5 MILLION LONG TONS OF GRANULAR CONCENTRATES PER YEAR

	OPERATING & MAINTENANCE COSTS					CAPITAL COSTS				TOTAL COSTS		
	Annual Cost (Millions Dollars)											
	Labor	Supplies & Utilities	Total	Per L Ton	Percent	Initial Capital Investment (Millions	Annual[1] Fixed Cost Dollars)	Per L Ton	Percent	Annual (Millions Dollars)	Per L Ton	Percent
Mining & Hauling to Concentrator	2.61	2.32	4.93	0.98	15.8	17.1	2.34	0.47	5.6	7.27	1.45	10.0
Ore Processing & Loading	1.42	5.85	7.27	1.46	23.4	50.2	4.20	0.84	10.1	11.47	2.30	15.7
Railroad Transportation to Port	5.90	9.43	15.33	3.07	49.3	333.0	29.66	5.93	71.0	44.99	9.00	61.7
Port-Handling & Shiploading	0.41	0.13	0.54	0.11	1.7	23.2	1.94	0.39	4.6	2.48	0.50	3.4
Subtotal - Direct Costs	10.34	17.73	28.07	5.62	90.2	423.5	38.14	7.63	91.3	66.21	13.25	90.8
Utilities	(Distributed to other accounts)					17.7	1.48	0.30	3.5	1.48	0.30	2.0
Indirect, Admin. & Overhead	1.07	1.99	3.06	0.61	9.8	25.1	2.17	0.43	5.2	5.23	1.04	7.2
Subtotal - F.O.B. Vessel	11.41	19.72	31.13	6.23	100.0%	466.3	41.79	8.36	100.0%	72.92	14.59	100.0%
Interest during Construction[2]						57.9	4.85	0.97		4.85	0.97	
Total Estimated Cost F.O.B. Vessel			31.13	6.23		524.2	46.64	9.33		77.77	15.56	
Freight - Skagway to Japan[3]			8.05	1.61		47.4[5]	3.97	0.79		12.02	2.40	
Total - C.I.F. Japan - January 1963			39.18	7.84		571.6	50.61	10.12		89.79	17.96	
Total - C.I.F. Japan - July 1968[4]			44.57	8.91		620.8	54.96	10.99		99.53	19.90	

1 Annual Fixed Cost based on actual life with 20 year maximum and interest of 5-1/2%.
2 Based on 5-1/2% on invested capital to July 1968.
3 Based on foreign flag 69,000 DWT class vessels.
4 Operating costs escalated to July 1968 at 2-1/2% per year. Capital costs escalated to date of expenditure.
5 Includes interest during construction (one year at 5-1/2%).

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

SUMMARY OF ESTIMATED COSTS

20 MILLION LONG TONS OF GRANULAR CONCENTRATES PER YEAR

	OPERATING & MAINTENANCE COSTS					CAPITAL COSTS				TOTAL COSTS		
	Annual Cost (Millions Dollars)											
	Labor	Supplies & Utilities	Total	Per L Ton	Percent	Initial Capital Investment (Millions	Annual[1] Fixed Cost Dollars)	Per L Ton	Percent	Annual (Millions Dollars)	Per L Ton	Percent
Mining & Hauling to Concentrator	8.22	8.93	17.15	0.86	19.2	42.0	5.65	0.28	8.4	22.80	1.14	14.6
Ore Processing & Loading	4.92	21.92	26.84	1.34	30.1	138.6	11.60	0.58	17.2	38.44	1.92	24.5
Railroad Transportation to Port	12.77	24.57	37.34	1.86	41.9	417.2	40.04	2.00	59.4	77.38	3.87	49.4
Port-Handling & Shiploading	0.88	0.50	1.38	0.07	1.5	32.5	2.72	0.14	4.0	4.10	0.20	2.6
Subtotal - Direct Costs	26.79	55.92	82.71	4.13	92.7	630.3	60.01	3.00	89.0	142.72	7.13	91.1
Utilities	(Distributed to other accounts)					27.8	2.33	0.12	3.5	2.33	0.12	1.5
Indirect, Admin. & Overhead	1.93	4.60	6.53	0.33	7.3	59.5	5.05	0.25	7.5	11.58	0.58	7.4
Subtotal - F.O.B. Vessel	28.72	60.52	89.24	4.46	100.0%	717.6	67.39	3.37	100.0%	156.63	7.83	100.0%
Interest During Construction[2]						70.9	5.93	0.30		5.93	0.30	
Total Estimated Cost F.O.B. Vessel			89.24	4.46		788.5	73.32	3.67		162.56	8.13	
Freight - Skagway to Japan[3]			32.14	1.61		190.0[5]	15.90	0.79		48.04	2.40	
Total - C.I.F. Japan - January 1963			121.38	6.07		978.5	89.22	4.46		210.60	10.53	
Total - C.I.F. Japan - July 1973[4]			153.24	7.66		1,097.2	100.04	5.00		253.28	12.66	

1 Annual Fixed Cost based on actual life with 20 year maximum and interest at 5-1/2%.
2 Based on 5-1/2% on invested capital to July 1973.
3 Based on foreign flag 69,000 DWT class vessels.
4 Operating costs escalated to July 1973 at 2-1/2% per year. Capital costs escalated to date of expenditure.
5 Includes interest during construction (one year at 5-1/2%).

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

SUMMARY OF ESTIMATED COSTS

10 MILLION LONG TONS OF PELLETS PER YEAR

	OPERATING & MAINTENANCE COSTS					CAPITAL COSTS				TOTAL COSTS		
	Annual Cost (Millions Dollars)											
	Labor	Supplies & Utilities	Total	Per L Ton	Percent	Initial Capital Investment (Millions	Annual Fixed Cost Dollars)[1]	Per L Ton	Percent	Annual (Millions Dollars)	Per L Ton	Percent
Mining & Hauling to Concentrator	4.70	4.46	9.16	0.92	13.1	28.3	3.50	0.35	5.7	12.66	1.27	9.6
Ore Processing & Loading	3.86	27.31	31.17	3.12	44.7	181.7	15.20	1.52	24.9	46.37	4.64	35.5
Railroad Transportation to Port	8.56	14.19	22.75	2.27	32.6	361.9	33.45	3.35	54.9	56.20	5.62	43.0
Port-Handling & Shiploading	0.55	0.25	0.80	0.08	1.2	26.3	2.20	0.22	3.6	3.00	0.30	2.3
Subtotal - Direct Costs	17.67	46.21	63.88	6.39	91.6	598.2	54.35	5.43	89.1	118.23	11.82	90.4
Utilities	(Distributed to other accounts)					34.2	2.86	0.29	4.7	2.86	0.29	2.2
Indirect, Admin. & Overhead	1.85	4.04	5.89	0.59	8.4	44.3	3.78	0.38	6.2	9.67	0.97	7.4
Subtotal - F.O.B. Vessel	19.52	50.25	69.77	6.98	100.0%	676.7	60.99	6.10	100.0%	130.76	13.08	100.0%
Interest During Construction[2]						75.1	6.28	0.63		6.28	0.63	
Total Estimated Cost F.O.B. Vessel			69.77	6.98		751.8	67.27	6.73		137.04	13.71	
Freight - Skagway to Japan[3]			16.08	1.61		94.7[5]	7.92	0.79		24.00	2.40	
Total - C.I.F. Japan - January 1963			85.85	8.59		846.5	75.19	7.52		161.04	16.11	
Total - C.I.F. Japan - July 1969[4]			99.80	9.98		926.7	82.31	8.23		182.11	18.21	

1 Annual Fixed Cost based on actual life with 20 year maximum and interest at 5-1/2%.
2 Based on 5-1/2% on invested capital to July 1969.
3 Based on foreign flag 69,000 DWT class vessels.
4 Operating costs escalated to July 1969 at 2-1/2% per year. Capital costs escalated to date of expenditure.
5 Includes interest during construction (one year at 5-1/2%).

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

SUMMARY OF ESTIMATED COSTS

5 MILLION LONG TONS OF PELLETS PER YEAR

	OPERATING & MAINTENANCE COSTS					CAPITAL COSTS				TOTAL COSTS		
	Annual Cost (Millions Dollars)											
	Labor	Supplies & Utilities	Total	Per L Ton	Percent	Initial Capital Investment (Millions	Annual[1] Fixed Cost Dollars)	Per L Ton	Percent	Annual (Millions Dollars)	Per L Ton	Percent
Mining & Hauling to Concentrator	2.61	2.31	4.92	0.98	12.2	17.1	2.34	0.47	5.0	7.26	1.45	8.3
Ore Processing & Loading	2.03	13.77	15.80	3.16	39.2	103.6	8.67	1.73	18.4	24.47	4.89	28.0
Railroad Transportation to Port	5.90	9.43	15.33	3.07	38.1	334.3	29.83	5.96	63.3	45.16	9.03	51.7
Port-Handling & Shiploading	0.41	0.13	0.54	0.11	1.3	23.2	1.94	0.39	4.1	2.48	0.50	2.8
Subtotal - Direct Costs	10.95	25.64	36.59	7.32	90.8	478.2	42.78	8.55	90.8	79.37	15.87	90.8
Utilities	(Distributed to other accounts)					22.6	1.89	0.38	4.0	1.89	0.38	2.2
Indirect, Admin. & Overhead	1.32	2.39	3.71	.74	9.2	28.3	2.44	0.49	5.2	6.15	1.23	7.0
Subtotal - F.O.B. Vessel	12.27	28.03	40.30	8.06	100.0%	529.1	47.11	9.42	100.0%	87.41	17.48	100.0%
Interest During Construction[2]						69.9	5.85	1.17		5.85	1.17	
Total Estimated Cost F.O.B. Vessel			40.30	8.06		599.0	52.96	10.59		93.26	18.65	
Freight - Skagway to Japan[3]			8.05	1.61		47.4[5]	3.97	0.79		12.02	2.40	
Total - C.I.F. Japan - January 1963			48.35	9.67		646.4	56.93	11.38		105.28	21.05	
Total - C.I.F. Japan - July 1968[4]			55.00	11.00		699.2	61.58	12.32		116.58	23.32	

[1] Annual Fixed Cost based on actual life with 20 year maximum and interest of 5-1/2%.
[2] Based on 5-1/2% on invested capital to July 1968.
[3] Based on foreign flag 69,000 DWT class vessels.
[4] Operating costs escalated to July 1968 at 2-1/2% per year. Capital costs escalated to date of expenditure.
[5] Includes interest during construction (one year at 5-1/2%).

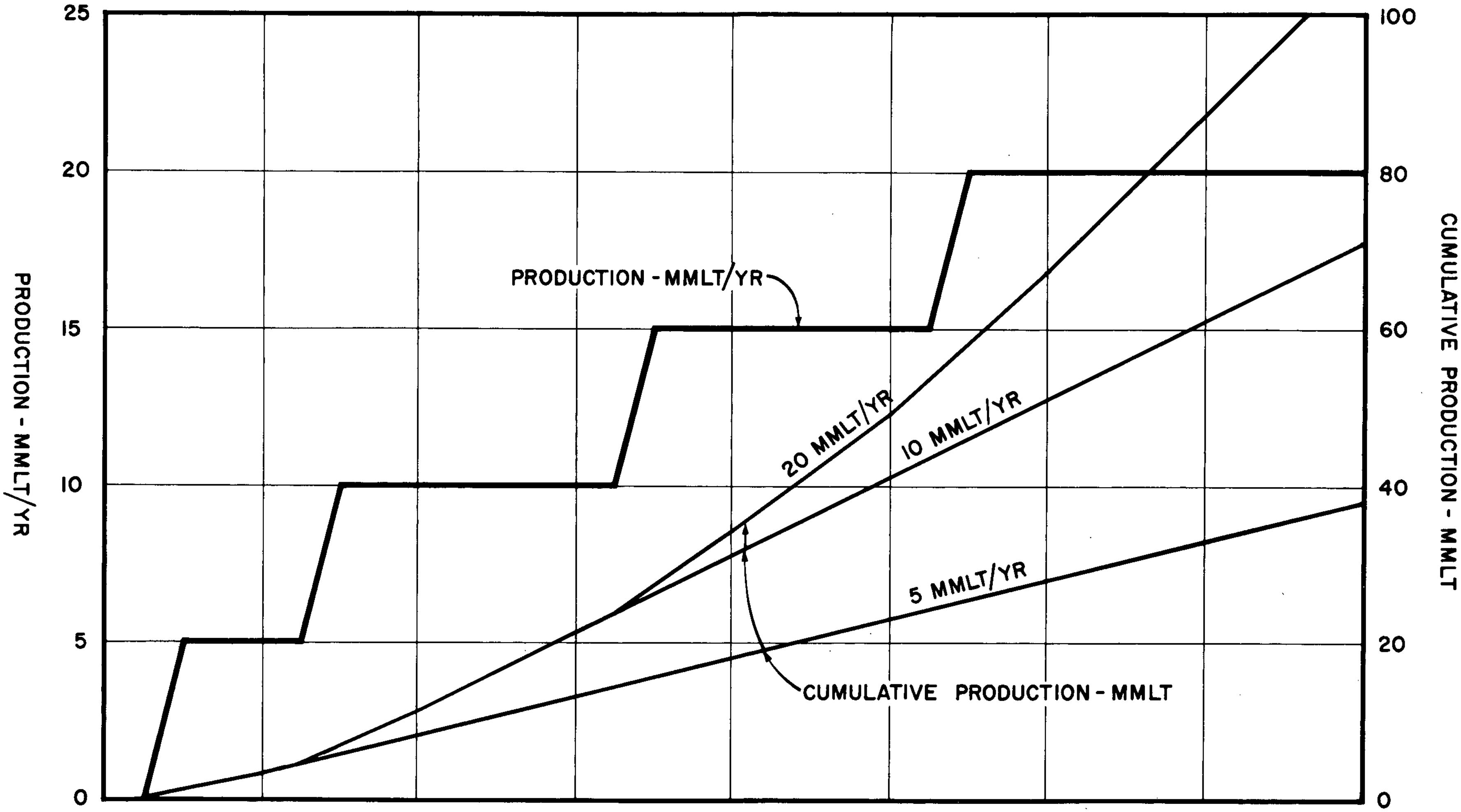
CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

SUMMARY OF ESTIMATED COSTS

20 MILLION LONG TONS OF PELLETS PER YEAR

	OPERATING & MAINTENANCE COSTS					CAPITAL COSTS				TOTAL COSTS		
	Annual Cost (Millions Dollars)											
	Labor	Supplies & Utilities	Total	Per L Ton	Percent	Initial Capital Investment (Millions	Annual[1] Fixed Cost Dollars)	Per L Ton	Percent	Annual (Millions Dollars)	Per L Ton	Percent
Mining & Hauling to Concentrator	8.22	8.90	17.12	0.86	13.6	42.0	5.65	0.28	6.5	22.77	1.14	10.7
Ore Processing & Loading	7.42	54.29	61.71	3.09	48.9	328.6	27.50	1.37	31.8	89.21	4.46	41.9
Railroad Transportation to Port	12.77	24.57	37.34	1.86	29.6	422.4	40.73	2.04	47.1	78.07	3.90	36.7
Port-Handling & Shiploading	0.88	0.50	1.38	0.07	1.1	32.5	2.72	0.14	3.2	4.10	0.21	2.0
Subtotal - Direct Costs	29.29	88.22	117.55	5.88	93.2	825.5	76.60	3.83	88.6	194.15	9.71	91.3
Utilities	(Distributed to other accounts)					47.0	3.93	0.20	4.5	3.93	0.20	1.9
Indirect, Admin. & Overhead	2.59	5.94	8.53	0.42	6.8	70.4	5.97	0.30	6.9	14.50	0.72	6.8
Subtotal - F.O.B. Vessel	31.88	94.20	126.08	6.30	100.0%	942.9	86.50	4.33	100.0%	212.58	10.63	100.0%
Interest During Construction[2]						90.5	7.57	0.38		7.57	0.38	
Total Estimated Cost F.O.B. Vessel			126.08	6.30		1,033.4	94.07	4.71		220.15	11.01	
Freight - Skagway to Japan[3]			32.14	1.61		190.0[5]	15.90	0.79		48.04	2.40	
Total - C.I.F. Japan - January 1963			158.22	7.91		1,223.4	109.97	5.50		268.19	13.41	
Total - C.I.F. Japan - July 1973[4]			199.75	9.99		1,381.4	124.17	6.21		323.92	16.20	

1 Annual Fixed Cost based on actual life with 20 year maximum and interest at 5-1/2%.
2 Based on 5-1/2% on invested capital to July 1973.
3 Based on foreign flag 69,000 DWT class vessels.
4 Operating costs escalated to July 1973 at 2-1/2% per year. Capital costs escalated to date of expenditure.
5 Includes interest during construction (one year at 5-1/2%).



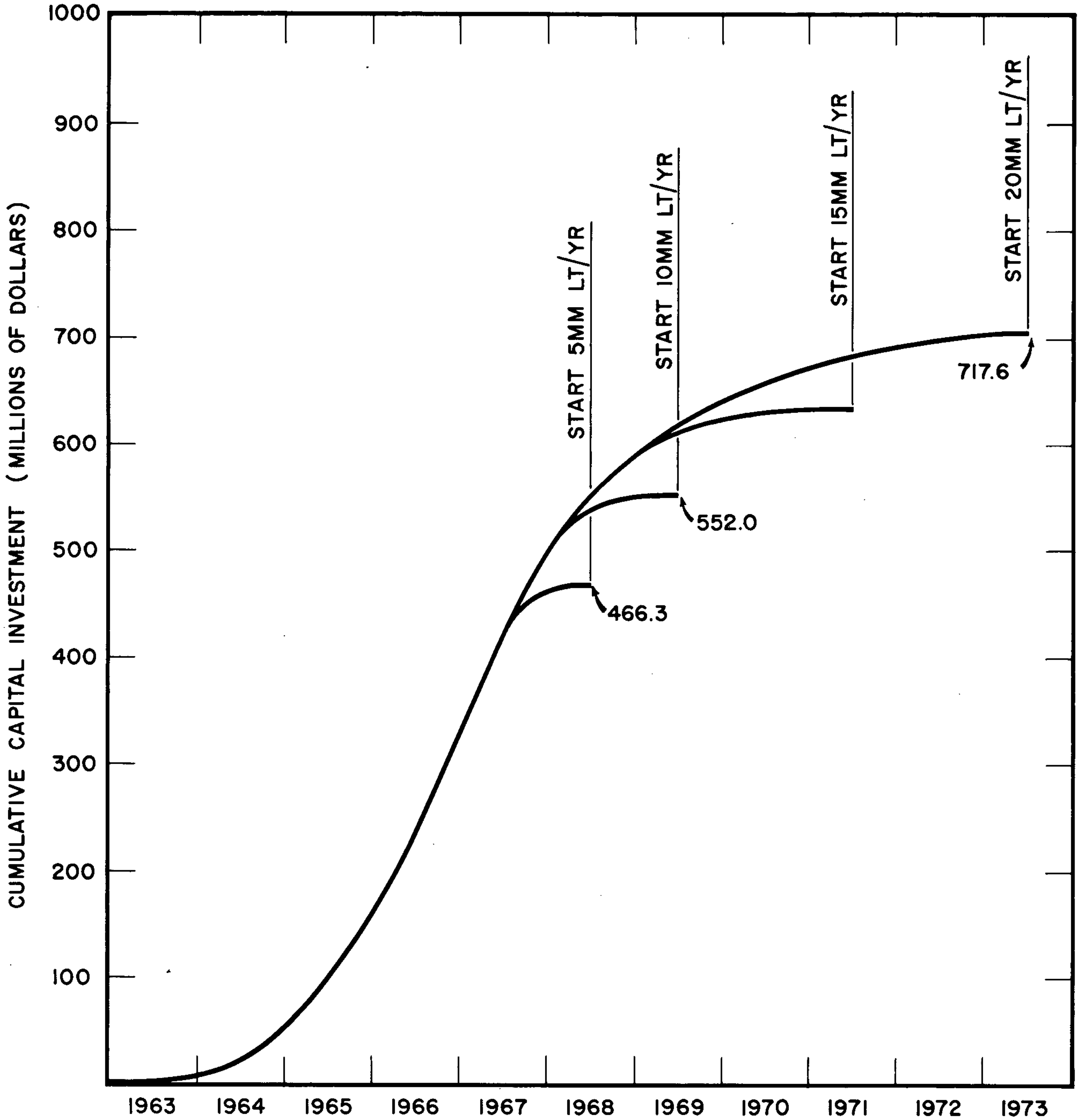
CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

PRODUCTION START-UP SCHEDULE

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

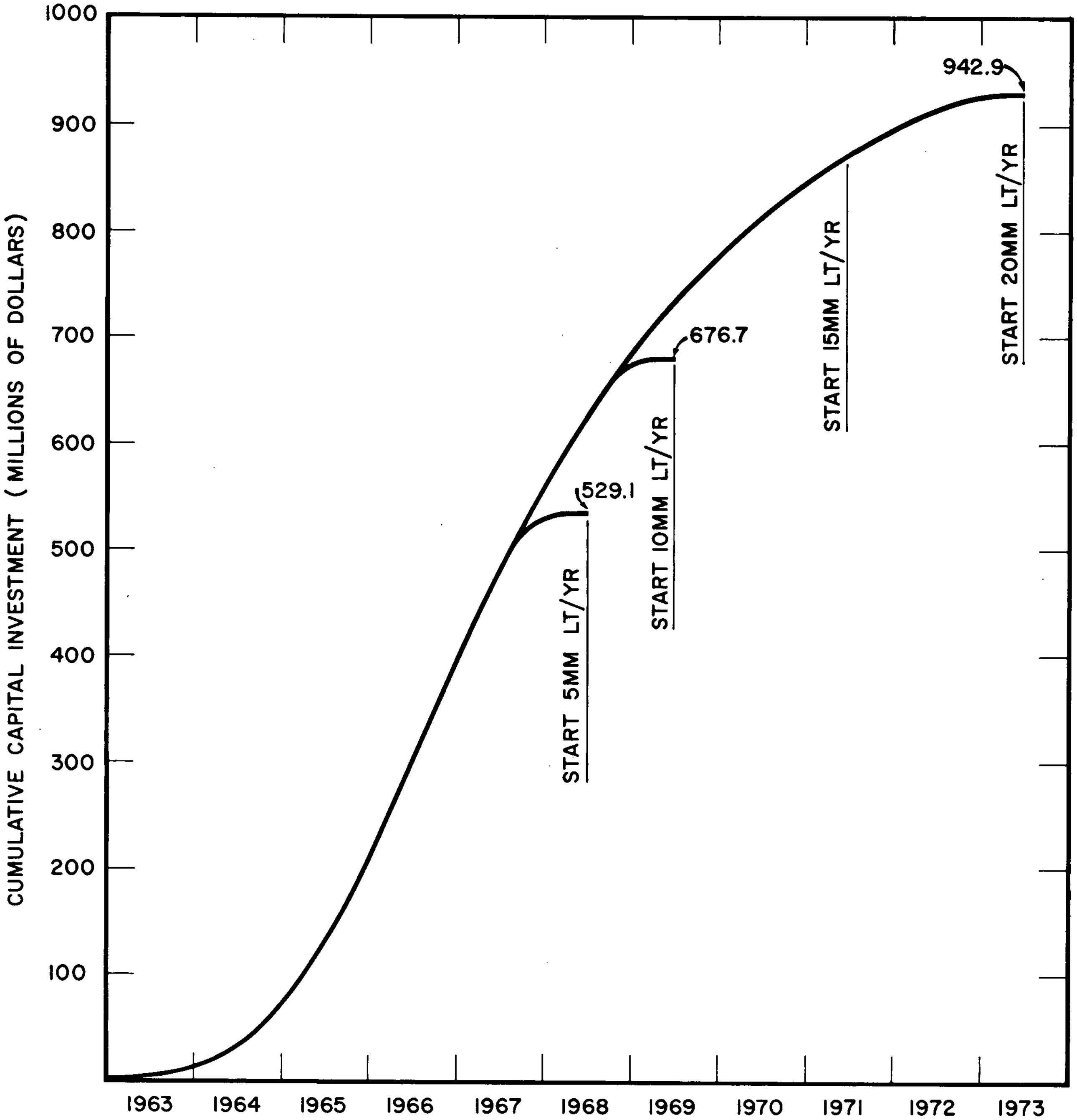
SCHEDULE OF CAPITAL INVESTMENT
(Millions Dollars)

Year	GRANULAR CONCENTRATES 5 MMLT/Yr. During Year	GRANULAR CONCENTRATES 5 MMLT/Yr. Cumu. To Date	GRANULAR CONCENTRATES 10 MMLT/Yr. During Year	GRANULAR CONCENTRATES 10 MMLT/Yr. Cumu. To Date	GRANULAR CONCENTRATES 20 MMLT/Yr. During Year	GRANULAR CONCENTRATES 20 MMLT/Yr. Cumu. To Date	PELLETS 5 MMLT/Yr. During Year	PELLETS 5 MMLT/Yr. Cumu. To Date	PELLETS 10 MMLT/Yr. During Year	PELLETS 10 MMLT/Yr. Cumu. To Date	PELLETS 20 MMLT/Yr. During Year	PELLETS 20 MMLT/Yr. Cumu. To Date
1963	15		15	15	15	15	20	20	20	20	20	20
1964	35	50	35	50	35	50	50	70	50	70	50	70
1965	110	160	110	160	110	160	140	210	140	210	140	210
1966	170	330	170	330	170	330	190	400	190	400	190	400
1967	135	465	170	500	170	500	125	525	155	555	155	555
1968	1.3	466.3	50	550	90	590	4.1	529.1	115	670	125	680
1969			2.0	552.0	50	640			6.7	676.7	90	770
1970					37	677					75	845
1971					24	701					55	900
1972					13	714					35	935
1973					3.6	717.6					7.9	942.9



CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

SCHEDULE OF CUMULATIVE CAPITAL INVESTMENT
GRANULAR CONCENTRATES



CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

SCHEDULE OF CUMULATIVE CAPITAL INVESTMENT
PELLETS

CREST EXPLORATION LIMITED

YUKON IRON ORE PRELIMINARY EVALUATION

INVESTMENT INTEREST SCHEDULE

(Millions Dollars)

GRANULAR CONCENTRATES

Ultimate Production	20 MM LT/YR					10 MM LT/YR			5 MM LT/YR
Production Staging	5 MM	10 MM	15 MM	20 MM	Total	5 MM	10 MM	Total	Total 5 MM
Starting Date for 1/ Interest Payout	7/68	7/69	7/71	7/73		7/68	7/69		7/68
Total Interest 2/ (MM Dollars)	61.1	2.6	5.1	2.1	70.9	61.0	0.6	61.6	57.9
Annual Payment 3/									
1967									
1968	2.56				2.56	2.55		2.55	2.43
1969	5.11	.11			5.22	5.10	.03	5.13	4.85
1970	5.11	.22			5.33	5.10	.05	5.15	4.85
1971	5.11	.22	.22		5.55	5.10	.05	5.15	
1972	5.11	.22	.43		5.76				
1973	5.11	.22	.43	.09	5.85				
1974	5.11	.22	.43	.17	5.93				
1975	5.11	.22	.43	.17	5.93				

PELLETS

Ultimate Production	20 MM LT/YR					10 MM LT/YR			5 MM LT/YR
Production Staging	5 MM	10 MM	15 MM	20 MM	Total	5 MM	10 MM	Total	Total 5 MM
Starting Date for 1/ Interest Payout	7/68	7/69	7/71	7/73		7/68	7/69		7/68
Total Interest 2/ (MM Dollars)	72.3	3.9	9.5	4.8	90.5	72.3	2.8	75.1	69.9
Annual Payment 3/									
1967									
1968	3.03				3.03	3.03		3.03	2.93
1969	6.05	.16			6.21	6.05	.12	6.17	5.85
1970	6.05	.32			6.37	6.05	.23	6.28	5.85
1971	6.05	.32	.40		6.77	6.05	.23	6.28	
1972	6.05	.32	.79		7.16				
1973	6.05	.32	.79	.21	7.37				
1974	6.05	.32	.79	.41	7.57				
1975	6.05	.32	.79	.41	7.57				

Notes: 1/ Payment Starts When Full Production of Applicable Stage Starts.

2/ Interest at 5-1/2%

3/ Annual Payment Computed at 5-1/2% for 20 Years.

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

OPERATING AND MAINTENANCE LABOR COSTS
(MILLIONS DOLLARS PER YEAR)

GRANULAR CONCENTRATES

	5 MMLT/YR		10 MMLT/YR		20 MMLT/YR	
	Number Employees	Cost	Number Employees	Cost	Number Employees	Cost
Mining & Hauling to Concentrator						
Salaried	44	.318	66	.473	102	.701
Bargaining Unit	298	2.290	550	4.227	974	7.515
TOTAL	342	2.608	616	4.700	1,076	8.216
Ore Processing and Loading						
Salaried	10	.122	16	.170	23	.262
Bargaining Unit	160	1.299	305	2.438	583	4.661
TOTAL	170	1.421	321	2.608	606	4.923
Railroad Transportation to Port						
Salaried	106	1.255	139	1.615	180	2.039
Bargaining Unit	422	3.764	757	5.793	1,168	9.284
Summer Employees	308	.884	412	1.151	502	1.457
TOTAL	836	5.903	1,308	8.559	1,850	12.780
Port Handling and Shiploading						
Salaried	2	.035	3	.045	4	.055
Bargaining Unit	45	.378	59	.506	98	.806
TOTAL	47	.413	62	.551	102	.861
Indirect, Administration and Overhead						
Salaried	84	.840	107	1.070	130	1.300
Bargaining Unit	32	.233	50	.378	80	.625
TOTAL	116	1.073	157	1.448	210	1.925

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

OPERATING AND MAINTENANCE LABOR COSTS
(MILLIONS DOLLARS PER YEAR)

PELLETS

	5 MMLT/YR		10 MMLT/YR		20 MMLT/YR	
	Number Employees	Cost	Number Employees	Cost	Number Employees	Cost
Mining & Hauling to Concentrator						
Salaried	44	.318	66	.473	102	.701
Bargaining Unit	298	2.290	550	4.227	974	7.515
TOTAL	342	2.608	616	4.700	1,076	8.216
Ore Processing and Loading						
Salaried	11	.134	19	.224	29	.360
Bargaining Unit	240	1.398	465	3.635	903	7.055
TOTAL	251	1.532	484	3.859	932	7.415
Railroad Transportation to Port						
Salaried	106	1.255	139	1.615	180	2.039
Bargaining Unit	422	3.764	759	5.793	1,168	9.284
Summer Employees	308	.884	412	1.151	502	1.457
TOTAL	836	5.903	1,310	8.559	1,850	12.780
Port Handling and Shiploading						
Salaried	2	.035	3	.045	4	.055
Bargaining Unit	45	.378	59	.506	98	.806
TOTAL	47	.413	62	.551	102	.861
Indirect Administration and Overhead						
Salaried	96	.960	120	1.200	143	1.430
Bargaining Unit	46	.363	81	.649	140	1.156
TOTAL	142	1.323	201	1.849	283	2.586

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

SUMMARY OF PAYROLL COSTS (DOLLARS)

(a) Job Class	(b) Shifts/ Day	(c) Days/ Week	(d) Weeks/ Year	(e) Hours/ Year	(f) Base Rate	(g) Adj. Base Rate	(h) Hours Worked/ Week/ Empl.	(i) Wages/ Week/ Empl.	(j) Wages/ Year Empl. (d)x(i)	(k) Holiday Premium	(l) Total Wages/ Empl./ Year (j)+(k)	(m) Work-man's Comp.	(n) U.I.C.	(o) Total Cost/ Empl./ Year (l)+(m)+(n)	(p) Hours Worked/ Empl. / Year	(q) No. Emp. Required by Schedule (e)÷(p)	(r) Total cost to cover Schedule (q)x(o)
1	3	7	52	8,736	3.50	3.55	48	185	9,620	341	9,961	160	48	10,169	2,352	3,714	37,768
(Foreman,	3	6	52	7,488	3.50	3.55	48	185	9,620	341	9,961	160	48	10,169	2,352	3.184	32,378
Railroad	1	6	52	2,496	3.50	3.50	48	182	9,464	336	9,800	160	48	10,008	2,352	1,061	10,618
Engineers)	1	6	22	1,056	3.50	3.50	48	182	4,004	328	4,332	67	35	4,434	1,056	(s)	4,434
2	3	7	52	8,736	3.25	3.30	48	172	8,944	317	9,261	160	48	9,469	2,352	3.714	35,168
(Operators,	2	7	52	5,824	3.25	3.30	48	172	8,944	317	9,261	160	48	9,469	2,352	2.476	23,445
1st Class	2	6	52	4,992	3.25	3.30	48	172	8,944	317	9,261	160	48	9,469	2,352	2.122	20,093
Maintenance)	1	6	52	2,496	3.25	3.25	48	169	8,788	312	9,100	160	48	9,308	2,352	1.061	9,876
3	3	7	52	8,736	3.00	3.05	48	159	8,268	293	8,561	160	48	8,769	2,352	3.714	32,568
(Railroad	2	7	52	5,824	3.00	3.05	48	159	8,268	293	8,561	160	48	8,769	2,352	2.476	21,712
Brakeman,	1	6	52	2,496	3.00	3.00	48	156	8,112	288	8,400	160	48	8,608	2,352	1.061	9,133
Conductors)	1	6	22	1,056	3.00	3.00	48	156	3,432	281	3,713	67	30	3,810	1,056	(s)	3,810
4	3	7	52	8,736	2.65	2.70	48	140	7,280	259	7,539	160	48	7,747	2,352	3.714	28,772
(Maintenance	2	7	52	5,824	2.65	2.70	48	140	7,280	259	7,539	160	48	7,747	2,352	2.476	19,182
and Operator	2	6	52	4,992	2.65	2.70	48	140	7,280	259	7,539	160	48	7,747	2,352	2.122	16,439
Helpers)	1	6	52	2,496	2.65	2.65	48	138	7,176	254	7,430	160	48	7,638	2,352	1.061	8,104
	1	6	22	1,056	2.65	2.65	48	138	3,036	249	3,285	67	26	3,378	1,056	(s)	3,378
5	3	7	52	8,736	2.30	2.35	48	122	6,344	226	6,570	160	48	6,778	2,352	3.714	25,173
(Laborers)	2	7	52	5,824	2.30	2.35	48	122	6,344	226	6,570	160	48	6,778	2,352	2.476	16,782
	2	6	52	4,992	2.30	2.35	48	122	6,344	226	6,570	160	48	6,778	2,352	2.122	14,383
	1	6	52	2,496	2.30	2.30	48	120	6,240	221	6,461	160	48	6,669	2,352	1.061	7,076
	1	6	22	1,056	2.30	2.30	48	120	2,640	216	2,856	67	23	2,946	1,056	(s)	2,946

FOOTNOTES FOR TABLE

(g) Includes shift differential of $.05/hr for afternoon and $.09/hr midnight.
(i) Overtime over 40 hrs. at 1-1/2 adjusted base.
(j) Includes vacation pay at average pay rate.
(k) Premium for 8 holidays at 1-1/2 times adjusted base for all-year employees. Four holidays plus 4% vacation allowance for summer employees.
(m) Based on 4% of $333.33/mo. base.
(n) Based on 0.8% of $6000/yr base.
(p) Average vacation deduction is 3 weeks for all year employees.
(s) Summer Employee.

NOTE:

Following items are not included:

Pension
Sick Leave
Medical Insurance - Company paid doctors and hospital.
Subsistence - Partial subsidy included in Personnel Amenities
Travel Allowance - Included in Personnel Ammenities.

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

OPERATING AND MAINTENANCE SUPPLY COSTS
(MILLIONS DOLLARS PER YEAR)

GRANULAR CONCENTRATE PRODUCTION

	5 MMLT/YR				10 MMLT/YR				20 MMLT/YR			
	Power	Fuel	Misc.	Total	Power	Fuel	Misc.	Total	Power	Fuel	Misc.	Total
Mining & Hauling to Concentrator	.09	.27	1.96	2.32	.16	.49	3.85	4.50	.25	.98	7.70	8.93
Ore Processing & Loading	.79	.70	4.36	5.85	1.45	1.40	8.73	11.58	2.45	2.81	16.66	21.92
Railroad Transp. to Port	.09	2.31	7.03	9.43	.12	3.94	10.13	14.19	.13	7.28	17.16	24.57
Port Handling & Shiploading	.05		.08	.13	.10		.15	.25	.20		.30	.50
Total Direct	1.02	3.28	13.43	17.73	1.83	5.83	22.86	30.52	3.03	11.07	41.82	55.92
Utilities	Distributed to other account											
Indirect, Admin. & Overhead	.03	.17	1.79	1.99	.05	.25	2.69	2.99	.06	.34	4.20	4.60
TOTAL	1.05	3.45	15.22	19.72	1.88	6.08	25.55	33.51	3.09	11.41	46.02	60.52

PELLET PRODUCTION

	5MMLT/YR				10 MMLT/YR				20 MMLT/YR			
	Power	Fuel	Misc.	Total	Power	Fuel	Misc.	Total	Power	Fuel	Misc.	Total
Mining & Hauling to Concentrator	.08	.27	1.96	2.31	.12	.49	3.85	4.46	.22	.98	7.70	8.90
Ore Processing & Loading	2.25	2.11	9.41	13.77	4.25	4.23	18.83	27.31	8.20	8.46	37.63	54.29
Railroad Transp. to Port	.09	2.31	7.03	9.43	.12	3.94	10.13	14.19	.13	7.28	17.16	24.57
Port Handling & Shiploading	.05		.08	.13	.10		.15	.25	.20		.30	.50
Total Direct	2.47	4.69	18.48	25.64	4.59	8.66	32.96	46.21	8.75	16.72	62.79	88.26
Utilities	Distributed to other accounts											
Indirect, Admin. & Overhead	.03	.19	2.17	2.39	.37	.28	3.39	4.04	.05	.38	5.51	5.94
TOTAL	2.50	4.88	20.65	28.03	4.96	8.94	36.35	50.25	8.80	17.10	68.30	94.20

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

INDIRECT, ADMINISTRATION AND OVERHEAD COSTS
(THOUSANDS DOLLARS PER YEAR)

	5 MMLT/YR				10 MMLT/YR				20 MMLT/YR			
	Labor		Maint. &		Labor		Maint. &		Labor		Maint. &	
	No. Empl.	Cost	Oper. Supplies	Total Cost	No. Empl.	Cost	Oper. Supplies	Total Cost	No. Empl.	Cost	Oper. Supplies	Total Cost
Concentrates												
Laboratories												
Port	4	32	10	42	7	52	20	72	10	77	30	107
Mine	6	45	10	55	11	89	20	109	22	178	40	218
Supply Transports' Handling	23	166	178	344	33	247	348	595	50	390	700	1,090
General Administration	83	830	508	1,338	106	1,060	585	1,645	128	1,280	662	1,942
Personnel Amenities			1,082	1,082			1,712	1,712			2,770	2,770
Power			33	33			46	46			59	59
Fuel			169	169			250	250			336	336
TOTAL	116	1,073	1,990	3,063	157	1,448	2,981	4,429	210	1,925	4,597	6,522
Pellets												
Laboratories												
Port	4	32	10	42	7	52	20	72	10	77	30	107
Mine	11	85	10	95	21	169	40	209	40	338	80	418
Supply Transports' Handling	32	256	405	661	55	448	791	1,239	93	771	1,591	2,362
General Administration	95	950	560	1,510	118	1,180	637	1,817	140	1,400	715	2,115
Personnel Amenities			1,182	1,182			1,902	1,902			3,090	3,090
Power			29	29			37	37			53	53
Fuel			187	187			281	281			375	375
TOTAL	142	1,323	2,383	3,706	201	1,849	3,708	5,557	283	2,586	5,934	8,520

CRESTEXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

POWER REQUIREMENTS AND OPERATING COSTS

	GRANULAR CONCENTRATES						PELLETS					
	5MMLT/YR		10MMLT/YR		20MMLT/YR		5MMLT/YR		10MMLT/YR		20MMLT/YR	
	Demand Meg. W	Consump. MMKWH Per Yr.	Demand Meg. W	Consump. MMKWH Per Yr.	Demand Meg. W	Consump. MMKWH Per Yr.	Demand Meg. W	Consump. MMKWH Per Yr.	Demand Meg. W	Consump. MMKWH Per Yr.	Demand Meg. W	Consump. MMKWH Per Yr.
Power Requirements												
Mine	2.8	12	5.0	22	9.1	41	2.8	12	5.0	22	9.1	41
Ore Processing	13.2	104	26.4	208	52.7	415	48.5	382	97.0	764	193.0	1527
Shops	.9	3	1.5	5	2.0	8	.9	3	1.5	5	2.0	8
Camp & Office	3.8	10	5.7	15	9.4	25	4.2	11	8.0	18	11.3	30
Subtotal	20.7	129	38.6	250	73.2	489	56.4	408	111.5	809	215.4	1606
Aux's. & Losses @ 5%	1.0	6	1.9	13	3.7	24	2.8	20	5.6	41	10.8	80
TOTAL	21.7	135	40.5	263	76.9	513	59.2	428	117.1	850	226.2	168

Operating Costs - Mills/KWH	Granular 5MMLT/YR	Granular 10MMLT/YR	Granular 20MMLT/YR	Pellets 5MMLT/YR	Pellets 10MMLT/YR	Pellets 20MMLT/YR
Labor & Supplies	1.25	.85	.50	.70	.35	.30
Fuel @ $3.12/Bbl	6.45	6.20	5.45	5.70	5.20	5.10
TOTAL	7.7	7.1	6.0	6.4	5.6	5.4

MINING EQUIPMENT
5 MILLION T/YR

Item	Number of Units Granular Concentrates and Pellets
MINING	
Drill Rigs (JPM-4)	2
Shovels (Marion 191-M)	2
45 Ton Trucks (10 LD)	15
Drill Rigs (Benchmaster)	1
Drill Truck Units (W Compressor Jacklegs, etc.)	1
Dozers (D-8)	3
100 T Locomotives - E	2
83 L. T. Ore Cars	30
Misc. Trucks (Powder, Fuel, Water, Lube)	10
Water Wagons (6,000 gal.)	2
STRIPPING	
Drill Rigs (Benchmaster)	1
Shovels (4-1/2 cu. yd. - D - E)	1
30 Ton Trucks (69 TD)	9
Drill Truck Units	1
Dozers (D-8)	2
SERVICES	
(Road Construction & Maintenance, Supervision & Maintenance Services)	
Graders	4
Dozers (D-8)	2
Shovels (71-B)	1
Drill Rigs (Benchmaster)	-
Drill Truck Units	1
30 Ton Trucks (69 TD)	5
Service Trucks	6
Pick-ups, Panels, etc.	25
Snow Blowers	1
Ambulance	1
Fork-Lift Trucks	1

ORE PROCESSING
5 MILLION LT/YR

Item	Number of Units: Granular Concentrates	Number of Units: Pellets
CRUSHER		
60 in. x 109 in. Primary	1	1
7 ft. Standard Cone	2	2
7 ft. Shorthead Cone	4	4
FEEDING		
Coarse Ore Pile (84 in. Apron)	4	4
Primary Feed (Chain)	-	-
Primary Feed (84 in. Apron)	-	-
Primary Discharge (84 in. Apron)	2	2
Secondary Feed (60 in. Apron)	2	2
Tertiary Feed (48 in. Apron)	4	4
SCREENING		
Secondary Feed 6 ft. x 14 ft.	2	2
Secondary Discharge 8 ft. x 14 ft.	2	2
Tertiary Discharge 8 ft. x 16 ft.	4	4
GRINDING		
Rod Mills 13 ft. x 18 ft.	4	4
DSM Screens 4 ft.	40	40
CONCENTRATION		
Rougher Spirals	1000	1000
Cleaner Spirals	800	800
Recleaner Spirals	600	600
TAILINGS DISPOSAL		
Hydroseparator - 35 ft. Dia.	1	1
Thickener - 170 ft. Dia.	1	1
FILTERING		
Top Feed Drum Filter 10 ft. x 10 ft.	4	0
DRYING		
Fluo Solids Dryer - 16 ft. Dia.	2	0

ORE PROCESSING
5 MILLION LT/YR

Item	Number of Units: Granular Concentrates	Number of Units: Pellets
REGRINDING		
Ball Mills 13 ft. x 17 ft.	0	8
THICKENING		
Thickeners 75 ft. Dia.	0	4
FILTERING		
Disc Filters 6 ft. 9 in. x 10 Disc.	0	12
PELLETIZING MACHINES & EQUIPMENT	0	4

MINE LOADING AND STOCKING EQUIPMENT

5 MILLION LT/YR

Item	Number of Units: Granular Concentrates	Number of Units: Pellets
Transfer Tower (30 ft. x 30 ft. x 75 ft.)	1	1
Stockpile Conveyor, Gallery, & Tripper Unloader @ 125 ft. Elev.	24 in. x 750 ft.	24 in. x 750 ft.
Covered Storage	15,000 LT	None
Draw Chutes with Heavy Duty Vibratory Feeders	12	12
Reclaim Belt Conveyor	42 in. x 1,050 ft.	24 in. x 1,050 ft.
Transfer Belt to Car Loaders Elevate to 75 ft.	42 in. x 400 ft.	42 in. x 400 ft.
Car Loader	1	1
Marshalling Yard Trackage	11 Miles	11 Miles
Marshalling Yard for Misc. Supplies & Spurs to Plantsite	5 Miles	5 Miles

RAILROAD EQUIPMENT
5 MILLION LT/YR

Item	Number of Units: Granular Concentrates	Number of Units: Pellets
LOCOMOTIVES		
Road Locomotives, Type U25B, 2,500 H.P.	28	28
Switch Locomotives, 1,800 H.P. Mine and Port Switching	4	4
Maintenance of Way Locomotives, 1,200 H.P.	5	5
ORE CARS - 26 Short Ton Open Gondola Cars, Capacity 100 Short Tons		700
- With 2 ft. added Freeboard	700	
TANK CARS - Capacity 20,000 Gal.	100	150
MISCELLANEOUS SUPPLY CARS	130	150
PASSENGER CARS	2	2
SERVICE EQUIPMENT		
Rotary Snow Plow	1	1
Pusher Plows	3	3
Ice Flangers	3	3
Outfit Cars	40	40
Air Dump Cars	20	20
Flat Cars	20	20
150 Ton Wrecking Crane	1	1
Burro Cranes	5	5
Rubber Tired Cranes	5	5
Inspection Cars	10	10
Specialized Rail Mounted Equipment for rail, tie and ballast maintenance	Lot	Lot
Construction Type Equipment	Lot	Lot
Division Shop Tools and Equipment	Lot	Lot
Locomotive and Car Shop Equipment	Lot	Lot
Automotive Equipment	Lot	Lot
Hand and Air Tools	Lot	Lot
Piggy-back House Trailers (2 Men) for seasonal maintenance of Way Personnel	130	130

PORT EQUIPMENT
5 MILLION LT/YR

Item	Number of Units	
Rotary Car Dumper, Hoppers Feeders & Transfer Belt	One Car Per Cycle	
Radiant Heating Shed	1	
Transfer Belt to Stockout Conveyor - Inclined	54 in. x 800 ft.	
Overhead Stockpile Conveyor	54 in. x 900 ft.	
Reclaim Tunnels & Conveyors	60 in. x 2200 ft.	
Heavy Duty Vibrating Feeders for Reclaim Tunnels	50	
Transfer Belt to Shiploader	72 in. x 500 ft.	
Shiploader Belt	72 in. x 1800 ft.	
	Granular Concentrates	Pellets
Marshalling Yard Trackage	10 mi.	11 mi.

MINING EQUIPMENT
10 MILLION T/YR

Item	Number of Units Granular Concentrates and Pellets
MINING	
Drill Rigs (JPM-4)	4
Shovels (Marion 191-M)	4
45 Ton Trucks (10 LD)	30
Drill Rigs (Benchmaster)	1
Drill Truck Units (W Compressor Jacklegs, etc.)	2
Dozers (D-8)	5
100 T Locomotives - E	3
83 L. T. Ore Cars	62
Misc. Trucks (Powder, Fuel, Water, Lube)	14
Water Wagons (6,000 gal.)	3
STRIPPING	
Drill Rigs (Benchmaster)	2
Shovels (4-1/2 cu.yd. - D - E)	2
30 Ton Trucks (69 TD)	9
Drill Truck Units	1
Dozers (D-8)	3
SERVICES	
(Road Construction & Maintenance, Supervision & Maintenance Services)	
Graders	6
Dozers (D-8)	2
Shovels (71-B)	1
Drill Rigs (Benchmaster)	1
Drill Truck Units	1
30 Ton Trucks (69 TD)	8
Service Trucks	12
Pick-ups, Panels, etc.	32
Snow Blowers	2
Ambulance	1
Fork-Lift Trucks	2

ORE PROCESSING EQUIPMENT
10 MILLION LT/YR

Item	Number of Units: Granular Concentrates	Number of Units: Pellets
CRUSHER		
60 in. x 109 in. Primary	2	2
7 ft. Standard Cone	4	4
7 ft. Shorthead Cone	8	8
FEEDING		
Coarse Ore Pile (84 in. Apron)	4	4
Primary Feed (Chain)	-	-
Primary Feed (84 in. Apron)	-	-
Primary Discharge (84 in. Apron)	4	4
Secondary Feed (60 in. Apron)	4	4
Tertiary Feed (48 in. Apron)	8	8
SCREENING		
Secondary Feed 6 ft. x 14 ft.	4	4
Secondary Discharge 8 ft. x 14 ft.	4	4
Tertiary Discharge 8 ft. x 16 ft.	8	8
GRINDING		
Rod Mills 13 ft. x 18 ft.	8	8
DSM Screens 4 ft.	80	80
CONCENTRATION		
Rougher Spirals	2000	2000
Cleaner Spirals	1600	1600
Recleaner Spirals	1200	1200
TAILINGS DISPOSAL		
Hydroseparator 50 ft. Dia.	1	1
Thickener 250 ft. Dia.	1	1
FILTERING		
Top Feed Drum Filter 10 ft. x 10 ft.	8	0
DRYING		
Fluo Solids Dryer 16 ft. Dia.	4	0
REGRINDING		
Ball Mills 13 ft. x 17 ft.	0	16
THICKENING		
Thickeners 75 ft. Dia.	0	8

ORE PROCESSING EQUIPMENT
10 MILLION LT/YR

Item	Number of Units: Granular Concentrates	Number of Units: Pellets
FILTERING		
Disc Filters 6 ft. 9 in. x 10 Disc.	0	24
PELLETIZING MACHINES AND EQUIPMENT	0	8

MINE LOADING AND STOCKING EQUIPMENT

10 MILLION LT/YR

Item	Number of Units: Granular Concentrates	Number of Units: Pellets
Transfer Tower (30 ft. x 30 ft. x 75 ft.)	1	1
Stockpile Conveyor, Gallery, & Tripper Unloader @ 125 ft. Elev.	30 in. x 1,050 ft.	30 in. x 1,050 ft.
Covered Storage	25,000 LT	None
Draw Chutes with Heavy Duty Vibratory Feeders	22	22
Reclaim Belt Conveyor	42 in. x 1,700 ft.	42 in. x 1,700 ft.
Transfer Belt to Car Loaders Elevate to 75 ft.	42 in. x 400 ft.	42 in. x 400 ft.
Car Loader	1	1
Marshalling Yard Trackage	13 Miles	13 Miles
Marshalling Yard for Misc. Supplies & Spurs to Plant-site	6 Miles	6 Miles

RAILROAD EQUIPMENT
10 MILLION LT/YR

Item	Number of Units	
	Granular Concentrates	Pellets
LOCOMOTIVES		
Road Locomotives, Type U25B 2,500 H.P.	55	58
Switch Locomotives, 1,800 H.P. Mine and Port Switching	4	4
Maintenance of Way Locomotives, 1,200 H.P.	5	5
ORE CARS - 26 Short Ton Open Gondola Cars, Capacity 100 Short Tons		1,400
- With 2 ft. added Freeboard	1,400	
TANK CARS - Capacity 20,000 Gal.	150	270
MISCELLANEOUS SUPPLY CARS	150	225
PASSENGER CARS	3	3
SERVICE EQUIPMENT		
Rotary Snow Plow	1	1
Pusher Plows	7	7
Ice Flangers	7	7
Outfit Cars	50	50
Air Dump Cars	30	30
Flat Cars	30	30
150 Ton Wrecking Crane	1	1
Burro Cranes	5	5
Rubber Tired Cranes	5	5
Inspection Cars	10	10
Specialized Rail Mounted Equipment for rail, tie and ballast maintenance	Lot	Lot
Construction Type Equipment	Lot	Lot
Division Shop Tools and Equipment	Lot	Lot
Locomotive and Car Shop Equipment	Lot	Lot
Automotive Equipment	Lot	Lot
Hand and Air Tools	Lot	Lot
Piggy-back House Trailers (2 Men) for seasonal maintenance of Way Personnel	150	150

PORT EQUIPMENT
10 MILLION LT/YR

Item	Number of Units	
Rotary Car Dumper, Hoppers Feeders & Transfer Belt	One Car Per Cycle	
Radiant Heating Shed	1	
Transfer Belt to Stockout Conveyor - Inclined	54 in. x 800 ft.	
Overhead Stockpile Conveyor	54 in. x 1600 ft.	
Reclaim Tunnels & Conveyors	60 in. x 3600 ft.	
Heavy Duty Vibrating Feeders for Reclaim Tunnels	100	
Transfer Belt to Shiploader Belt	72 in. x 500 ft.	
Shiploader Belt	72 in. x 1800 ft.	
	Granular Concentrates	Pellets
Marshalling Yard Trackage	13 mi.	15 mi.

MINING EQUIPMENT
20 MILLION T/YR

Item	Number of Units Granular Concentrates and Pellets
MINING	
Drill Rigs (JPM-4)	6
Shovels (Marion 191-M)	6
45 Ton Trucks (10 LD)	60
Drill Rigs (Benchmaster)	3
Drill Truck Units (W Compressor Jacklegs, etc.)	4
Dozers (D-8)	9
100 T Locomotives - E	5
83 L.T. Ore Cars	125
Misc. Trucks (Powder, Fuel, Water, Lube)	18
Water Wagons (6,000 gal.)	6
STRIPPING	
Drill Rigs (Benchmaster)	4
Shovels (4-1/2 cu.yd. - D - E)	3
30 Ton Trucks (69 TD)	28
Drill Truck Units	2
Dozers (D-8)	5
SERVICES	
(Road Construction & Maintenance, Supervision & Maintenance Services)	
Graders	9
Dozers (D-8)	3
Shovels (71-B)	2
Drill Rigs (Benchmaster)	1
Drill Truck Units	2
30 Ton Trucks (69 TD)	16
Service Trucks	22
Pick-ups, Panels, etc.	55
Snow Blowers	2
Ambulance	1
Fork-Lift Trucks	2

ORE PROCESSING
20 MILLION LT/YR

Item	Number of Units: Granular Concentrates	Number of Units: Pellets
CRUSHER		
60 in. x 109 in. Primary	3	3
7 ft. Standard Cone	8	8
7 ft. Shorthead Cone	16	16
FEEDING		
Coarse Ore Pile (84 in. Apron)	8	8
Primary Feed (Chain)	1	1
Primary Feed (84 in. Apron)	1	1
Primary Discharge (84 in. Apron)	4	4
Secondary Feed (60 in. Apron)	8	8
Tertiary Feed (48 in. Apron)	16	16
SCREENING		
Secondary Feed 6 ft. x 14 ft.	8	8
Secondary Discharge 8 ft. x 14 ft.	8	8
Tertiary Discharge 8 ft. x 16 ft.	16	16
GRINDING		
Rod Mills 13 ft. x 18 ft.	16	16
DSM Screens 4 ft.	160	160
CONCENTRATION		
Rougher Spirals	4000	4000
Cleaner Spirals	3200	3200
Recleaner Spirals	2400	2400
TAILINGS DISPOSAL		
Hydroseparator 50 ft. Dia.	2	2
Thickener 250 ft. Dia.	2	2
FILTERING		
Top Feed Drum Filter 10 ft. x 10 ft.	16	0
DRYING		
Fluo Solids Dryer - 16 ft. Dia.	8	0
REGRINDING		
Ball Mills 13 ft. x 17 ft.	0	32
THICKENING		
Thickeners 75 ft. Dia.	0	16

ORE PROCESSING
20 MILLION LT/YR

Item	Number of Units: Granular Concentrates	Number of Units: Pellets
FILTERING		
Disc Filters 6 ft. 9 in. x 10 Disc.	0	48
PELLETIZING MACHINES & EQUIPMENT	0	16

MINE LOADING AND STOCKING EQUIPMENT

20 MILLION LT/YR

Item	Number of Units: Granular Concentrates	Number of Units: Pellets
Transfer Tower (30 ft. x 30 ft. x 75 ft.)	1	1
Stockpile Conveyor, Gallery, & Tripper Unloader @ 125 ft. Elev.	42 in. x 1,400 ft.	42 in. x 1,400 ft.
Covered Storage	40,000 LT	None
Draw Chutes with Heavy Duty Vibratory Feeders	34	34
Reclaim Belt Conveyor	42 in. x 2,350 ft.	42 in. x 2,350 ft.
Transfer Belt to Car Loaders Elevate to 75 ft.	42 in. x 400 ft.	42 in. x 400 ft.
Car Loader	2	2
Marshalling Yard Trackage	19 Miles	19 Miles
Marshalling Yard for Misc. Supplies & Spurs to Plant-site	7 Miles	7 Miles

RAILROAD EQUIPMENT
20 MILLION LT/YR

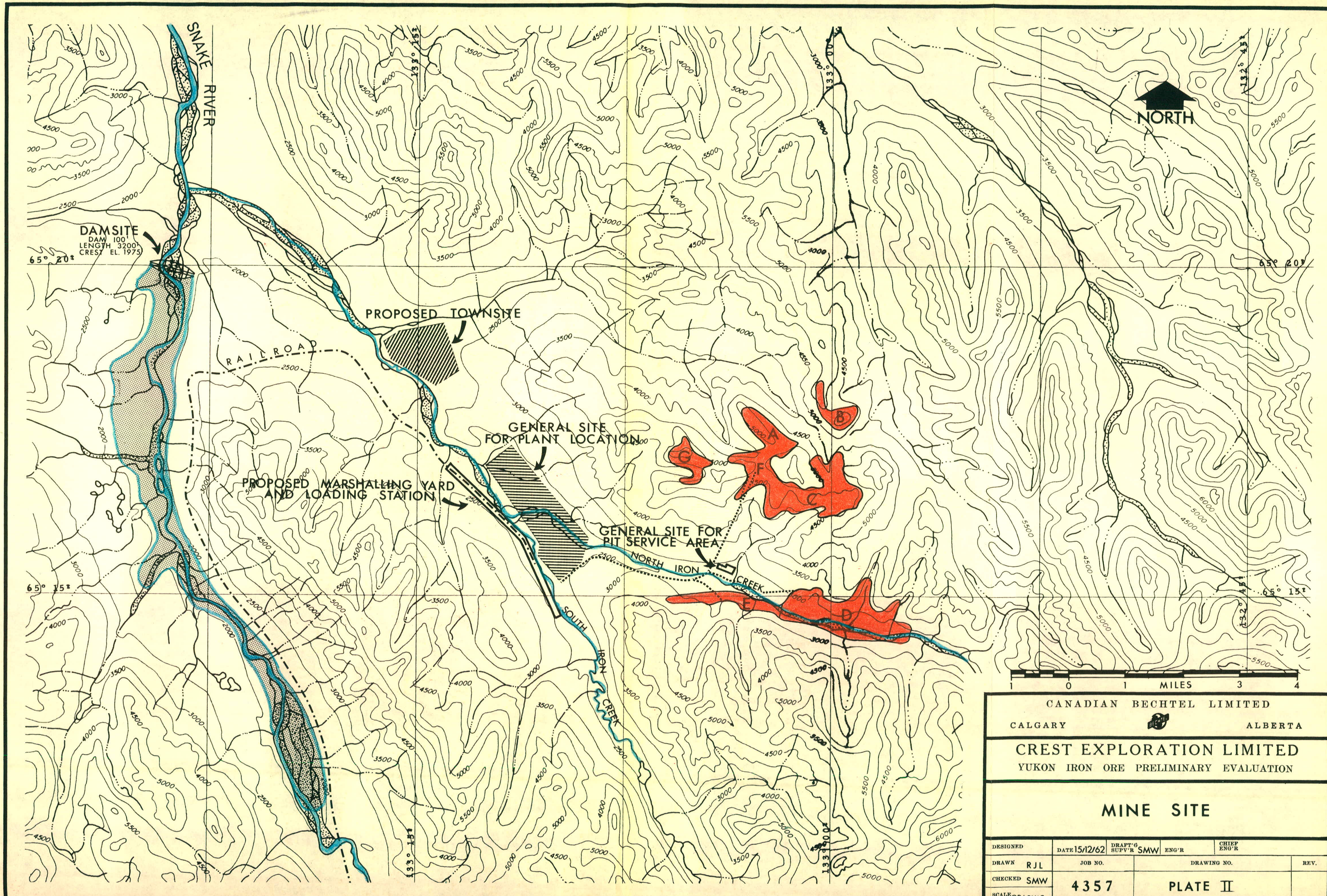
Item	Number of Units: Granular Concentrates	Number of Units: Pellets
LOCOMOTIVES		
Road Locomotives, Type U25B, 2,500 H.P.	106	107
Switch Locomotives, 1,800 H.P. Mine and Port Switching	6	6
Maintenance of Way Locomotives, 1,200 H.P.	5	5
ORE CARS - 26 Short Ton Open Gondola Cars, Capacity 100 Short Tons		2,800
- With 2 ft. added Freeboard	2,800	
TANK CARS - Capacity 20,000 Gal.	270	400
MISCELLANEOUS SUPPLY CARS	175	300
PASSENGER CARS	3	3
SERVICE EQUIPMENT		
Rotary Snow Plow	1	1
Pusher Plows	10	10
Ice Flangers	10	10
Outfit Cars	50	50
Air Dump Cars	30	30
Flat Cars	30	30
150 Ton Wrecking Crane	1	1
Burro Cranes	5	5
Rubber Tired Cranes	5	5
Inspection Cars	10	10
Specialized Rail Mounted Equipment for rail, tie and ballast maintenance	Lot	Lot
Construction Type Equipment	Lot	Lot
Division Shop Tools and Equipment	Lot	Lot
Locomotive and Car Shop Equipment	Lot	Lot
Automotive Equipment	Lot	Lot
Hand and Air Tools	Lot	Lot
Piggy-back House Trailers (2 Men) for seasonal Maintenance of Way Personnel	220	220

PORT EQUIPMENT
20 MILLION LT/YR

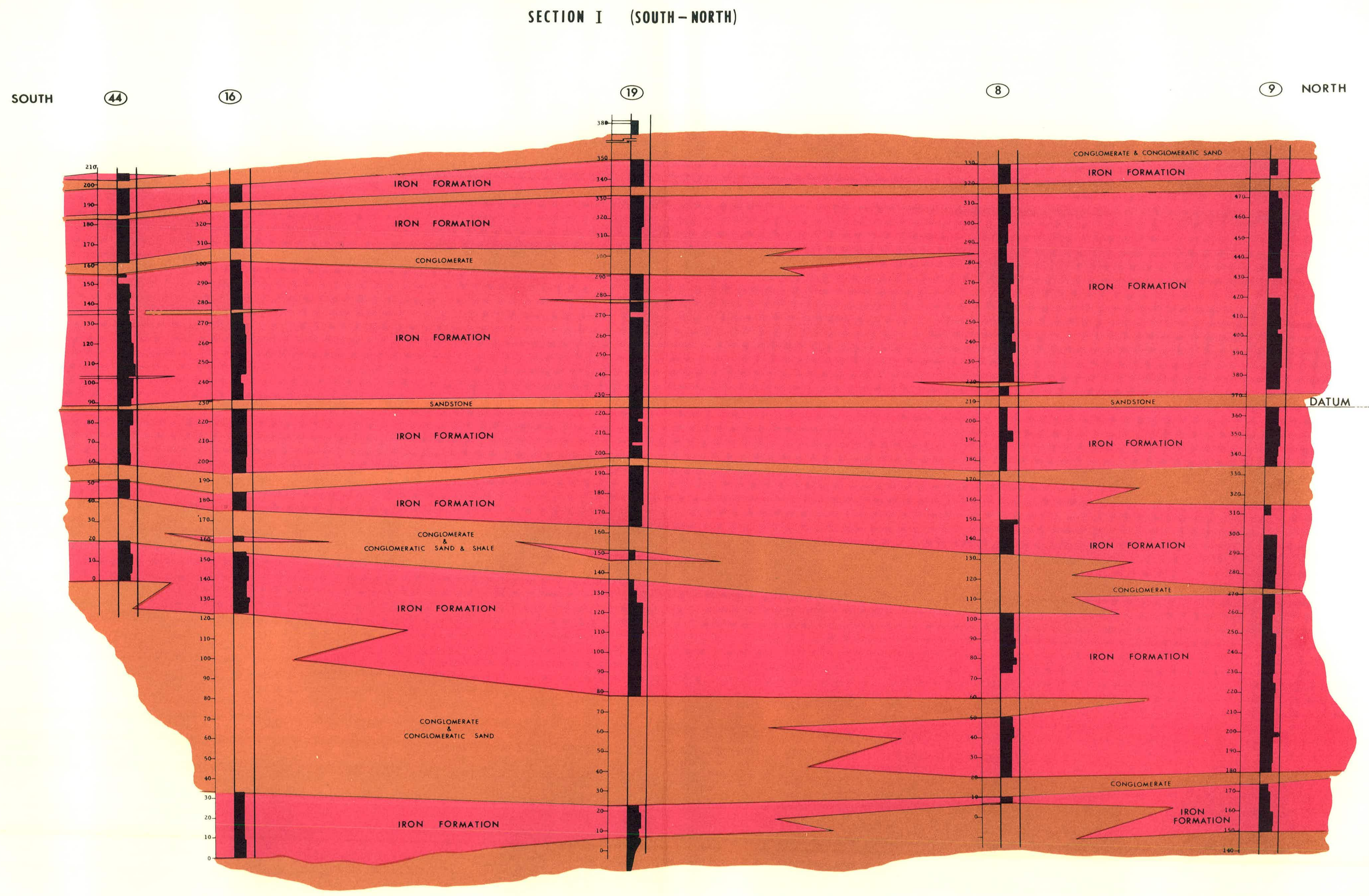
Item	Number of Units
Rotary Car Dumper, Hoppers Feeders & Transfer Belt	Two Cars Per Cycle
Radiant Heating Shed	1
Transfer Belt to Stockout Conveyor - Inclined	60 in. x 800 ft.
Overhead Stockpile Conveyor	60 in. x 2400 ft.
Reclaim Tunnels & Conveyors	72 in. x 5200 ft.
Heavy Duty Vibrating Feeders for Reclaim Tunnels	160
Transfer Belt to Shiploader Belt	72 in. x 500 ft.
Shiploader Belt	72 in. x 1800 ft.

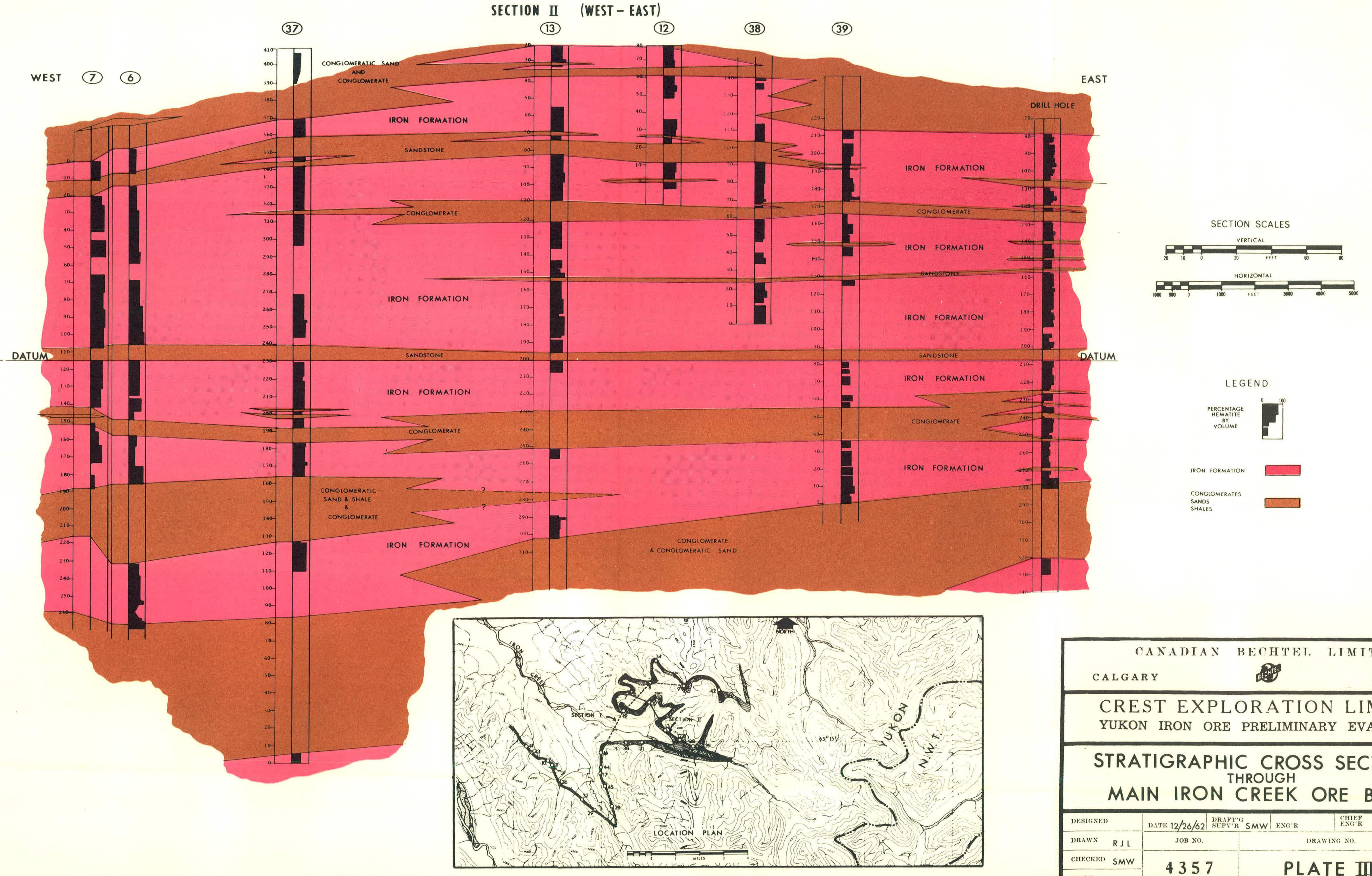
	Granular Concentrates	Pellets
Marshalling Yard Trackage	18 mi.	21 mi.

EXHIBITS



SNAKE RIVER
NORTH
DAMSITE
DAM 100'
LENGTH 3200'
CREST EL. 1975
PROPOSED TOWNSITE
RAILROAD
GENERAL SITE
FOR PLANT LOCATION
PROPOSED MARSHALLING YARD
AND LOADING STATION
GENERAL SITE FOR
PIT SERVICE AREA
NORTH IRON CREEK
SOUTH IRON CREEK
A
B
C
D
E
F
G
65° 20'
65° 15'
133° 15'
133° 00'
132° 45'
1 0 1 MILES 3 4
CANADIAN BECHTEL LIMITED
CALGARY ALBERTA
CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION
MINE SITE
DESIGNED
DATE 15/12/62
DRAFT'G SUPV'R SMW
ENG'R
CHIEF ENG'R
DRAWN RJL
JOB NO. 4357
DRAWING NO. PLATE II
REV.
CHECKED SMW
SCALE GRAPHIC





CANADIAN BECHTEL LIMITED

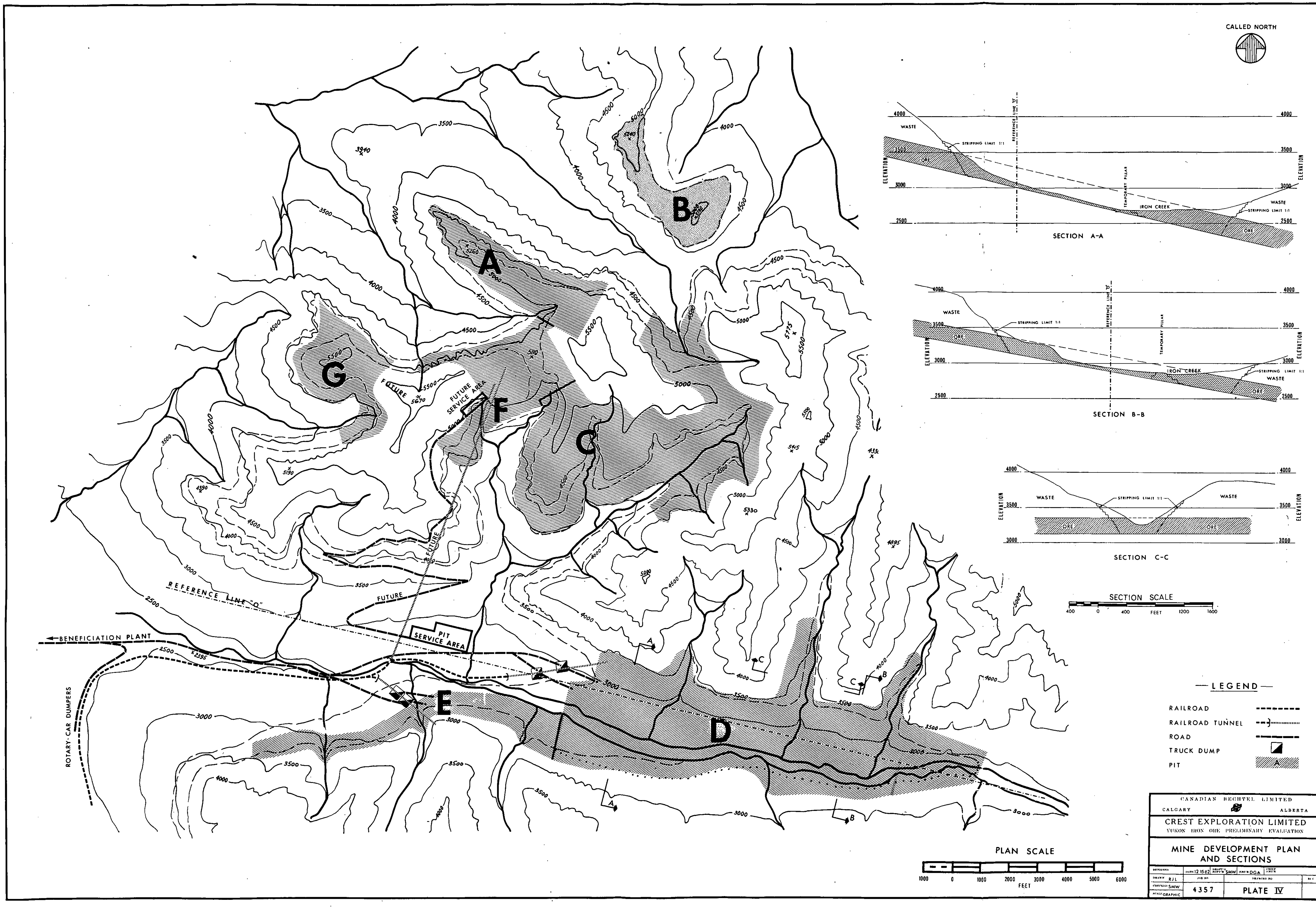
CALGARY ALBERTA

CREST EXPLORATION LIMITED

YUKON IRON ORE PRELIMINARY EVALUATION

STRATIGRAPHIC CROSS SECTIONS THROUGH MAIN IRON CREEK ORE BODY

DESIGNED	DATE 12/26/62	DRAFT'G SUPV'R SMW	ENG'R	CHIEF ENG'R	
DRAWN RJL	JOB NO.		DRAWING NO.		REV.
CHECKED SMW	4357		PLATE III		
SCALE GRAPHIC					


CALLED NORTH
SECTION A-A
SECTION B-B
SECTION C-C
WASTE
ORE
STRIPPING LIMIT 1:1
REFERENCE LINE "O"
TEMPORARY PILLAR
IRON CREEK
ELEVATION
SECTION SCALE
FEET
BENEFICIATION PLANT
ROTARY-CAR DUMPERS
PIT SERVICE AREA
FUTURE SERVICE AREA
FUTURE
REFERENCE LINE "O"
A
B
C
D
E
F
G
LEGEND
RAILROAD
RAILROAD TUNNEL
ROAD
TRUCK DUMP
PIT
PLAN SCALE
CANADIAN BECHTEL LIMITED
CALGARY ALBERTA
CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION
MINE DEVELOPMENT PLAN AND SECTIONS
4357
PLATE IV


PACIFIC OCEAN
ICY STRAIT
CHILKAT RANGE
COAST MOUNTAINS
ST. ELIAS MOUNTAINS
CANADA
U.S.A.
HAINES JUNCTION
HAINES
PORT AREA
SKAGWAY
CARCROSS
WHITEHORSE
CARMACKS
MINTO
PELLY CROSSING
STEWART CROSSING
MAYO
YUKON RIVER
PELLY RIVER
STEWART RIVER
SNAKE RIVER
IRON CREEK
MINE AREA
ROUTE 'A'
ALTERNATE 'B'
ALTERNATE 'C'
ALTERNATE 'D'
LEGEND
ROUTE "A"
ALTERNATE "B"
ALTERNATE "C"
ALTERNATE "D"
100 Kilometres
50 Nautical Miles
60 Statute Miles
CANADIAN BECHTEL LIMITED
CALGARY
ALBERTA
CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION
REGIONAL MAP
DESIGNED SMW
DATE 12/6/52
DRAFT'G SUPV'R SMW
ENG'R
CHIEF ENG'R
DRAWN SMW
JOB NO. 4357
DRAWING NO. PLATE I
REV.
CHECKED R.L
SCALE 1:1,000,000

DUMP TRUCKS
PITS "E" OR "D"
ROTARY CAR DUMPER
(2) PRIMARY CRUSHERS 60" x 109"
(2) APRON FEEDERS
COARSE ORE STOCKPILE (200,000 TONS)
(8) APRON FEEDERS
SECONDARY ORE BINS
(4) SECONDARY FEED SCREENS 6' x 14'
(4) SECONDARY CRUSHERS 7' STD. CONE
(4) SECONDARY DISCH. SCREENS 8' x 14'
TERTIARY ORE BINS
VIBRATING FEEDERS
(8) TERTIARY CRUSHERS 7' S.H. CONE
(8) TERTIARY DISCH. SCREENS 8' x 16'
20,000,000 T.P.Y
FINE ORE BINS
(80) DSM SCREENS 4' 10 PER ROD MILL
(8) ROD MILLS 13½' x 18' 1 PER SECTION
DISTRIBUTORS
(2000) ROUGHER SPIRALS 250 PER SECTION
DISTRIBUTORS
(1600) CLEANER SPIRALS 200 PER SECTION
DISTRIBUTORS
(1200) RE-CLEANER SPIRALS 150 PER SECTION
(8) TOP FEED DRUM FILTERS 10' x 10'
(4) FLUID SOLIDS DRYERS 16'
EXHAUST
FUEL OIL
COVERED STORAGE 20,000 TONS
VIBRATING FEEDERS
EMERGENCY STOCKPILE
VIBRATING FEEDERS
10,000,000 L.T.P.Y
LEGEND
PRIMARY FLOW
SECONDARY FLOW
ALTERNATE FLOW
MIDLINGS
CONCENTRATES
TAILINGS
ADDITIONAL CRUSHER FOR FUTURE UPPER LEVEL PITS
(1) PRIMARY CRUSHER 60" x 109"
ROTARY CAR DUMPER
(1) APRON FEEDER
MILL WATER
TO TAILINGS DISPOSAL 10,000,000 T.P.Y
(1) THICKENER 250'
(1) HYDROSEPARATOR 50'
CYCLONES 24"
BENTONITE ADDITION
(24) BALLING DRUMS 10'6" x 27' 3 PER SECTION
(24) GREEN BALL SCREENS 3 PER SECTION
FUEL OIL
(8) INDURATION MACHINES 1 PER SECTION
STORAGE PITS
ALTERNATE FLOW FOR PRODUCING PELLETS
10,000,000 L.T.P.Y
PELLET LOADOUT BINS 1000 TONS EACH
PELLET STORAGE VIBRATING FEEDERS
(16) REGRIND BALL MILLS 13' x 17' 2 PER SECTION
(8) THICKENERS 75' 3 PER SECTION
(24) DISC FILTERS 6'-9" x 10 DISC 3 PER SECTION
(8) CHIPS REGRIND MILLS 1 PER SECTION
CHIPS BIN
BENTONITE STORAGE BIN
CANADIAN BECHTEL LIMITED
CALGARY ALBERTA
CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION
FLOW DIAGRAM
10 MM T.P.Y. CONCENTRATOR & PELLETIZING PLANT
DESIGNED R.S.S
DATE 12-26-62
DRAFT'G SUPV'R
ENG'R
PROJ. ENG'R
CHIEF ENG'R
DRAWN J.E.G
JOB NO.
DRAWING NO.
REV.
CHECKED
SCALE
4357
PLATE V

REDUCED SCALE: HORIZONTAL 1" = 16 MILES
VERTICAL 1" = 1000 FEET

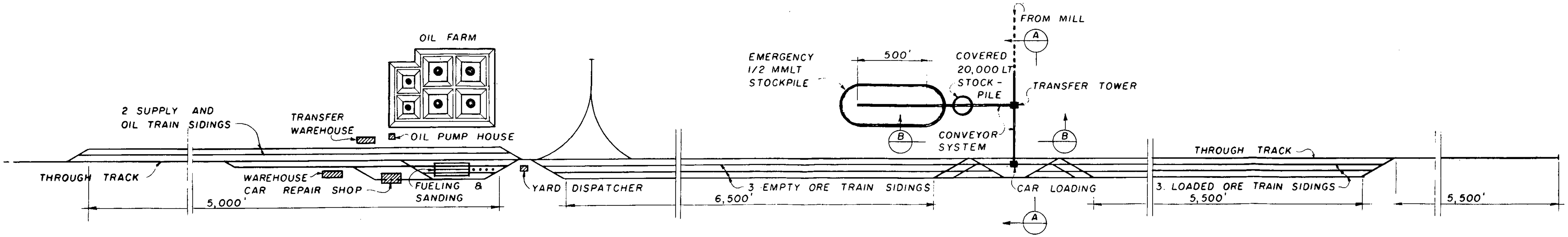
CANADIAN BECHTEL LIMITED
CALGARY ALBERTA

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

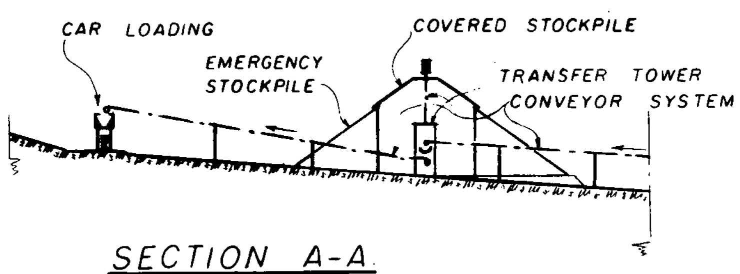
RAILROAD PROFILE

DESIGNED	DATE 12/17/62	DRAFT'G SUPV'R	ENG'R	CHIEF ENG'R
DRAWN	JOB NO.	DRAWING NO.	REV.	
CHECKED / SCALE	4357	PLATE VII		

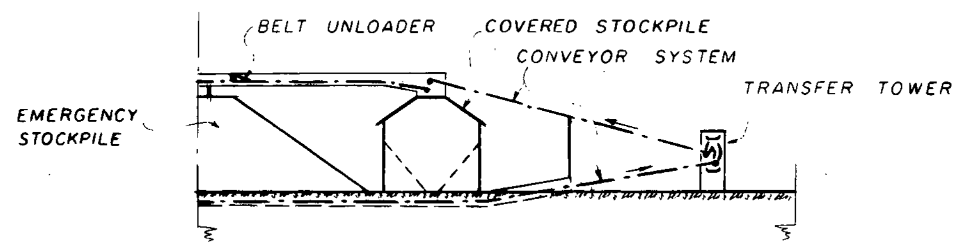
SIZE D



PLAN



SECTION A-A



SECTION B-B

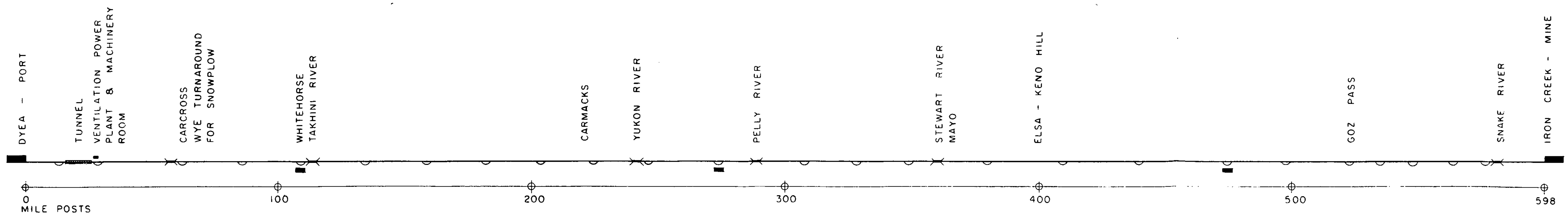
N

CANADIAN BECHTEL LIMITED
CALGARY ALBERTA

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

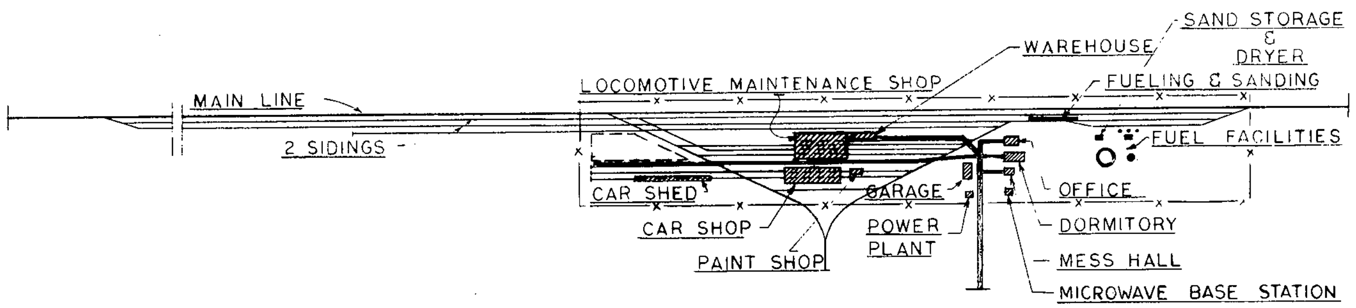
MINE AREA
STOCKPILE AND LOADING FACILITIES.

DESIGNED	DATE	DRAFT'G SUPV'R	ENG'R	CHIEF ENG'R
DRAWN	JOB NO.		DRAWING NO.	REV.
CHECKED / SCALE	4357		PLATE VI	

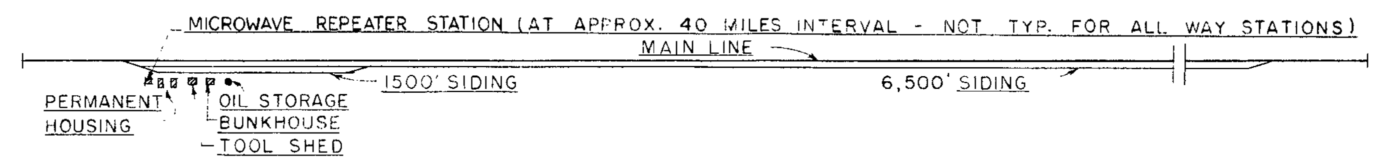


SCHEMATIC DIAGRAM OF RAILROAD

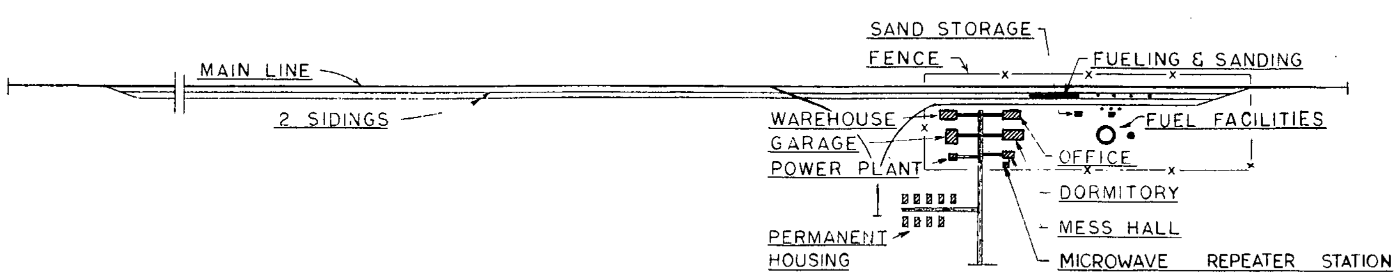
LEGEND — DIVISION STATION — WAY MAINTENANCE STATION



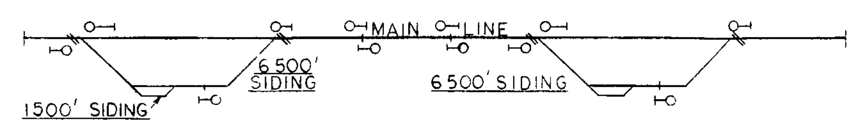
SCHEMATIC PLAN - RAILROAD HEADQUARTER - WHITEHORSE



SCHEMATIC PLAN - INTERMEDIATE WAY STATION



SCHEMATIC PLAN - DIVISION HEADQUARTER



TYPICAL SWITCH & SIGNAL ARRANGEMENT AT SIDINGS

LEGEND:

- SIGNAL
- SPRING SWITCH

NOTES

1. RAIL: MAIN LINE: 136 LBS NEW
   SIDINGS: 110 LBS RELAY
2. SWITCHES FOR PASSING SIDINGS TO BE SPRING OPERATED IN THE 5 & 10 MMLT/Y ALTERNATES AND POWER OPERATED IN THE 20 MMLT/Y ALTERNATE.
3. ALL SWITCHES TO BE EQUIPED WITH PROPANE HEATERS.
4. SIDING REQUIREMENTS:

	ALTERNATE, MMLT/Y		
	5	10	20
TOTAL NUMBER OF SIDINGS	25	25	48
AVERAGE DISTANCE BETWEEN SIDINGS, MILES	23	23	12

5. SIGNAL SYSTEM:
   5 & 10 MMLT/Y:
   AUTOMATIC BLOCK SIGNALS.
   20 MMLT/Y:
   AUTOMATIC BLOCK SIGNALS, CTC CONTROL, CENTER AT WHITEHORSE.
6. COMMUNICATIONS: TRAIN-TO-TRAIN, TRAIN-TO-DISPATCHER AND DISPATCHER-TO-TRAIN VIA RADIO.
7. POWER SUPPLY FOR 20 MMLT/Y SIGNAL & SWITCH OPERATION: POLE LINE.
8. SCHEMATIC PLANS SHOW FACILITIES FOR 10 MMLT/Y ALTERNATE.

CANADIAN BECHTEL LIMITED
CALGARY ALBERTA

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

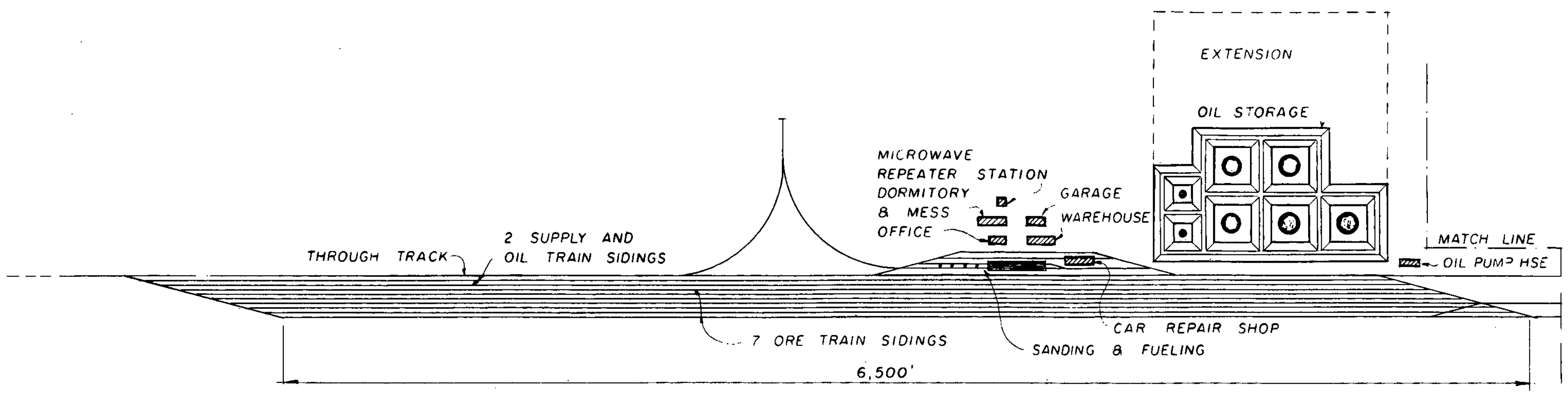
RAILROAD MAINTENANCE AND SERVICE YARDS.

DESIGNED — DATE — DRAFT'G SUPV'R — ENG'R — CHIEF ENG'R
DRAWN — JOB NO — DRAWING NO — REV.
CHECKED
SCALE

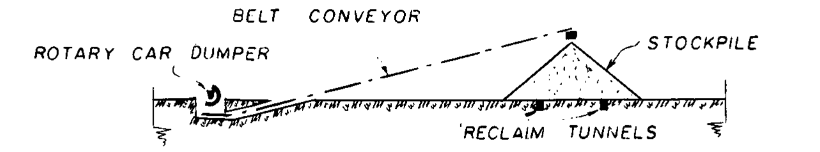
4357 PLATE VIII

SIZE D

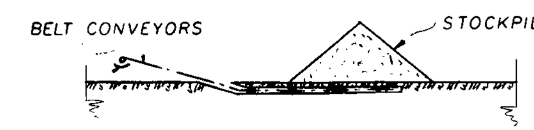
SIZE D



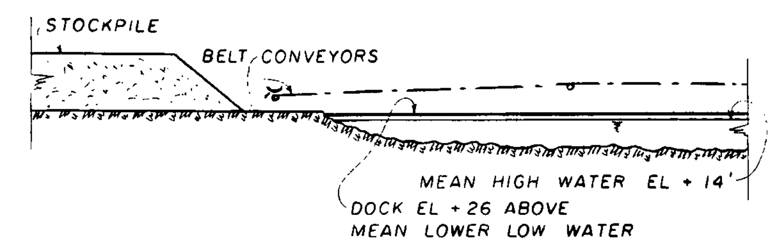
PLAN



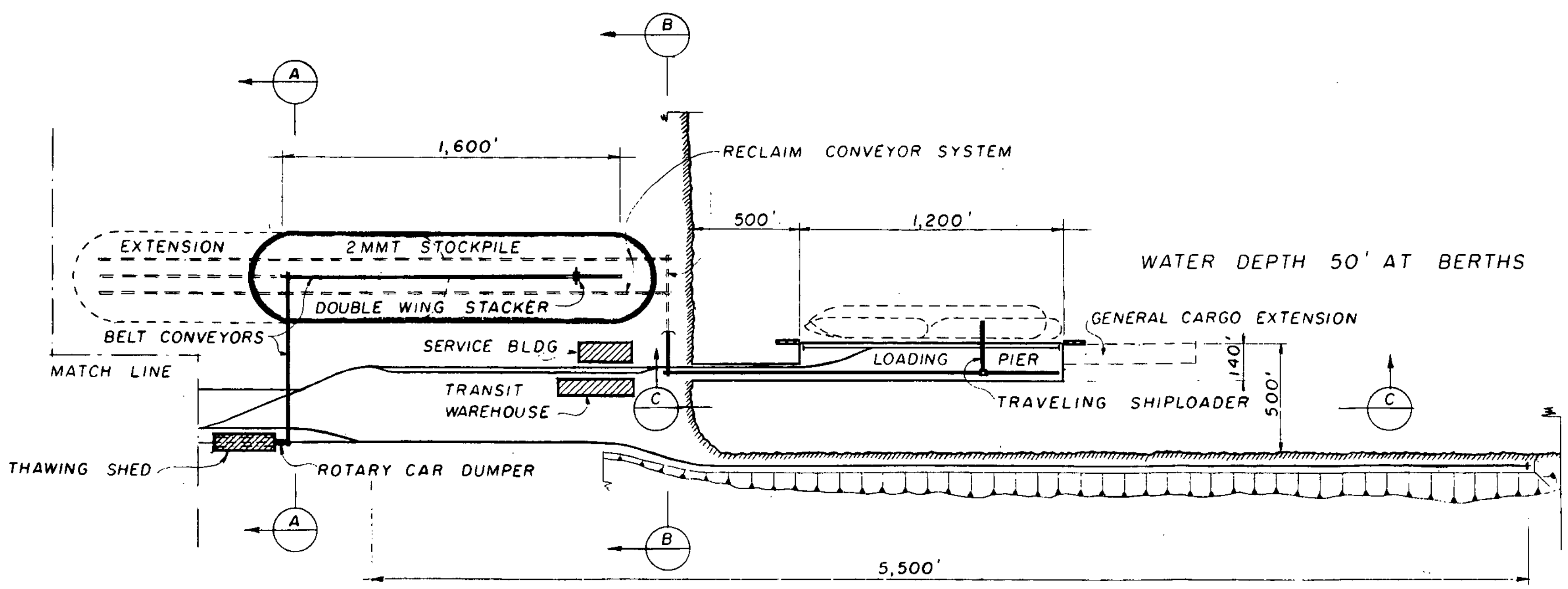
SECTION A-A THROUGH DUMPER



SECTION B-B THROUGH RECLAIM TUNNELS



SECTION C-C ALONG DOCK



PLAN

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CANADIAN BECHTEL LIMITED
CALGARY ALBERTA

CREST EXPLORATION LIMITED
YUKON IRON ORE PRELIMINARY EVALUATION

PORT FACILITIES.

DESIGNED	DATE	DRAFT'G SUPV'R	ENG'R	CHIEF ENG'R
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CHECKED				
SCALE	4357	PLATE IX		

FORM D PRINTED ON POLYTEX 126-3

APPENDIX A

VICTOR DOLMAGE
CONSULTING GEOLOGIST
1119 MARINE BUILDING
VANCOUVER 1, B.C.

GEOLOGICAL ASPECTS

of

SEVERAL POSSIBLE RAILWAY TUNNEL SITES CROSSING THE ALASKA-BRITISH COLUMBIA BOUNDARY NEAR SKAGWAY AND HAINES

Two general areas were considered, one leading to the Taiya river and crossing the international boundary west of Chilkoot pass and the other leading to Haines from Kelsall lake through Chilkat pass. The former area is considered to be the more favorable geologically.

SKAGWAY CHILKOOT PASS AREA

In this area two routes leading into the Taiya River valley are proposed; one from Partridge lake past Homan lake and under Mount Van Wagenen and Mount Hoffman crossing the International boundary 3 - 5 miles west of Chilkoot pass and the other leading from Lindeman lake to the east fork of the Taiya river passing close to Chilkoot pass. The length of this route is about one-half that of the other.

All of these tunnel routes pass through an exceptionally rugged terrain with a climate ranging from mild to severely cold and have a heavy precipitation, much of it in the form of snow.

GEOLOGY

The geology of the Canadian part of this region has been mapped and studied in considerable detail and most of the Alaskan part of the area has also been mapped geologically but in less detail. The geologists who did the work in both countries are well known to me and are men of superior calibre. Also, I have visited the area many times in the past and on October 20 - 23 I had a good opportunity to review and refresh my knowledge of the geology. Also, I have had some experience in tunnelling in the coast region of British Columbia where the geology is remarkably similar.

The region between Partridge lake and Lindeman lake and the Taiya and Skagway river valleys, as well as a large surrounding region, is occupied almost entirely by granitic rocks. These are part of an immense batholith which extends along the entire coast from Vancouver to and beyond the area in question. This is referred to as the Coast Range Batholith or Coast Intrusives. These rocks extend for miles in depth. Therefore, any tunnel driven in this region would be almost entirely in these granitic rocks. The only other rocks which might be encountered would be small bodies of older rocks which were caught up in the granitic rocks while they were still molten and frozen in. Irrespective of what type of rocks these were originally, they have been completely transformed by the heat, pressure and chemical action of the molten granite into hard, strong, impervious rocks, having tunnelling properties similar to those of the granitic rocks. Numerous tunnels have been driven in these rocks which with only a few small exceptions have proven highly satisfactory tunnelling rocks.

It may be predicted therefore that any one of the proposed tunnels driven in this region will pass through granitic rocks such as quartz diorite and granodiorite for almost its entire length. Small bodies of older included rocks will be encountered but these will not differ materially in tunnelling characteristics from the granitic rocks. Generally speaking, these rocks offer as good tunnelling conditions as any, but are not without some difficulties.

Tunnelling difficulties may be divided into two classes, those which are normally to be expected, which have a somewhat uniform influence on costs which can be fairly accurately judged by the experienced contractor and those of a catastrophic nature which may double the costs and cause very expensive delays.

Difficulties of the first order are due to joint cracks, faults and particularly large faults up to 50 or 100 feet wide filled with muddy crushed rock and sometimes water. Ordinarily these affect only short lengths of the tunnels and should not cause the experienced tunnellerserious delays. However, should one of these faults chance to run parallel to the tunnel for a long distance a serious delay might be caused. Live or active faults, of course, can be extremely troublesome but none such, or even faults of recent geological age, have ever been observed in this part of the continent.

Major difficulties in rock tunnelling are invariably due to either large open water channels discharging hundreds or thousands of gallons per minute or to the presence in the rocks of large amounts of soft, slippery minerals like the serpentines, micas and clay minerals. Large water channels are very common in limestones and some volcanic rocks of recent origin but are seldom found in other rocks. The soft, slippery minerals are confined to metamorphic rocks like schists and serpentine or to sedimentary rocks like shale and some volcanic ash rocks.

There is only one known condition under which these minerals might be found in troublesome amounts in granitic rocks, namely, where the rocks have been invaded by chemically active mineralizing solutions. These solutions are capable of altering the strong stable rock minerals such as the felspars to soft expansive clay type minerals sometimes over areas miles in extent. This often results in heavy and or squeezing ground in which it is extremely difficult to construct and maintain openings. However, such altered zones are almost always visible on the surface and would be particularly conspicuous in the areas in question where soil and vegetation are scarce or absent. Therefore, the danger of unexpectedly encountering a major difficulty in this area is remote indeed.

It will be noted that on the geological map of this part of British Columbia there appear an unusually large number of small broken wavy lines which according to the legend represent "lineaments (possibly faults) plotted from air photographs." It is equally apparent that the unbroken wavy lines representing faults that have been defined are absent. Some of these lineaments situated along the White-Pass and Yukon railway were examined and all were found to be either joints or faults too small to cause tunnelling difficulties. It is my opinion that these many lineament lines on the map create a false impression and that tunnels in this region will cross no more than the usual number of faults found in the Coast Intrusives.

WATER

It is probable that much water will enter the tunnel through joint cracks and faults. This water will come from melting snow and glaciers. The snowfall is heavy and the melting season somewhat prolonged. In the higher parts of the area the tunnels will be relatively dry throughout the long cold winter. In the lower parts melt water from snow will be plentiful through most of the year. The large glaciers of the area, unless they happen to rest on permafrost, will produce large amounts of water throughout the year. The Granduc mine situated not far to the south is under a glacier and is a very wet mine. A raise recently driven too near the ice-rock contact caused serious flooding. Glaciers can be more troublesome than lakes of comparable size and similarly situated because the lakes are usually floored with impervious layers of clay and silt. It is possible that some of the glaciers in this region situated at altitudes of 5000 feet or higher do rest on permanently frozen ground. Also, the tunnels will be 2000 or 3000 feet below the glaciers at which distance the number and size of connecting cracks and fissures will be smaller than at less distances. While the tunnel will no doubt be wet it is unlikely that the amount of water will be greater than can be contained in drainage ditches. The design gradients of 1.5 to 1.9% are steeper than ordinary mine tunnels or aqueducts which range from 1/2 to 1/4 percent. Therefore, the velocity of the water will be greater, which may be an advantage.

Large springs, and particularly hot springs, can cause serious difficulties and quite a number are known to occur along the Pacific Coast of British Columbia and Alaska south of Skagway. I have been unable, however, after many enquiries to learn of any springs in this area. It is quite certain that none exist either along the White Pass and Yukon railway or along the old Chilkoot Pass trail to Lindeman lake. Hot springs are easily detected in this climate by their vapor clouds.

The most important expense due to the presence of water will be that of pumping it out of the upper half of the tunnel during construction.

WATER POWER

The large amounts of water which will probably enter and flow through the tunnel, as well as the large amounts easily available from lake Bennett through Lindeman or Partridge lakes, could be cheaply converted to electric energy in small underground powerhouses excavated adjacent to the railway tunnel at the most economical locations and elevations. The power could be used for ventilation, for heating to prevent icing, and for haulage in the tunnel and perhaps for some distance beyond. The water will be available at no cost and will have to be conducted through the tunnel whether used or not and there is more than enough head between the tunnel portals. If a larger and more easily regulated flow of water were necessary it could be obtained from either lake at very little cost by pumping or by siphoning. The principal cost would be that of the steel pipes to conduct the water long distances under high pressure. However, only small diameter pipe would be necessary and more than one power station could be used to avoid excessive lengths of high strength pipes.

I have neither the knowledge nor the ability to calculate the costs of such power but the idea seemed worthy of mention. I have seen many underground power plants and I do know that the cost of the necessary excavations adjacent to the tunnel would be almost insignificant.

ICING OF PORTALS

There will be no problem at the south end. At the north end no water will flow out of the tunnel except that pumped out during construction. Also, it is very likely that the natural air circulation will be outwards at the upper portal. From experience mining in the Atlin district at somewhat higher latitude and elevation I would not expect to find permafrost in the near vicinity of any of the tunnel portals.

If one of the Partridge Lake routes were selected a shaft near Homan lake might prove practical. It would cost approximately $500 per foot. Air transportation using Homan lake as a landing field for floats in summer and skis in winter would be practical. The feasibility of such a shaft is purely a matter of economics and is an integral part of the cost estimates of these tunnels.

HAINES ROUTE

This route is unfavorable geologically.

A tunnel along this route would pass through some granodiorite but mostly through limestone, shale, slate, schist and basalt, the latter partly altered to serpentine. Serpentine, schist and shale consist mainly of the soft, slippery, treacherous minerals previously mentioned and could present major difficulties. Limestone, though relatively competent, is easily soluble and often contains large open water courses which in this climate would carry large amounts of water. Such water caused serious trouble during the construction of some of the Alpine tunnels in Europe.

Also, the Chilkat valley is known to be the locus of extensive faulting parallel to the valley and therefore parallel to the proposed tunnel route.

Unless this route offered some very important economic advantages or could be laid out so as to require very little tunnelling it should be avoided.

VENTILATION

Ventilation during construction need not be a serious problem, though it will be a significant item of cost. There would be ample room for ventilating ducts above the spring line and clear of the muck trains.

I have no useful opinion to offer regarding the permanent ventilation which might be required assuming the use of diesel locomotives. However, during the repair of the 11 mile Kemano tunnel in 1961 the natural circulation was found to be exceedingly sluggish and artificial ventilation on a considerable scale was required. The smaller size of the proposed railway tunnel and steeper gradient might give a better natural air circulation.

SUMMARY

It is known with considerable assurance that any one of the suggested tunnels in the White pass Chilkoot pass area will pass almost entirely through granitic rocks (quartz diorite and granodiorite) of the Coast Intrusive or older rocks of equal competence and that rocks of this complex afford better than average tunnelling conditions.

Considerable experience has shown that larger tunnels in this complex on the average require support over only 20 or 25 percent of their total length. There are many miles, perhaps hundreds of miles, of mine tunnels in these rocks which require virtually no support.

The rocks are invariably jointed and no doubt a number of faults also will be encountered. The number and size of these will determine the amount of support required and the amount of water which will enter the tunnel, but there is no reason to expect more than the normal number found in these rocks.

It should be possible to drive these tunnels at an average rate of 1000 feet and possibly 1300 feet per month per heading. Better rates have been achieved but are exceptional. The average rate of the 11 mile Kemano tunnel was 823 feet per month, or about 27.4 feet per day. This was a 25-foot diameter horseshoe tunnel and was accessible from a central adit as well as both ends.

COSTS

Time was not available to perform a rigorous estimate of the cost of these tunnels including the alternate routes, alternate methods, all the types of support and the Homan Lake shaft. However, if such a study were desired, my organization is sufficiently competent and experienced to do so and has available a number of cost figures to use for comparison. The following figures are based on recent experience. You may expect bids in the neighborhood of $10 per cubic yard for unsupported excavation, but I have seen figures from Sweden as low as $6 or $7. Assuming the cross sectional area of the tunnels in question to be 500 square feet or 18 cubic yards per foot of length, the cost would be therefore about $180 per foot. This figure includes a profit for the contractor, a liberal allowance for unforeseen difficulties, and all other costs except that for supports. The supports will be in the form of rock bolts or wood or steel arch sets with wood lagging, or gunite or concrete lining, or some combination of these. Bolting is the cheapest and is finding an increasingly wide acceptance as techniques are improved and its application to various conditions is better understood. The three 50' tunnels at Peace River Power project are being supported exclusively by bolts.

Concrete lining is the most expensive and may be roughly estimated at $90 to $100 per lineal foot in place for 15" thick concrete. It would appear to me that very little of this type of support would be required. Unit bids for other types of support in place may very well loom a great deal larger in total costs than expected or than might seem justified by the character of the ground traversed. The alternative to such unit bidding is to invite the contractor to assume the risk of excessive flows of water or squeezing or heavy ground in his estimates at correspondingly higher figures. This alternative is not recommended.

I think the over-all cost of these tunnels per lineal foot advanced will be less than $300.

Respectfully submitted,

V. Dolmage

V. Dolmage.

November 9, 1962.

APPENDIX B

R. M. HARDY & ASSOCIATES LTD.

FINAL REPORT

TO

CANADIAN BECHTEL LIMITED

ON

MUSKEG AND PERMAFROST PROBLEMS

RE

CREST EXPLORATION LIMITED

YUKON IRON ORE FEASIBILITY STUDY

December, 1962

CONTENTS

R. M. HARDY & ASSOCIATES LTD.
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FINAL REPORT RE CREST EXPLORATION LIMITED YUKON IRON ORE FEASIBILITY STUDY MUSKEG AND PERMAFROST PROBLEMS

This report deals with the general aspects of the problems that will be encountered due to muskeg and permafrost soil conditions along the proposed railroad transportation route from a coastal point in the vicinity of Skagway, Alaska, to the Crest Exploration Limited iron ore property located close to the Yukon-Northwest Territories border about 200 miles northeast of Mayo Landing in the Yukon. It also deals briefly with the special foundation conditions which will arise in connection with mine building and living quarters at the mine due to the fact that the mine is in a permafrost area. It consolidates our "Preliminary" Report dated November 9, 1962, and gives more complete details of several aspects of the anticipated problems in regard to muskeg and permafrost. The report has been prepared at the request of Canadian Bechtel Limited acting in their capacity as consultants to Crest Exploration Limited.

MUSKEG CHARACTERISTICS

Muskeg soil is organic soil formed by the decomposition of swamp grasses, moss, shrubs and tree roots in an environment deficient in oxygen. The swamp growth occurs in areas of poor surface drainage in which the water table is generally only a few inches below the surface. A large percentage of the surface terrain in Northern Canada is muskeg. Many muskeg areas are characteristically bowl-shaped with the distance across the bowl being anything from a few hundred feet to several miles in extreme cases. At the centre of the bowl there may be open water; that is, the water table is above the surface. Around the edge of the open water grass growth occurs, further away it merges into shrub growth, and finally into heavy black spruce tree growth around the outer rim of the bowl. The transition from shrub to tree growth is usually quite sharp. The variation in surface growth from grass to heavy black spruce trees reflects only a difference in depth of water table below the surface. However, even in areas of the heaviest tree growth the water table may be only one to two feet below the surface. The present growth of live surface moss is most sparse in the grassed areas of the muskegs and heaviest in the treed areas. In the areas of tree growth the height of the growth can be taken as a relative measure of the stability of the underlying muskeg.

The depth of organic soil varies from a few feet to as much as 75 feet. However, along the proposed railroad route it is unlikely that the depth of the muskegs will exceed 15 to 20 feet. The only exception to this may be in the bottom of mountain valleys, where it may be of greater depth. Muskeg is usually underlaid by highly impermeable soil such as silt or clay. However, it is sometimes found underlaid by sand and/or gravel. In these cases the sand or gravel must be underlaid by impermeable soil such as silt or clay because otherwise the conditions of high water table conducive to the growth of muskeg would not exist.

Geologically muskeg has formed since the last glacial retreat. It therefore is a recent deposit of soil and has consolidated only under its own submerged weight plus the weight of surface tree growth and a foot or two of frozen muskeg. This means that it may only have been consolidated under a weight of about 150 lbs. per sq. ft. of frozen soil and surface growth plus unfrozen submerged overburden weight as low as about 10 lbs. per cu. ft. As a result of this natural muskeg has very low shearing and bearing strengths, its moisture content is very high ranging from 100 to 1500% based on the dry weight of the material, and it is highly compressible. However, even with these poor engineering characteristics, muskeg in areas of severe winter freezing temperatures is relatively more stable than in coastal areas where the frost penetration is only a few inches.

However, research over the past ten years, concerned with the engineering properties of muskeg, with which the writer has been associated, has shown that there is an appreciable increase in shearing strength with depth below the surface of muskeg, and also a corresponding decrease in moisture content and compressibility with depth. Moreover, both laboratory and field tests have shown that it is feasible to greatly improve the engineering properties of muskeg by consolidating it, for example by placing the weight of an embankment fill on it. It is essential, however, that the rate of application of the consolidating load should be sufficiently slow such that the muskeg will not be failed in shear before consolidation can occur. Practically this means that the embankment must be built up in stages of limited thickness. While it is possible to greatly improve the shearing strength of muskeg by consolidation a remaining difficulty is that comparatively high deflections must be accepted in order to develop the shearing strength.

Sufficient laboratory test data and field performance experience are now available to permit a reasonably accurate rational design to be made of the stability and deformation characteristics of embankments built on muskeg. No great difficulty is involved in heights of embankment less than about 10 feet. However, for greater heights more accurate determination of the muskeg properties at the actual site may be necessary to produce a safe design.

The inorganic soil, such as marl, silt, clay or sand, immediately underlying muskeg may also be a recent deposit geologically. It may, therefore, also only be consolidated under the submerged weight of the overlying muskeg plus a couple of feet of frozen soil and surface growth. Experience has shown that these inorganic soils immediately below the muskeg frequently are more difficult to handle, from the stability point of view of an embankment built on the surface, than is the muskeg itself. Almost invariably if a shearing failure does occur below an embankment it is seated in underlying inorganic soil rather than being confined to the muskeg. However, such failures due to the weight of embankments less than 10 feet in height are rare in areas of severe winter temperatures.

It has been noted above that the surface conditions in a muskeg area can vary from open water near the centre of the muskeg area through grass to shrubs and to heavy tree growth progressively towards the outer areas of the muskeg. These four classes of surface condition and growth do not always exist. As drainage from the muskeg area develops the open water will disappear and be taken over by grass growth. This may be followed progressively with time by the disappearance of grass and shrubs and the whole muskeg area is then covered with tree growth.

The engineering properties of muskeg, such as shearing strength and compressibility characteristics, vary considerably. However, experience has shown that, in terms of surface conditions and growth, the most stable muskeg from the point of view of strength occurs below tree growth, and the heavier the tree growth the better in the muskeg. It becomes progressively worse for surface growth of shrubs, and then grass, and below surface water it has the poorest quality.

PERMAFROST

Permafrost is defined as permanently frozen ground, or ground which remains frozen both summer and winter except for a surface skin which thaws during the summer. The surface skin of the permafrost which does thaw each summer is called the "active layer". Permafrost includes both soil and rock. It is known to occur in areas where the mean annual temperature of the ground surface is less than about 30°F. Permafrost occurs over a very extensive portion of Northern Canada.

It is not possible to correlate meteorological temperature data exactly with the occurrence of permafrost. The reason for this is that the actual ground surface mean annual temperature varies widely in a given locality, and reflects the direction of the topographic exposure, the nature of the surface growth and the exposure to prevailing winds. Attempts have been made by Canadian Government research authorities to draw on a map of Canada the boundary of the southern limit of permafrost. However, experience has shown that permafrost exists as much as a couple of hundred miles south of this so-called boundary.

A more realistic approach recognizes that permafrost will be of wide occurrence in any areas where the meteorological temperature records show the mean annual temperature to be below about 25°F. However, in areas where such records show the mean annual temperature to be between about 25° and 32°F sporadic permafrost will be encountered. In these latter areas, called fringe areas, much of the permafrost will be in a condition of degradation; that is, its temperature during the summer will be between 31° and 32°F, it may be partially thawed, and in terms of present long term climatic conditions it is gradually disappearing. The sporadic permafrost in the fringe areas is usually in a delicate state of equilibrium between the frozen and thawed conditions. As a consequence engineering construction which changes this delicate balance, such as by clearing an area of trees, stripping off the surface overburden, excavating into the frozen ground, paving an area, or building a heated building on the permafrost, is likely to result in complete thawing of the permafrost locally within a period of a few months. Moreover, heated buildings built on permafrost, or surface pavements using asphalt blacktop must be expected to result in local thawing of the permafrost even in colder areas north of the fringe zone.

Thawing of the permafrost in rock creates no problems. However, in soils such as muskeg, silt, clay or silty sands and gravels the process of their original freezing usually results in the sucking of water to the frost line and the formation of thin layers of pure ice known as ice lenses. This process of ice segregation in soils results in the soil becoming extremely unstable if and when it thaws. Moreover, after the ice lenses melt the water is gradually squeezed out of the soil and this results in settlement of the surface which may amount to anything from a few inches to several feet.

A further problem that arises in engineering work in permafrost areas is that re-freezing of the active layer each winter may be accompanied by ice segregation within the active layer. This produces heaving of the surface with subsequent settlement on thawing during the following summer.

In general with engineering construction in permafrost areas it is the problem of thawing of the permafrost, with the resultant settlement and the annual cycles of freezing and thawing in the active layer, that creates the most difficulties. Therefore, a general rule for construction in permafrost areas is that if at all possible the permafrost should be kept frozen if it is soil in which ice segregation has occurred, or if it will be soft and unstable when thawed. This is possible in areas where the mean annual temperature is below about 25°F, but becomes more difficult in the fringe areas, and close to its southerly limits it may be economically impossible to accomplish this.

INSPECTION OF PROPOSED RAILROAD ROUTE

The section of the proposed railroad route from Keno Hill to Skagway was inspected with Messrs. M. K. Boyle and Shelby Craig of Canadian Bechtel Limited between September 27 and October 1, 1962. Possible routes from Whitehorse to Skagway were inspected from a light aircraft, and the section from Whitehorse to Mayo Landing and Keno Hill was driven by car. A considerable amount of probing for permafrost was done on the trip and we had available to us the results of similar probing by Canadian Bechtel field personnel. The general muskeg and permafrost conditions were assessed, soil conditions at major river crossings were considered and the general soil stability conditions along the route were given attention.

CONCLUSIONS AND RECOMMENDATIONS

In the light of the above-noted general comments concerning muskeg and permafrost, and our observations during the inspection of the proposed railroad route from September 27 to October 1, 1962, the following conclusions and recommendations are submitted. Because of the very extensive geographic area involved, these are largely in general form. Pertinent detailed information is included but it should be appreciated that for final design purposes more detailed field data would be required at least at certain specific locations.

1. A large proportion of the area through which the railroad will be located is muskeg terrain. In the interests of maintaining satisfactory grades and alinement it will be essential that the grade be built on muskeg for a large proportion of the mileage.

2. All four types of muskeg based on surface growth and conditions, as noted above, exist along the route. That is, open water muskeg, grass, shrub and varying degree of height of black spruce growth all occur on the route. However, the area of black spruce growth, that is, the most stable muskeg, predominates. The moss in the area of spruce growth is predominantly sphagnum moss and generally occurs as a thick growth up to about 2 feet in thickness.

3. Probings during the inspection trip showed permafrost to exist below the moss in black spruce areas at all locations from Whitehorse north to Keno Hill. The thickness of the

active layer on September 29 and 30, 1962, varied from only about 3 inches to a maximum of about 5 feet in these black spruce areas. In any particular area the thickness of the active layer is affected by the insulating effect of the muskeg cover plus the shading effect of the tree growth. However, our field observations indicated that the insulation effect of the muskeg cover was the predominant factor.

4. Permafrost was not found below open water, in grassed areas near the centre of the muskegs, nor within a few feet of lakes and water courses.

5. The northern limit of the fringe area for permafrost appears to be about 50 to 75 miles north of Whitehorse on the Whitehorse-Mayo Landing road. The minimum thickness of active layer, (3 inches), was found along the highway about 100 miles north of Whitehorse. Whitehorse is in the fringe zone and in this area and as far west as the western slope of the Coast Range, the permafrost will be sporadic except near the summit of White Pass. However, from the area 50 to 75 miles north of Whitehorse to the mine, the permafrost will be general in occurrence, and it will be solid in nature, except below open water in muskegs, and within a few feet of lakes and water courses.

6. The general soil conditions from the point of view of bank stability and so forth are relatively good over the whole length of the route. They certainly are much better than further south along the Alaska Highway from Whitehorse.

7. No effort should be made to avoid muskeg or permafrost north of the fringe area for permafrost. However, the location should to the extent possible be selected so it is on the more stable muskeg, that is, through areas of muskeg supporting black spruce growth. In the location it will be essential to avoid open water in the centers of muskeg.

8. In the fringe area for permafrost the location should if possible avoid muskeg with permafrost below it. It is recognized, however, that it probably will not be feasible to do this. It is probable that the major soil problem in the construction of the railroad will be with construction of embankments on muskeg over degradading permafrost in the fringe areas. In locations of degradading permafrost in fringe areas there is no practical way of preventing rapid thawing and settlement of the soil within the depth of previously frozen soil, due to disturbance of the subsoil thermal balance which will result from clearing of the right-of-way and loss of insulation of the surface muskeg when it is disturbed or compacted by the weight of an embankment fill. The settlements and temporary loss in stability of the subsoil must be accommodated. This can best be accomplished by stage construction in which the clearing, grading and final track laying is spread over at least one winter and following summer, or preferably two winters and two summers. Furthermore, for ease of access it is essential that the clearing and initial stage of grade construction be done in the winter when the

muskeg is frozen. Freezing of the muskeg frequently does not occur until mid-winter. The following construction details for such fringe areas are recommended in the light of these factors:

(a) The right-of-way should be cleared during the winter.

(b) The surface moss should not be stripped off the area of the railroad embankment, or for that matter off any portion of the right-of-way, and no drainage ditches should be cut along the right-of-way. If drainage ditches are necessary they should be cut transversely across the right-of-way.

(c) A mat not less than three feet in thickness and not more than five feet in thickness, and with a top width not less than 30 feet should be placed as the initial lift for the railroad embankment before the spring break-up during the first winter when clearing is done. The material placed in the embankment can be any inorganic soil that is most readily available, but pit run gravel will be the most desirable material and wet highly plastic clay will be the least desirable material. The side slopes on this mat should not be steeper than 3:1. The material would not be compacted except for what will result from the earth-moving equipment.

(d) The embankment noted above in (c) would be allowed to sit until at least mid-September the following summer without any additional fill being placed on it. During the summer thawing of the permafrost below the embankment will occur and this will be accompanied by varying degrees of settlement possible to a maximum of a couple of feet. Experience has shown that thawing proceeds slowly and instability sufficient to produce a foundation failure does not occur because pore pressures dissipate as thawing slowly occurs. After mid-September in the first summer but before freeze-up the lift should be given not less than four passes with a vibratory roller, and the areas of settlement brought back up to grade with compacted inorganic soil. Immediately following this compaction and levelling operation the embankment can be built up to final grade to the elevation of the bottom of the ballast. This second lift should be inorganic material of the best economically available quality. The material for the second lift should be given standard compaction with vibratory rollers and should be built up to final grade with about a ten foot top and side slopes of 2:1.

(e) The final grade of the embankment should not be less than five feet above the original muskeg surface, and if the alinement requires an embankment in excess of ten feet in height, it will need to be given special design attention and its construction possibly will need to be done in three stages.

(f) If the construction schedule requires the completion of the railroad embankment in one year, then the ballast, ties and tracks can be placed immediately following completion of the second lift noted above in (d). However, it must be recognized that this would require track adjustment during the second summer to take up additional settlement. This would need to be done before the railroad was put into regular operation, and additional annual track adjustments would probably be required for the following two to three years.

(g) If the construction schedule can be spread over two years, the second lift noted above in (d) should be allowed to sit until about mid-September of the second summer. Any additional settlements that had occurred would then be taken up with compacted inorganic soil of good quality. The ballast, ties and rails could then be laid at any time. Even with a two year construction schedule it should be anticipated that track adjustments to take up additional settlements will be required for a year or two. These settlements, of course, would be taken up in the ballast.

(h) Culverts should be kept to a minimum in number and will need to be given detailed design consideration. Two principal problems are to be expected with culverts. First, they settle with the embankment and their grade is lost. Second, frost heaving can occur below them in the winter which can result in a dangerous "hump" in the track above the culvert. The first problem can be largely solved by placing the culverts just ahead of commencement of the second construction stage for the embankment, and providing a camber estimated from the magnitude of settlement under the first embankment stage. The second problem is more difficult to solve completely, but will be partially solved by the longer culverts required with the comparatively wide embankment base recommended.

(i) No side ditches should be excavated along the toes of the embankment. They would result in increased settlement of the embankment, would increase the hazard of a subsoil shearing failure below the embankment, and are unnecessary for surface drainage because the settlement produced by the embankment will create a natural surface ditch along the toes of the embankment.

(j) If local subsoil conditions should be encountered that are more severe than have been anticipated in the above-noted recommendations, to the extent that a subsoil shearing failure under the weight of the final embankment appears possible, the conditions can be compensated for by widening the base of the initial embankment lift as construction is underway.

9. In locations north of the fringe area for permafrost, that is, north from the area about 50 miles north of Whitehorse, it is recommended that the railroad embankment should be built so as to permanently retain the permafrost below the railroad embankment after construction of the railroad. This can be accomplished by means of a comparatively wide embankment base and a sufficient depth of fill so that adequate insulation is provided for the permafrost. The following construction details are recommended:

(a) The right-of-way should be cleared during the winter.

(b) The moss should <u>not</u> be stripped off the area of the railroad embankment, or for that matter off any portion of the right-of-way.

(c) A mat not less than three feet in thickness and not more than five feet in thickness and with a top width not less than 30 feet should be placed as the initial lift for the railroad embankment before the spring break-up the same year. This material can be any inorganic matedial most readily available, but pit run gravel will be the most desirable material and wet highly plastic clay will be the least desirable. The side slopes on this mat should not be steeper than 3:1. The material would not be compacted except for what will result from the earth-moving equipment.

(d) Following the spring break-up the lift should be given not less than four passes with a vibratory roller, and then the railroad embankment built up to final grade with about a ten foot top and side slopes of 2:1. The material for the final lift should be given standard compaction with vibratory rollers and should preferably be pit run gravel.

(e) If the final grade is more than 10 feet above the original ground surface the initial mat should not be less than 5 feet thick and its width should be increased to provide a berm not less than 8 feet wide from the toe of the upper lift.

(f) Culverts should be kept to a minimum in number and will need to be given special design consideration. The problem with culverts in areas where the intention is to retain the permafrost is that thawing can occur below them during the summer. This can result in settlement of the railroad grade. It can be overcome by insulating the underside of the culvert with moss.

(g) No side ditches should be excavated through muskeg areas. Ditches which cut through the natural surface cover of muskeg will precipitate thawing of the permafrost which in turn would result in settlement and sloughing of the embankment slopes. If surface drainage ditches are necessary they should be built along the outside edges of the right-of-way as far from the railroad grade as convenient.

10. Glaciation Problems - Experience with highway construction along the Alaska Highway has shown that on side hill construction glaciation is a major problem during the winter at locations where the cut intersects water-bearing strata. This will also be a problem with the proposed railroad embankment on side hills. The conditions at such locations will not always be identical and some will require detailed design attention. The condition is likely to be more severe in the fringe areas rather than in the heavy permafrost areas.

In general the solution is to catch the water in a drain before it discharges into freezing air temperatures, and then conduct it to the downhill side of the railroad grade in drains protected from freezing. Usually the water flows as seepage from relatively thin permeable strata in the backslope. In this case the backslope can be over-excavated along the water-bearing zone, a drain installed along the water-bearing layer and then the over-excavated slope and drain backfilled to a depth of not less than five feet. The drainage can be carried in a culvert, protected from frost by backfilling, across the uphill ditch and through the railroad embankment to discharge on as steep a slope as possible on the downhill side of the railroad.

Alternatively, the backslope seepage conditions may be such that horizontal drain pipes installed at intervals back into the face in the seepage zone will stop seepage from the face. These horizontal drains are about 2 inch diameter perforated pipes. Flow from them would be carried to the downhill side of the railroad grade in a frost-protected culvert as noted above.

In the case of seepage from a backslope on a comparatively flat side hill, it may be possible to cut off the seepage flow by an intercepting ditch in the natural slope above the railroad backslope.

It will thus be clear that the glaciation problem can arise from a variety of seepage conditions, and that a variety of solutions are possible depending upon the precise conditions at a particular location. However, in my experience the difficulties with glaciation on side hills along the Alaska Highway arose in the first instance because no attention whatsoever was given to the problem in the original design and construction. If the problem is recognized prior to or during construction it is usually possible at moderate expense to eliminate the glaciation hazard.

11. Mine Building and Living Quarters Foundations - The mine itself is in an area of heavy permafrost. Building foundations will need to be designed to suit these conditions. No problem will exist if buildings are built on rock foundations. Conventional foundation design can be used for this condition. However, if buildings are to be built on soil it will be essential that the usual precautions for foundations in permafrost areas be followed. In areas of heavy permafrost, such as at this location, this requires that no heated buildings be built resting on the surface.

The buildings must be built with no basements, and with the ground floor built above the ground surface so that air can circulate below the floor. The distance above the ground surface required for adequate air circulation to prevent thawing of the permafrost varies with the width of the building. In the locality of this mine about two feet would be required for buildings exceeding about fifty feet in width, but for buildings less than about thirty feet in width the space can be reduced to about one foot, and in this case a ribbed floor providing ducts for air circulation across the building can be satisfactorily used. The buildings can be carried on piles steam-jetted into the permafrost, or alternatively on spread footings. Piles should extend into the ground not less than ten feet, or to a depth of three times the active layer. The surface insulation naturally existing over the area of the building must be restored if it is damaged during construction, and the bottom of the floor must be thoroughly insulated to prevent heat from the floor radiating to the ground surface. Heating pipes or ducts below the floor must be similarly insulated. An alternative construction which has been successfully used could be to erect at least some buildings on a mat of mine tailings material. Heated floors would still need to be kept above the mat but the foundation could be spread footings in the mat.

12. Utility Lines - Utility lines such as water, sewer and heating lines can be carried below ground if in rock, but they must be insulated. In soil it is customary to carry all lines in a utilidor carried on piles above the ground in an insulated box.

13. River Crossings - Special problems with bridge foundations will exist in permafrost areas. However, these will not appreciably affect the overall costs of the bridge structures. In the fringe areas the bottom of the valleys will be free of permafrost, but degradading permafrost may be encountered on the valley sides, particularly on slopes with heavy surface growth on northern exposures. In such cases bridge pier foundations will need to be carried through the permafrost zone, probably using piled foundations.

In the more northerly zones, north of Whitehorse, permafrost is to be expected all across the valleys. In some cases no permafrost will exist immediately below the actual river channel, but in others permafrost will exist right across the valley floor. In this latter case the rivers usually freeze from the bottom up in the winter, and problems of uplift of the piers by frost action must be given special attention. Except for this uplift problem, the design of bridge piers in heavy permafrost areas can be based on the same principles as the design of foundations for unheated buildings on permafrost. The foundations are usually carried into the permafrost to a depth of about twice the thickness of the active layer that is estimated will occur under the surface conditions existing following the construction of the bridge. Special attention must therefore be given to the restoration of the surface insulation around bridge piers after construction.

All bridge sites will require a specific site subsoil investigation before final detailed bridge foundation designs can be made. However, based on the known general geology in the overall area of the project, it is unlikely that poor foundations for bridge piers will exist to any great depth below the surface.

14. Side Hill Construction of Railroad Embankments in Heavy Permafrost - In the more northerly sections of the railroad location where heavy permafrost exists, sidehill construction of the railroad grade will present difficulties. These will arise because the disturbance to the surface insulation conditions will induce a thicker active layer during the summer. This can lead to embankment foundation instability, backslope instability, and glaciation in the winter. Some locations will, undoubtedly, require special design attention, but in

general the basic principle that should be followed is to avoid disturbance of the natural permafrost regime to the greatest extent possible. This may well dictate the use of borrow material from off the right-of-way, instead of the usual practice of sidehill cut to provide the embankment fill material.

ENGINEERING CHARACTERISTICS OF MUSKEG AND PERMAFROST - There is available in the engineering literature a considerable amount of data on the shearing strength and compressibility characteristics of muskeg. The shearing strengths can best be determined by in-situ tests rather than laboratory tests. Portable vane testers or cone penetrometers in suitable form areavailable for in-situ tests. It has been shown that such in-situ strength tests do give reasonably reliable values as indicated by measurements taken for embankment failure conditions.

In general it is known that the shearing strength of muskeg varies from about 100 lbs. per sq. ft. to as much as 1000 lbs. per sq. ft. The strength increases with depth, but for depths of less than ten feet the average shearing strength seldom exceeds about 300 lbs. per sq. ft. These shearing strengths, however, can only be developed after comparatively large deformations occur. These deformations must be accommodated in the design and construction procedures.

Muskeg is highly compressible and settlement of from 20 to 50% of the thickness of the muskeg must be anticipated, depending upon the height of embankment placed. However, it is also definitely known that consolidation of the muskeg under the weight of an embankment always produces an increase in shearing strength in the muskeg. The rate of consolidation in the muskeg is comparatively rapid, and 75% of the settlement is usually complete within six months of the time of load application.

Experience has shown that muskegs in areas of severe winter climate will usually carry embankments up to a height of about 10 feet without a shearing failure in the foundation. For greater heights of fill it is essential to use stage construction, so that the shearing strength of the muskeg is built up in stages as the load is applied.

Experience has also shown that the inorganic soil immediately below the muskeg may be very soft and unstable. It may have a lower shearing strength than the overlying muskeg. This inorganic soil may also consolidate more slowly than the muskeg, and therefore a longer time is required to build up shearing strength in the inorganic soil than is required for the muskeg. It is therefore essential that in-situ shear vane or penetrometer tests be made on the inorganic soil immediately below the muskeg in foundation site surveys.

Permafrost in soil (as distinct from rock) usually contains segregated ice in thin layers. Therefore, if it thaws the soil usually is exceedingly unstable. It cannot be depended upon for any shearing strength. It drains slowly and settles appreciably as it drains. However, after it becomes drained and consolidated it can have sufficient shearing strength to carry the weight of embankments. It must be appreciated, however, that thawing permafrost is a very difficult material to handle in any construction activity. If at all possible conditions should be avoided where excavation into permafrost is required during construction.

LITERATURE

A bibliography of articles in the engineering literature pertinent to the problems on this project arising from the muskeg and permafrost conditions is attached herewith as Appendix I. The construction practice under both muskeg and permafrost conditions has varied considerably over the years, and many procedures which have been used are diametrically opposed in principle to those used by others. One of the main reasons for this is that the practice has built up largely on an empirical basis without the benefit of an understanding of basic principles.

One of the most controversial points is whether or not to drain muskegs before construction of embankments. Practice in the past has favoured drainage. However, it must be appreciated that this practice has usually involved summer construction work. Our recommendations, in which drainage of muskegs is opposed previous to construction of embankments, is based on winter construction. We have found the recommended procedures to be completely satisfactory on several separate projects. In particular, it has proven to be completely feasible and very economical on the construction of eleven miles of dikes largely on muskeg on the Brazeau Power Project in Western Alberta. These dikes varied in height to a maximum of about twenty feet.

Respectfully submitted,

R. M. HARDY & ASSOCIATES LTD.,

Per: R. M. Hardy

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Consultant.

RMH:bw

10214 - 112 Street,
Edmonton, Alberta,
December 13, 1962.

R.M.H

APPENDIX I

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APPENDIX I

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<u>Abbreviations</u>

N.R.C., D.B.R. - National Research Council of Canada, Ottawa, Division of Building Research.

H.R.B. - Highway Research Board, Washington, D.C.

A.S.C.E. - American Society of Civil Engineers.

APPENDIX C

APPENDIX C

LIST OF SHIPPING COST TABLES

Table			
7A	To Piombino, Italy	from Haines, Alaska	
7B		from San Juan, Peru	
7C		from Seven Islands, Quebec	
7D		from Puerto Ordaz, Venezuela	
7E		from Port Entienne, French West Africa	
7F		from Vitoria, Brazil	
8A	To Philadelphia, Pennsylvania	from San Juan, Peru	
8B		from Seven Islands, Quebec	
8C		from Puerto Ordaz, Venezuela	
8D		from Port Entienne, French West Africa	
8E		from Vitoria, Brazil	
9A	To Morrisville, Pennsylvania	from San Juan, Peru	
9B		from Seven Islands, Quebec	
9C		from Puerto Ordaz, Venezuela	
9D		from Port Entienne, French West Africa	
9E		from Vitoria, Brazil	

APPENDIX C

COST OF OCEAN TRANSPORT
REPORT BY JOSHUA HENDY CORPORATION

Appendix C contains the estimates and comments of Joshua Hendy Corporation concerning shipping costs for iron ore from Haines, Alaska to selected world markets and comparable costs for shipments from other potential sources of ore. Costs include present day operating expenses, amortisation of capital and interest on investment, port charges, fuel, and insurance. Overhead costs and escalation have not been included in costs shown in the appendix. Joshua Hendy letter of November 5, 1962, included herein, recommends an overhead allowance of $100 per vessel day which is included in the summary tables of Section 8 of the main report. The Joshua Hendy recommendations for escalation have not been included since escalation of all costs is made in the project cost summaries of Section 9. No allowance has been included for profit in either the summary tables or cost breakdowns. The cost breakdowns are shown in this appendix in U. S. dollars since U. S. currency is widely used in international trade but all unit costs in the summary tables of Section 8 are shown in Canadian funds. Conversion may be made on the October, 1962 midrate of 7-1/8% premium on the U. S. dollar.

Operating and capital costs from Haines to foreign markets are based on using ships of foreign flag and construction. Cost for shipments from Haines to the United States ports are based on using ships of U. S. flag and construction.

Shipping costs were determined for several vessel classes and capital write-off periods of 10, 15 and 20 years. Of the four classes of vessels considered, the 35,400-ton Rio and 50,343-ton Neptune classes, are currently in service as ocean ore carriers. The two larger classes, 69,000 tons and 100,000 tons would constitute new building but the shipping industry anticipates the use of these larger vessels by 1970. Construction of 69,000-ton ore carriers presently is under way and the shipping industry anticipates the use of 100,000-ton vessels by 1970.

Included in this comparative study are shipping costs from Port Hedland, Australia, the shipping port for an iron ore project currently under development. The study includes costs based on large class vessels. These vessels, however, will not be able to enter Port Hedland as it is now being built. Because of draught limitations, the port will not be able to handle vessels larger than 40, 000 deadweight tons. Plans for further increasing the harbour depth are not known but it is understood that this would constitute a major undertaking.

Backhaul of oil also was investigated for the San Juan, Peru to Tabata, Japan, and the Haines to Tabata runs. Costs for each case were determined on the basis of backhauling oil from Sumatra or Bahrein to San Francisco. The summary tables and cost breakdowns give the net cost per long ton of ore for each alternative after deducting oil revenues.

JOSHUA HENDY CORPORATION
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LOS ANGELES 17, CALIFORNIA

November 5, 1962

Mr. R. A. Cheatham, Manager
Industrial Plant Engineering
Bechtel Corporation
101 California Street
San Francisco 11, California

Dear Mr. Cheatham:

Many thanks for your letters of October 17 and November 1, 1962.

We will try to give you as concisely as possible our opinion of the factors which may effect the figures previously given to you covering the cost of delivering ore between various ports in the world. You will recognize that the state of shipping is such at the present time as to make mathematical predictions of the future based on past results very difficult and practically impossible. Therefore, the factors we give to you are based on our own judgment and experience and are admittedly best guesses.

In order that you may clearly understand the range of prices we gave you and its relation to the market, we should explain that the normal expected life of a ship is twenty years. The figures we have given you for a twenty year payout, therefore, are the actual cost of delivering ore at the present time with present shipbuilding prices and operating costs and with no profit or management fees.

The shipbuilding market at the present time is so depressed that it is possible to obtain chartered vessels in the market at prices about equivalent to a twenty year payout without profit. Under what might be considered normal circumstances, it might be anticipated that long term arrangements could be made with an independent shipping company at prices equivalent to a ten year payout for the vessels. Although it is difficult to predict, we anticipate that more normal conditions will exist by 1970 and, therefore, the ten year payout figures for all foreign shipping would be a reasonable anticipation of the market at that time, corrected only by anticipated increases in shipbuilding costs and operating costs which we will discuss separately.

These conditions are true if taxes are not taken into consideration. In the case of operation of a U. S. flag vessel which would be required as indicated in our summary for delivery to U. S. ports from Alaska, the Bureau of Internal Revenue allows depreciation on vessels on a twenty years basis. Therefore, the figures shown in our tables for a twenty year payout are correct even if taxes are taken into consideration. For fifteen year and ten year payouts, the figures shown in our tables are misleading since the effect of present corporate taxes would require higher delivered costs for the ore in these two cases. On the assumption of average interest over the period of amortization and existing U.S. corporate tax rates, the corrected figures taking taxes into account are, therefore, about as follows:

	Years	Ore 35,400 Dwt.	Ore 50,343 Dwt.	Ore 69,000 Dwt.
U.S. - San Francisco	10	3.00	2.40	2.13
	15	2.35	1.87	1.64
	20	2.02	1.60	1.40
U.S. - Los Angeles	10	3.49	2.78	2.44
	15	2.73	2.16	1.88
	20	2.34	1.85	1.60
U.S. - Mobile	10	10.78	9.23	9.39
	15	8.52	7.26	7.36
	20	7.37	6.28	6.36
U.S. - Baltimore	10	11.54	9.86	9.98
	15	9.07	7.74	7.81
	20	7.84	6.68	6.73

In 1970, if the producing ore company decides to operate vessels for its own account with no profit in the operation of its vessels, then the figure shown in the summary for a twenty year payout can be maintained, corrected only for increases in shipbuilding and operating costs in the interim as mentioned below plus an allowance of about $100 per ship day for the cost of management.

The present state of shipping and shipbuilding is such as to make past records impossible to use for future predictions and, therefore, the situation in 1970 can only be based on an educated guess which is, in turn, based on our experience in shipping. However, our opinions and the reasons for them are as follows:

1. Shipbuilding Costs

The present shipbuilding prices are extremely low. In fact, if actual costs of building ships is taken into consideration, they are artificially low. This is due to the fact that an excess of shipbuilding capacity exists in the world as compared to demand. The result is that shipbuilders are willing to take prices which include no shipbuilding profit whatsoever and even in some cases, at a loss in order to keep their organizations busy. The actual cost of shipbuilding labor throughout the world has continued to increase during the past few years even though prices have been reduced. So long as the surplus of ships exists, this condition will continue. Present indications are that if no war or serious international disturbance intervenes for a protracted period, shipbuilding prices will probably stay low for another three to five years.

Corrective forces are, of course, at work in the form of reduction of shipbuilding capacity by failures and bankruptcy and in the form of ship scrapping which will eventually bring supply and demand into balance and produce an eventual rise in prices.

On the other side of the picture, the continued increase in shipbuilding labor costs should be somewhat offset by increased use of automation and new capital investments in shipbuilding plant. In view of all of this, no pattern exists in the past to serve as a mathematical basis for production for the future.

With this in mind, we believe shipbuilding prices will remain low for the next three or four years but will then gradually increase. By 1970, we believe it is reasonable to expect that the price of ships will be between 10% and 20% above present prices.

2. Operating Costs

The labor component of ship operating costs as indicated by wage rates has constantly increased over the past several years throughout the world and shows no signs of reducing. As the standard of living of Europeans continues to increase, wages of all labor, especially that of seamen, will undoubtedly continue this upward trend.

Countering this, however, is a trend of very recent origin toward shipboard automation and a resulting reduction in the number of personnel employed aboard ships. Taking both factors into account, we believe operating costs will continue to increase gradually over the next few years and that by 1970, this increase will be between 10% and 15% above present costs.

The original summary we gave to you gave a true comparison of moving ore from Alaska to various places as to competitive movements from different sources all based on the same assumptions. It is, therefore, a relative competitive picture. Any factors which apply to the cost of moving ore from Alaska will, of course, similarly apply to the others and so the competitive picture will remain the same. For simplification, however, if you desire to approximate conditions in 1970, we suggest you merely add 15% to the various rates shown.

We hope the above gives you all that you need at the present time. If you desire anything further, we will be happy to supply it.

Yours very truly,

JOSHUA HENDY CORPORATION

T. W. Anderson
Vice President

TWA/jm

TABLE 1A

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN
PORT OF ORIGIN: HAINES, ALASKA

Vessel Class	RIO			NEPTUNE		
Deadweight Tonnage (LT		35,400			50,343	
Voyage Distance (mi)		8,242			8,242	
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers
Travel	611		1,375	568		1,799
Load and Unload	72		36	72		42
Delays	12		9	12		9
Total Hours/RT	695 Hrs.		1,420 LT	652 Hrs.		1,850 LT
Total Days/RT		28.958 Days			27.166 Days	
RT/Yr. (351 Operating Days)		12.121			12.920	
Cargo Dwt.						
Dwt. Vessel	35,400			50,353		
C&S	150			150		
F/W	100			100		
Bunkers	870			1,150		
Cargo Dwt. Summer	34,280			48,953		
Cargo Dwt. Winter	33,274			47,477		
Annual Average Cargo/Vessel	33,777			48,215		
Annual Cargo Tons/Vessel	409,411			622,938		
Operating Costs						
Basis: Operating Cost/Day	$1,280			$1,454		
Bunker Source	Tabata			Tabata		
Bunker Cost/LT	$18.62			$18.62		
T/C Ins./Day	$30.00			$35.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 37,066	$ 37,066	$ 37,066	$ 39,499	$ 39,499	$ 39,499
T/C Ins./RT	869	869	869	951	951	951
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500
Port Charges: Market	2,500	2,500	2,500	2,700	2,700	2,700
Bunkers	26,440	26,440	26,440	34,447	34,447	34,447
Total Operating/RT	68,875	68,875	68,875	80,127	80,127	80,127
Amortization and Interest	53,254	39,238	32,259	60,906	44,878	36,891
Total Cost/RT	$122,129	$108,113	$101,134	$141,033	$125,005	$117,018
Net Cost/LT ore (US $)	$3.62	$3.20	$2.99	$2.39	$2.59	$2.43
Net Cost/LT ore (Canadian $)	$3.90	$3.45	$3.22	$3.15	$2.79	$2.62

TABLE IA (CONTINUED)

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN
PORT OF ORIGIN: HAINES, ALASKA

Vessel Class	NEW BUILDING			NEW BUILDING		
Deadweight Tonnage (LT		69,000			100,000	
Voyage Distance (mi)		8,242			8,242	
Voyage RT Time and Fuel	Time		Bunker	Time		Bunker
Travel	500		2,333	500		2,708
Load and Unload	96		48	120		90
Delays	12		9	12		13
Total Hours/RT	608 Hrs.		2,390 LT	632 Hrs.		2,811 LT
Total Days/RT		25.333 Days			26.333 Days	
RT/Yr. (351 Operating Days)		13.855			13.329	
Cargo Dwt.						
Dwt. Vessel	69,000			100,000		
C&S	150			150		
F/W	100			100		
Bunkers	1,500			1,795		
Cargo Dwt. Summer	67,250			97,955		
Cargo Dwt. Winter	65,380			94,847		
Annual Average Cargo/Vessel	66,315			96,401		
Annual Cargo Tons/Vessel	918,794			1,284,928		
Operating Costs						
Basis: Operating Cost/Day	$1,689			$2,055		
Bunker Source	Tabata			Tabata		
Bunker Cost/LT	$18.62			$18.62		
T/C Ins. /Day	$40.00			$45.00		
Payour Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$42,787	$42,787	$42,787	$54,114	$54,114	$54,114
T/C Ins. /RT	1,013	1,013	1,013	1,185	1,185	1,185
Port Charges: Origin	3,000	3,000	3,000	3,500	3,500	3,500
Port Charges: Market	3,000	3,000	3,000	3,500	3,500	3,500
Bunkers	44,501	44,501	44,501	52,340	52,340	52,340
Total Operating/RT	$95,301	95,301	95,301	114,639	114,639	114,639
Amortization and Interest	71,337	52,565	43,192	102,593	75,628	62,145
Total Cost/RT	$166,638	$147,866	$138,492	$217,232	$190,267	$176,784
Net Cost/LT ore (US $)	$2.51	$2.23	$2.09	$2.25	$1.97	$1.83
Net Cost/LT ore (Canadian $)	$2.70	$2.40	$2.25	$2.42	$2.12	$1.97

TABLE 1B

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN
PORT OF ORIGIN: SAN JUAN, PERU

Vessel Class	RIO		NEPTUNE	
Deadweight Tonnage (LT)	35,400		50,343	
Voyage Distance (mi)	17,266		17,266	
Voyage RT Time and Fuel	Time	Bunker	Time	Bunker
Travel	1,279	2,878	1,191	3,771
Load and Unload	72	36	72	42
Delays	12	9	12	9
Total Hours/RT	1,363 Hrs.	2,923 LT	1,275 Hrs.	3,822 LT
Total Days/RT	56.791 Days		53.125 Days	
RT/Yr. (351 Operating Days)	6.180		6.607	
Cargo Dwt.				
Dwt. Vessel	35,400		50,353	
C&S	150		150	
F/W	100		100	
Bunkers	1,620		2,150	
Cargo Dwt. Summer	33,530		47,953	
Cargo Dwt. Winter	33,530		47,953	
Annual Average Cargo/Vessel	33,530		47,953	
Annual Cargo Tons/Vessel	207,216		316,825	
Operating Costs				
Basis: Operating Cost/Day	$1,280		$1,454	
Bunker Source	San Juan		San Juan	
Bunker Cost/LT	$18.62		$18.62	
T/C Ins. /Day	$30.00		$35.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.
Operating Cost/RT	$ 72,692	$ 72,692	$ 72,692	$ 77,244	$ 77,244	$ 77,244
T/C Ins. /RT	1,704	1,704	1,704	1,859	1,859	1,859
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,500	2,500	2,500	2,700	2,700	2,700
Bunkers	54,426	54,426	54,426	71,166	71,166	71,166
Total Operating/RT	132,322	132,322	132,322	153,969	153,969	153,969
Amortization and Interest	104,439	76,952	63,265	119,106	87,763	72,144
Total Cost/RT	$236,761	$209,274	$194,587	$273,075	$241,732	$226,113
Net Cost/LT ore (US $)	$7.06	$6.25	$5.80	$5.69	$5.04	$4.72
Net Cost/LT ore (Canadian $)	$7.60	$6.73	$6.24	$6.13	$5.43	$5.08

TABLE 1B (CONTINUED)

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN

PORT OF ORIGIN: SAN JUAN, PERU

Vessel Class	NEW BUILDING		NEW BUILDING	
Deadweight Tonnage (LT)	69,000		100,000	
Voyage Distance (mi)	17,266		17,266	
Voyage RT Time and Fuel	Time	Bunker	Time	Bunker
Travel	1,046	4,881	1,046	5,665
Load and Unload	96	48	120	90
Delays	12	9	12	13
Total Hours/RT	1,154 Hrs.	4,938 LT	1,178 Hrs.	5,768 LT
Total Days/RT	48.083 Days		49.083 Days	
RT/Yr. (351 Operating Days)	7.300		7.151	
Cargo Dwt.				
Dwt. Vessel	69,000		100,000	
C&S	150		150	
F/W	100		100	
Bunkers	2,775		3,275	
Cargo Dwt. Summer	65,975		96,475	
Cargo Dwt. Winter	-		-	
Annual Average Cargo/Vessel	65,975		96,475	
Annual Cargo Tons/Vessel	481,617		689,892	
Operating Costs				
Basis: Operating Cost/Day	$1,689		$4,055	
Bunker Source	San Juan		San Juan	
Bunker Cost/LT	$18.62		$18.62	
T/C Ins. /Day	$40.00		$45.00	

Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 81,212	$ 81,212	$ 81,212	$100,865	$100,865	$100,865
T/C Ins. /RT	1,923	1,923	1,923	2,206	2,206	2,206
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	3,000	3,000	3,000	3,500	3,500	3,500
Bunkers	91,945	91,945	91,945	107,251	107,251	107,251
Total Operating/RT	179,080	179,080	179,080	214,822	214,822	214,822
Amortization and Interest	135,401	99,772	81,981	191,227	140,966	115,835
Total Cost/RT	$314,481	$278,852	$261,061	$406,049	$355,788	$330,657
Net Cost/LT ore (US $)	$4.77	$4.23	$3.96	$4.21	$3.69	$3.43
Net Cost/LT ore (Canadian $)	$5.14	$4.55	$4.26	$4.53	$3.97	$3.69

TABLE 1C

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN
PORT OF ORIGIN: VICTORIA, BRAZIL

Vessel Class	RIO		NEPTUNE	
Deadweight Tonnage (LT)	35,400		50,343	
Voyage Distance (mi.)	25,022		25,022	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers
Travel	1,853	4,169	1,726	5,465
Load and Unload	72	36	72	42
Delays	24	18	24	21
Total Hours/RT	1,949 Hrs.	4,223 LT	1,822 Hrs.	5,528 LT
Total Days/ RT	81.208 Days		75.916 Days	
RT/Yr. (351 Operating Days)	4.322		4.623	
Cargo Dwt.				
Dwt. Vessel	35,400		50,343	
C&S	150		150	
F/W	100		100	
Bunkers	2,325		3,063	
Cargo Dwt. Summer	32,825		47,030	
Cargo Dwt. Winter	31,819		45,554	
Annual Average Cargo/Vessel	32,322		46,292	
Annual Cargo Tons/Vessel	139,695		214,007	
Operating Costs				
Basis: Operating Cost/Day	$1,280		$1,454	
Bunker Source	Tabata		Tabata	
Bunker Cost/LT	$18.62		$18.62	
T/C Ins. /Day	$30.00		$35.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.
Operating Cost/RT	$103,946	$103,946	$103,946	$110,383	$110,383	$110,383
T/C Ins. /RT	2,436	2,436	2,436	2,657	2,657	2,657
Port Charges: Origin	2,600	2,600	2,600	3,100	3,100	3,100
Port Charges: Market	2,500	2,500	2,500	2,700	2,700	2,700
Bunkers	78,632	78,632	78,632	102,932	102,932	102,932
Total Operating/RT	190,114	190,114	190,114	221,772	221,772	221,772
Amortization and Interest	149,341	110,036	90,465	170,204	125,413	103,094
Total Cost/RT	$339,455	$300,150	$280,579	$391,976	$347,185	$324,866
Net Cost/LT ore (US $)	$10.50	$9.29	$8.68	$8.47	$7.50	$7.02
Net Cost/LT ore (Canadian $)	$11.31	$10.00	$9.35	$9.12	$8.08	$7.56

TABLE 1C (CONTINUED)

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN

PORT OF ORIGIN: VICTORIA, BRAZIL

Vessel Class	NEW BUILDING		NEW BUILDING	
Deadweight Tonnage (LT)	69,000		100,000	
Voyage Distance (mi.)	25,022		25,022	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers
Travel	1,517	7,078	1,517	8,216
Load and Unload	96	48	120	90
Delays	24	18	24	27
Total Hours/RT	1,637 Hrs.	7,144 LT	1,661 Hrs.	8,333 LT
Total Days/RT	68.208 Days		69.208 Days	
RT/Yr. (351 Operating Days)	5.146		5.071	
Cargo Dwt.				
Dwt. Vessel	69,000		100,000	
C&S	150		150	
F/W	100		100	
Bunkers	4,020		4,500	
Cargo Dwt. Summer	64,730		95,250	
Cargo Dwt. Winter	62,860		92,142	
Annual Average Cargo/Vessel	63,795		93,696	
Annual Cargo Tons/Vessel	328,289		475,132	
Operating Costs				
Basis: Operating Cost/Day	$1,689		$2,055	
Bunker Source	Tabata		Tabata	
Bunker Cost/LT	$18.62		$18.62	
T/C Ins./Day	$40.00		$45.00	

Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$115,203	$115,203	$115,203	$142,222	$142,222	$142,222
T/C Ins. RT	2,728	2,728	2,728	3,114	3,114	3,114
Port Charges: Origin	4,000	4,000	4,000	5,200	5,200	5,200
Port Charges: Market	3,000	3,000	3,000	3,500	3,500	3,500
Bunkers	133,022	133,022	133,022	155,160	155,160	155,160
Total Operating/RT	257,953	257,953	257,953	309,196	309,196	309,196
Amortization and Interest	192,142	141,600	116,363	269,634	198,765	163,330
Total Cost/RT	$450,095	$399,553	$374,316	$578,830	$507,961	$472,526
Net Cost/LT ore (US $)	$7.06	$6.26	$5.87	$6.18	$5.42	$5.04
Net Cost/LT ore (Canadian $)	$7.60	$6.74	$6.32	$6.65	$5.84	$5.43

TABLE 1D

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN
PORT OF ORIGIN: PORT HEDLAND, AUSTRALIA

Vessel Class	RIO		NEPTUNE	
Deadweight Tonnage (LT)	35,400		50,343	
Voyage Distance (mi.)	6,892		6,892	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers
Travel	511	1,150	475	1,504
Load and Unload	72	36	72	42
Delays	12	9	12	9
Total Hours/RT	595 Hrs.	1,195 LT	559 Hrs.	1,555 LT
Total Days/RT	24.782 Days		23.292 Days	
RT/Yr. (351 Operating Days)	14.157		15.069	
Cargo Dwt.				
Dwt. Vessel	35,400		50,343	
C&S	150		150	
F/W	100		100	
Bunkers	760		1,003	
Cargo Dwt.	34,490		49,090	
Annual Average Cargo/Vessel	34,490		49,090	
Annual Cargo Tons/Vessel	485,443		739,737	
Operating Costs				
Basis: Operating Cost/Day	$1,280		$1,454	
Bunker Source	Tabata		Tabata	
Bunker Cost/LT	$18.62		$18.62	
T/C Ins./Day	$30.00		$35.00	

	RIO			NEPTUNE		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 31,734	$ 31,734	$ 31,734	$ 33,867	$ 33,867	$ 33,867
T/C Ins. /RT	744	744	744	815	815	815
Port Charges: Origin	2,900	2,900	2,900	3,000	3,000	3,000
Port Charges: Market	2,500	2,500	2,500	2,700	2,700	2,700
Bunkers	22,251	22,251	22,251	28,954	28,954	28,954
Total Operating/RT	60,129	60,129	60,129	69,336	69,336	69,336
Amortization and Interest	45,592	33,593	27,618	52,221	38,478	31,631
Total Cost/RT	$105,721	$ 93,722	$ 87,747	$121,557	$107,814	$100,967
Net Cost/LT ore (US $)	$3.08	$2.73	$2.56	$2.48	$2.20	$2.06
Net Cost/LT ore (Canadian $)	$3.32	$2.94	$2.76	$2.67	$2.37	$2.22

TABLE 1D (CONTINUED)

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN
PORT OF ORIGIN: PORT HEDLAND, AUSTRALIA

Vessel Class	NEW BUILDING		NEW BUILDING	
Deadweight Tonnage (LT)	69,000		100,000	
Voyage Distance (mi.)	6,892		6,892	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers
Travel	418	1,950	418	2,264
Load and Unload	96	48	120	90
Delays	12	9	12	13
Total Hours/RT	526 Hrs.	2,007 LT	550 Hrs.	2,367 LT
Total Days/RT	21.917 Days		22.917 Days	
RT/Yr. (351 Operating Days)	16.014		15.316	
Cargo Dwt.				
Dwt. Vessel	69,000		100,000	
C&S	150		150	
F/W	100		100	
Bunkers	1,340		1,575	
Cargo Dwt.	67,410		98,175	
Annual Average Cargo/Vessel	67,410		98,175	
Annual Cargo Tons/Vessel	1,079,503		1,503,648	
Operating Costs				
Basis: Operating Cost/Day	$1,689		$2,055	
Bunker Source	Tabata		Tabata	
Bunker Cost/LT	$18.62		$18.62	
T/C Ins. /Day	$40.00		$45.00	

Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 37,018	$ 37,018	$ 37,018	$ 47,094	$ 47,094	$ 47,094
T/C Ins. /RT	877	877	877	1,031	1,031	1,031
Port Charges: Origin	3,100	3,100	3,100	3,200	3,200	3,200
Port Charges: Market	3,000	3,000	3,000	3,500	3,500	3,500
Bunkers	37,370	37,370	37,370	44,074	44,074	44,074
Total Operating/RT	81,365	81,365	81,365	98,899	98,899	98,899
Amortization and Interest	61,740	45,500	37,390	89,285	65,818	54,084
Total Cost/RT	$143,105	$126,865	$118,755	$188,184	$164,717	$152,983
Net Cost/LT ore (US $)	$2.12	$1.88	$1.76	$1.92	$1.68	$1.56
Net Cost/LT ore (Canadian $)	$2.28	$2.02	$1.89	$2.07	$1.81	$1.68

TABLE IE

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN
PORT OF ORIGIN: HAINES, ALASKA
OIL BACKHAUL: SUMATRA

Vessel Class	NEPTUNE		NEW BUILDING		NEW BUILDING	
Deadweight Tonnage (LT)	50,343		69,000		100,000	
Voyage Distance (mi.)	16,058		16,058		16,058	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	1,107	3,504	974	4,545	974	5,275
Load and Unload	144	152	192	186	216	267
Delays	24	21	24	18	24	27
Total Hours/RT	1,275 Hrs.	3,677 LT	1,190 Hrs.	4,749 LT	1,214 Hrs.	5,569 LT
Total Days/RT	53.125 Days		49.583 Days		50.583 Days	
RT/Yr. (351 Operating Days)	6.607		7.079		6.939	

Cargo Dwt.	Ore	Oil	Ore	Oil	Ore	Oil
Dwt. Vessel	50,343	50,343	69,000	69,000	100,000	100,000
C&S	150	150	150	150	150	150
F/W	100	100	100	100	100	100
Bunkers	1,127	1,913	1,500	2,515	1,745	2,920
Cargo Dwt. Summer	48,966	48,180	67,250	66,235	98,005	96,830
Cargo Dwt. Winter	47,490	-	65,774	-	94,897	-
Annual Average Cargo/Vessel	48,228	48,180	66,512	66,235	96,451	96,830
Annual Cargo Tons/Vessel	318,642	318,325	470,838	468,878	669,273	671,903

Operating Costs	NEPTUNE	NEW BUILDING	NEW BUILDING
Basis: Operating Cost/Day	$1,483	$1,728	$2,112
Bunker Source -	Tabata/San Francisco	Tabata/San Francisco	Tabata/San Francisco
Bunker Cost/LT - Tabata	$18.62	$18.62	$18.62
Bunker Cost/LT - San Francisco	$15.08	$15.08	$15.08
T/C Ins./Day	$35.00	$40.00	$45.00

Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 78,784	$ 78,784	$ 78,784	$ 85,679	$ 85,679	$ 85,679	$106,831	$106,831	$106,831
T/C Ins./RT	1,859	1,859	1,859	1,983	1,983	1,983	2,276	2,276	2,276
Port Charges: Haines	3,000	3,000	3,000	3,000	3,000	3,000	3,500	3,500	3,500
Port Charges: Tabata	2,700	2,700	2,700	3,000	3,000	3,000	3,500	3,500	3,500
Port Charges: Sumatra	2,000	2,000	2,000	2,500	2,500	2,500	2,500	2,500	2,500
Port Charges: San Francisco	2,500	2,500	2,500	3,000	3,000	3,000	3,000	3,000	3,000
Bunkers - Tabata	42,677	42,677	42,677	55,339	55,339	55,339	64,239	64,239	64,239
Bunkers - San Francisco	20,886	20,886	20,886	26,797	26,797	26,797	31,954	31,954	31,954
Total Operating/RT	154,406	154,406	154,406	181,298	181,298	181,298	217,800	217,800	217,800
Amortization and Interest	129,041	95,094	78,147	152,369	112,305	92,274	215,837	159,083	130,706
Total Cost/RT	$283,447	$249,500	$232,553	$333,667	$293,603	$273,572	$433,637	$376,883	$348,506
Net Oil Revenue (A.T.R.S. -70 + 1-1/4%)	152,008	152,008	152,008	208,971	208,971	208,971	305,499	305,499	305,499
Net Cost Ore	$131,439	$ 97,492	$ 80,545	$124,696	$ 84,632	$ 64,601	$128,138	$ 71,384	$ 43,007
Net Cost/LT ore (US $)	$2.73	$2.02	$1.67	$1.87	$1.27	$ .97	$1.33	$ .74	$ .45
Net Cost/LT ore (Canadian $)	$2.94	$2.17	$1.80	$2.01	$1.37	$1.04	$1.43	$ .80	$ .48

TABLE 1F

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN
PORT OF ORIGIN: HAINES, ALASKA
OIL BACKHAUL: BAHREIN

Vessel Class	NEPTUNE			NEW BUILDING			NEW BUILDING		
Deadweight Tonnage	50,343			69,000			100,000		
Voyage Distance (mi.)	16,058			16,058			16,058		
Voyage RT Time and Fuel	Time	Bunkers		Time	Bunkers		Time	Bunkers	
Travel	1,568	5,004		1,379	6,435		1,379	7,468	
Load and Unload	144	152		192	186		216	267	
Delays	24	21		24	18		24	27	
Total Hours/RT	1,736 Hrs.	5,177 LT		1,595 Hrs.	6,639 LT		1,619 Hrs.	7,762 LT	
Total Days/RT	72.333 Days			66.458 Days			67.458 Days		
RT/Yr. (351 Operating Days)	4.852			5.281			5,203		
Cargo Dwt.	Ore	Oil		Ore	Oil		Ore	Oil	
Dwt. Vessel	50,343	50,343		69,000	69,000		100,000	100,000	
C&S	150	150		150	150		150	150	
F/W	100	100		100	100		100	100	
Bunkers	1,127	2,638		1,500	3,450		1,745	4,000	
Cargo Dwt. Summer	48,966	47,460		67,250	65,300		98,005	95,750	
Cargo Dwt. Winter	47,490	-		65,774	-		94,897	-	
Annual Average Cargo/Vessel	48,228	47,460		66,512	65,300		96,451	95,750	
Annual Cargo Tons/Vessel	234,002	230,275		351,250	344,849		501,834	498,187	
Operating Costs									
Basis: Operating Cost/Day	$1,483			$1,728			$2,112		
Bunker Source	Tabata/Bahrein/San Francisco			Tabata/Bahrein/San Francisco			Tabata/Bahrein/San Francisco		
Bunker Cost/LT - Tabata	$18.62			$18.62			$18.62		
Bunker Cost/LT - Bahrein	$12.30			$12.30			$12.30		
Bunker Cost/LT - San Francisco	$15.08			$15.08			$15.08		
T/C Ins. /Day	$35.00			$40.00			$45.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$107,270	$107,270	$107,270	$114,839	$114,839	$114,839	$142,471	$142,471	$142,471
T/C Ins. /RT	2,532	2,532	2,532	2,658	2,658	2,658	3,035	3,035	3,035
Port Charges: Haines	3,000	3,000	3,000	3,000	3,000	3,000	3,500	3,500	3,500
Port Charges: Tabata	2,700	2,700	2,700	3,000	3,000	3,000	3,500	3,500	3,500
Port Charges: Bahrein	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Port Charges: San Francisco	2,500	2,500	2,500	3,000	3,000	3,000	3,000	3,000	3,000
Bunkers: Tabata	42,677	42,677	42,677	32,585	32,585	32,585	37,817	37,817	37,817
Bunkers: Bahrein	29,557	29,557	29,557	38,278	38,278	38,278	44,427	44,427	44,427
Bunkers: San Francisco	20,886	20,886	20,886	26,797	26,797	26,797	31,954	31,954	31,954
Total Operating/RT	213,622	213,622	213,622	226,657	226,657	226,657	272,204	272,204	272,204
Amortization and Interest	175,697	129,476	106,402	204,225	150,527	123,678	287,843	212,155	174,311
Total Cost/RT	$389,319	$343,098	$320,024	$430,882	$377,184	$350,335	$560,047	$484,359	$446,515
Net Oil Revenue (A.T.R.S.-70 + 1-1/4%)	213,000	213,000	213,000	293,066	293,066	293,066	429,726	429,726	429,726
Net Cost Ore	$176,319	$130,098	$107,024	$137,816	$ 84,118	$ 57,269	$130,321	$ 54,633	$ 16,789
Net Cost/LT ore (US $)	$3.66	$2.70	$2.22	$2.07	$1.26	$ .86	$1.35	$ .57	$ .17
Net Cost/LT ore (Canadian $)	$3.94	$2.91	$2.39	$2.23	$1.36	$ .93	$1.45	$ .61	$ .18

TABLE 1G

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN
PORT OF ORIGIN: SAN JUAN, PERU
OIL BACKHAUL: SUMATRA

Vessel Class	NEPTUNE		NEW BUILDING		NEW BUILDING	
Deadweight Tonnage (LT)	50,343		69,000		100,000	
Voyage Distance (mi.)	23,352		23,352		23,352	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	1,610	5,097	1,415	6,602	1,415	7,663
Load and Unload	144	114	192	186	216	267
Delays	24	21	24	18	24	27
Total Hours/RT	1,778 Hrs.	5232 LT	1,631 Hrs.	6,806 LT	1,655 Hrs.	7,748 LT
Total Days/RT	74.083 Days		67.958 Days		68.958 Days	
RT/Yr. (351 Operating Days)	4.738		5.165		5.090	
Cargo Dwt.	Ore	Oil	Ore	Oil	Ore	Oil
Dwt. Vessel	50,343	50,343	69,000	69,000	100,000	100,000
C&S	150	150	150	150	150	150
F/W	100	100	100	100	100	100
Bunkers	2,113	1,913	2,775	2,515	3,220	2,920
Cargo Dwt. Summer	47,980	48,180	65,975	66,235	96,530	96,830
Cargo Dwt. Winter	-	-	-	-	-	-
Annual Average Cargo/Vessel	48,980	48,180	65,975	66,235	96,530	96,830
Annual Cargo Tons/Vessel	227,329	228,276	340,760	342,103	491,337	492,864
Operating Costs						
Basis: Operating Cost/Day	$1,483		$1,728		$2,112	
Bunker Source	Tabata/San Francisco		Tabata/San Francisco		Tabata/San Francisco	
Bunker Cost/LT - Tabata	$18.62		$18.62		$18.62	
Bunker Cost/LT - San Francisco	$15.08		$15.08		$15.08	
T/C Ins./Day	$35.00		$40.00		$45.00	

Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$109,865	$109,865	$109,865	$117,431	$117,431	$117,431	$145,639	$145,639	$145,639
T/C Ins./RT	2,593	2,593	2,593	2,718	2,718	2,718	3,103	3,103	3,103
Port Charges: San Juan	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Tabata	2,700	2,700	2,700	3,000	3,000	3,000	3,500	3,500	3,500
Port Charges: Sumatra	2,000	2,000	2,000	2,500	2,500	2,500	2,500	2,500	2,500
Port Charges: San Francisco	2,500	2,500	2,500	3,000	3,000	3,000	3,000	3,000	3,000
Bunkers - Tabata	42,677	42,677	42,677	55,339	55,339	55,339	64,239	64,239	64,239
Bunkers - San Francisco	45,119	45,119	45,119	57,817	57,817	57,817	67,829	67,829	67,829
Total Operating/RT	208,454	208,454	208,454	242,805	242,805	242,805	290,810	290,810	290,810
Amortization and Interest	179,948	132,609	108,976	208,835	153,925	126,470	294,243	216,872	178,187
Total Cost/RT	$388,402	$341,063	$317,430	$451,640	$396,730	$369,275	$585,053	$507,682	$468,997
Net Oil Revenue (A.T.R.S. -70 + -1-1/4%)	152,008	152,008	152,008	208,971	208,971	208,971	305,499	305,499	305,499
Net Cost Ore	$236,394	$189,055	$165,422	$242,669	$187,759	$160,304	$279,554	$202,183	$163,498
Net Cost/LT ore (US $)	$4.93	$3.94	$3.45	$3,86	$2.85	$2.43	$2.90	$2.09	$1.69
Net Cost/LT ore (Canadian $)	$5.31	$4.24	$3.71	$4.16	$3.07	$2.62	$3.12	$2.25	$1.69

TABLE 1H

SHIPPING COST BREAKDOWN

MARKET: TABATA, JAPAN
PORT OF ORIGIN: SAN JUAN, PERU
OIL BACKHAUL: BAHREIN

Vessel Class	NEPTUNE		NEW BUILDING		NEW BUILDING	
Deadweight Tonnage (LT)	50,343		69,000		100,000	
Voyage Distance (mi.)	23,352		23,352		23,352	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	2,071	6,597	1,820	8,492	1,870	9,856
Load and Unload	144	114	192	186	216	267
Delays	24	21	24	18	24	27
Total Hours/RT	2,239 Hrs.	6,732 LT	2,036 Hrs.	8,696 LT	2,060 Hrs.	10,150 LT
Total Days/RT	93.291 Days		84.833 Days		85.833 Days	
RT/Yr. (351 Operating Days)	3.762		4.137		4.089	
Cargo Dwt.	Ore	Oil	Ore	Oil	Ore	Oil
Dwt. Vessel	50,343	50,343	69,000	69,000	100,000	100,000
C&S	150	150	150	150	150	150
F/W	100	100	100	100	100	100
Bunkers	2,113	2,633	2,775	3,450	3,220	4,000
Cargo Dwt. Summer	47,980	47,460	65,975	65,300	96,530	95,750
Cargo Dwt. Winter	-	-	-	-	-	-
Annual Average Cargo/Vessel	47,980	47,460	65,975	56,300	96,530	95,750
Annual Cargo Tons/Vessel	180,500	178,544	272,938	270,146	394,711	391,521

Operating Costs

Basis:	NEPTUNE	NEW BUILDING	NEW BUILDING
Operating Cost/Day	$1,483	$1,728	$2,112
Bunker Source	Tabata/Bahrein/San Francisco	Tabata/Bahrein/San Francisco	Tabata/Bahrein/San Francisco
Bunker Cost/LT - Tabata	$18.62	$18.62	$18.62
Bunker Cost/LT - Bahrein	$12.30	$12.30	$12.30
Bunker Cost/LT - San Francisco	$15.08	$15.08	$15.08
T/C Ins./Day	$35.00	$40.00	$45.00

Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$138,321	$138,321	$138,321	$146,591	$146,591	$146,591	$181,279	$181,279	$181,279
T/C Ins./RT	3,264	3,264	3,264	3,393	3,393	3,393	3,862	3,862	3,862
Port Charges: San Juan	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Tabata	2,700	2,700	2,700	3,000	3,000	3,000	3,500	3,500	3,500
Port Charges: Bahrein	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Port Charges: San Francisco	2,500	2,500	2,500	3,000	3,000	3,000	3,000	3,000	3,000
Bunkers - Tabata	25,863	25,863	25,863	32,585	32,585	32,585	37,817	37,817	37,817
Bunkers:- Bahrein	29,557	29,557	29,557	38,278	38,278	38,278	44,427	44,427	44,427
Bunkers - San Francisco	45,119	45,119	45,119	57,817	57,817	57,817	67,829	67,829	67,829
Total Operating/RT	250,824	250,824	250,824	288,164	288,164	288,164	345,214	345,214	345,214
Amortization and Interest	226,555	166,955	137,202	260,692	192,147	157,874	366,249	269,944	221,792
Total Cost/RT	$477,379	$417,779	$388,026	$548,856	$480,311	$446,038	$711,463	$615,158	$567,006
Net Oil Revenue (A.T.R.S. -70 + -1-1/4%)	213,000	213,000	213,000	293,066	293,066	293,066	429,726	429,726	429,726
Net Cost Ore	$264,379	$204,779	$175,026	$255,790	$187,245	$152,972	$281,737	$185,432	$137,280
Net Cost/LT ore (US $)	$5.51	$4,27	$3.65	$3.88	$2.84	$2.32	$2.92	$1.92	$1.42
Net Cost/LT ore (Canadian $)	$5.93	$4.60	$3.93	$4.18	$3.06	$2.50	$3.14	$2.07	$1.53

TABLE 2A

SHIPPING COST BREAKDOWN

MARKET: SAN FRANCISCO
PORT OF ORIGIN: HAINES, ALASKA

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi)	2,874		2,874		2,874	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	213	479	198	627	174	812
Load and Unload	72	36	72	42	96	48
Delays	12	9	12	9	12	9
Total Hours/RT	297 Hrs.	524 LT	282 Hrs.	678 LT	282 Hrs.	869 LT
Total Days/RT	12.375 Days		11.75 Days		11.750 Days	
RT/Yr. (351 Operating Days)	28.363		29.872		29,872	
Cargo Dwt.						
Dwt. Vessel	35,400		50,343		69,000	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	425		563		770	
Cargo Dwt. Summer	34,725		49,530		67,980	
Cargo Dwt. Winter	33,719		48,054		66,110	
Annual Average Cargo/Vessel	34,222		48,792		67,045	
Annual Cargo Tons/Vessel	970,638		1,457,514		2,002,768	
Operating Costs						
Basis: Operating Cost/Day	$2,580		$2,844		$3,231	
Bunker Source	San Francisco		San Francisco		San Francisco	
Bunker Cost/LT	$15.08		$15.08		$15.08	
T/C Ins./Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 31,928	$ 31,928	$ 31,928	$ 33,417	$ 33,417	$ 33,417	$ 37,965	$ 37,965	$ 37,965
T/C Ins./RT	371	371	371	411	411	411	470	470	470
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	7,902	7,902	7,902	10,224	10,224	10,224	13,104	13,104	13,104
Total Operating/RT	44,201	44,201	44,201	49,052	49,052	49,052	57,539	57,539	57,539
Amortization and Interest	41,382	30,492	25,059	47,893	35,297	29,010	60,183	44,356	36,448
Total Cost/RT	$ 85,583	$ 74,693	$ 69,260	$ 96,945	$ 84,349	$ 78,062	$117,722	$101,395	$ 93,987
Net Cost/LT ore (US $)	$2.50	$2.18	$2.02	$1.99	$1.73	$1.60	$1.76	$1.51	$1.40
Net Cost/LT ore (Canadian $)	$2.69	$2.35	$2.17	$2.14	$1.86	$1.72	$1.89	$1.63	$1.51

TABLE 2B

SHIPPING COST BREAKDOWN

MARKET: SAN FRANCISCO
PORT OF ORIGIN: SAN JUAN, PERU

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT	35,400		50,343		69,000	
Voyage Distance (mi.)	8,438		8,438		8,438	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	625	1,406	582	1,843	511	2,384
Load and Unload	72	36	72	42	96	48
Delays	9	6	9	6	9	6
Total Hours/RT	706 Hrs.	1,448 LT	663 Hrs.	1,891 LT	616 Hrs.	2,438 LT
Total Days/RT	29.416 Days		27.625 Days		25.666 Days	
RT/Yr. (351 Operating Days)	11.932		12.705		13.675	
Cargo Dwt.						
Dwt. Vessel	35,400		50,343		69,000	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	885		1,175		1,555	
Cargo Dwt. Summer	34,265		48,918		67,195	
Cargo Dwt. Tropical	35,271		50,394		69,065	
Annual Average Cargo/Vessel	34,768		49,656		68,130	
Annual Cargo Tons/Vessel	414,851		630,879		931,677	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	San Francisco		San Francisco		San Francisco	
Bunker Cost/LT	$15.08		$15.08		$15.08	
T/C Ins. /Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 37,652	$ 37,652	$ 37,652	$ 40,167	$ 40,167	$ 40,167	$ 43,350	$ 43,350	$ 43,350
T/C Ins. /RT	882	882	882	967	967	967	1,026	1,026	1,026
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	21,836	21,836	21,836	28,516	28,516	28,516	36,765	36,765	36,765
Total Operating/RT	63,370	63,370	63,370	73,150	73,150	73,150	85,141	85,141	85,141
Amortization and Interest	54,096	39,858	32,769	61,935	45,637	37,515	72,301	53,283	43,786
Total Cost/RT	$117,466	$103,228	$ 96,139	$135,085	$118,787	$110,665	$157,442	$138,424	$128,927
Net Cost/LT ore (US $)	$3.39	$2.97	$2.77	$2.72	$2.39	$2.23	$2.31	$2.03	$1.89
Net Cost/LT ore (Canadian $)	$3.65	$3.20	$2.98	$2.93	$2.57	$2.40	$2.49	$2.19	$2.03

TABLE 3A

SHIPPING COST BREAKDOWN

MARKET: LOS ANGELES
PORT OF ORIGIN: HAINES, ALASKA

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT	35,400		50,343		69,000	
Voyage Distance (mi.)	3,542		3,542		3,542	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	262	590	244	773	215	1,003
Load and Unload	72	36	72	42	96	48
Delays	12	9	12	9	12	9
Total Hours/RT	346 Hrs.	635 LT	328 Hrs.	824 LT	323 Hrs.	1,060 LT
Total Days/RT	14.416 Days		13.666 Days		13.458 Days	
RT/Yr. (351 Operating Days)	24.348		25,684		26.081	
Cargo Dwt.						
Dwt. Vessel	35,400		50,343		69,000	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	480		643		865	
Cargo Dwt. Summer	34,670		49,450		67,885	
Cargo Dwt. Winter	33,664		47,974		66,015	
Annual Average Cargo/Vessel	34,167		48,712		66,950	
Annual Cargo Tons/Vessel	831,898		1,251,119		1,746,123	
Operating Costs						
Basis: Operating Cost/Day	$2,580		$2,844		$3,231	
Bunker Source	Los Angeles		Los Angeles		Los Angeles	
Bunker Cost/LT	$14.66		$14.66		$14.66	
T/C Ins. /Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 37,193	$ 37,193	$ 37,193	$ 38,866	$ 38,866	$ 38,866	$ 43,483	$ 43,483	$ 43,483
T/C Ins. RT	432	432	432	478	478	478	538	538	538
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	9,309	9,309	9,309	12,080	12,080	12,080	15,540	15,540	15,540
Total Operating/RT	50,934	50,934	50,934	56,424	56,424	56,424	65,561	65,561	65,561
Amortization and Interest	48,207	35,521	29,192	55,703	41,053	33,741	68,932	50,804	41,746
Total Cost/RT	$ 99,141	$ 86,455	$ 80,126	$112,127	$ 97,477	$ 90,165	$134,493	$116,365	$107,307
Net Cost/LT ore (US $)	$2.90	$2.53	$2.34	$2.30	$2.00	$1.85	$2.01	$1.74	$1.60
Net Cost/LT ore (Canadian $)	$3.12	$2.72	$2.52	$2.48	$2.15	$1.99	$2.16	$1.87	$1.72

TABLE 3B

SHIPPING COST BREAKDOWN

MARKET: LOS ANGELES
PORT OF ORIGIN: SAN JUAN, PERU

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	7,770			7,770			7,770		
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	576		1,296	536		1,697	471		2,198
Load and Unload	72		36	72		42	96		48
Delays	9		6	9		6	9		6
Total Hours/RT	657 Hrs.		1,338 LT	617 Hrs.		1,745 LT	576 Hrs.		2,252 LT
Total Days/RT	27.375 Days			25.708 Days			24.000 Days		
RT/Yr. (351 Operating Days)	12.822			13.653			14.625		
Cargo Dwt.									
Dwt. Vessel	35,400			50,343			69,000		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	830			1,100			1,460		
Cargo Dwt. Summer	34,320			48,993			67,290		
Cargo Dwt. Tropical	35,326			50,469			69,160		
Annual Average Cargo/Vessel	34,823			49,731			68,225		
Annual Cargo Tons/Vessel	446,500			678,977			997,790		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Los Angeles			Los Angeles			Los Angeles		
Bunker Cost/ LT	$14.66			$14.66			$14.66		
T/C Ins. /Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 35,040	$ 35,040	$ 35,040	$ 37,379	$ 37,379	$ 37,379	$ 40,536	$ 40,536	$ 40,536
T/C Ins. /RT	821	821	821	900	900	900	960	960	960
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	19,615	19,615	19,615	25,582	25,582	25,582	33,014	33,014	33,014
Total Operating/RT	58,476	58,476	58,476	67,361	67,361	67,361	78,510	78,510	78,510
Amortization and Interest	50,342	37,093	30,496	57,637	42,470	34,911	67,608	49,824	40,944
Total Cost/RT	$108,818	$ 95,569	$ 88,972	$124,998	$109,831	$102,272	$146,118	$128,334	$119,454
Net Cost/LT ore (US $)	$3.12	$2.74	$2.55	$2.51	$2.21	$2.06	$2.14	$1.88	$1.75
Net Cost/LT ore (Canadian $)	$3.36	$2.95	$2.75	$2.70	$2.38	$2.22	$2.30	$2.02	$1.88

TABLE 4A

SHIPPING COST BREAKDOWN

MARKET: MOBILE, ALABAMA
PORT OF ORIGIN: HAINES, ALASKA

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	12,056			12,056			12,056		
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	893		2,010	321		2,631	731		3,411
Canal Transit	36		40	36		57	40		93
Load and Unload	72		36	72		42	96		48
Delays	12		9	12		9	12		9
Total Hours/RT	1,013 Hrs.		2,095 LT	951 Hrs.		2,739 LT	879 Hrs.		3,561 LT
Total Days/RT	42.208 Days			39.625 Days			36.625 Days		
RT/Yr. (351 Operating Days)	8.316			8.858			9.583		
Cargo Dwt.									
Dwt. Vessel	35,400			45,131			51,200		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	1,200			555			765		
Cargo Dwt. Summer	33,950			44,326			50,185		
Cargo Dwt. Winter	32,944			-			-		
Annual Average Cargo/Vessel	33,447			44,326			50,185		
Annual Cargo Tons/Vessel	278,145			392,639			480,922		
Operating Costs									
Basis: Operating Cost/Day	$2,580			$2.844			$3,231		
Bunker Source	Mobile			Mobile			Mobile		
Bunker Cost/LT	$15.21			$15.21			$15.21		
T/C Ins. /Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$108,897	$108,897	$108,897	$112,694	$112,694	$112,694	$118,335	$118.335	$118.335
T/C Ins. /RT	1,266	1,266	1,266	1,387	1,387	1,387	1,465	1,465	1,465
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Canal Zone/RT	2,200	2,200	2,000	2,600	2,600	2,600	3,000	3,000	3,000
Canal Tolls @ 1.62 R/T	12,831	12,831	12,831	17,360	17,360	17,360	22,426	22,426	22,426
Bunkers	31,865	31,865	31,865	41,660	41,660	41,660	54,163	54,163	54,163
Total Operating/RT	$161,009	$161,009	$161,009	$180,701	$180,701	$180,701	$205,389	$205,389	$205,389
Amortization and Interest	141,144	104,001	85,471	161,511	119,034	97,834	187,593	138,260	113,610
Total Cost/RT	$302,203	$265,060	$246,530	$342,212	$299,735	$278,535	$392,982	$343,649	$318,999
Net Cost/LT ore (US $)	$9.04	$7.94	$7.37	$7.72	$6.76	$6.28	$7.83	$6.84	$6.36
Net Cost/LT ore (Canadian $)	$9.73	$8.55	$7.94	$8.31	$7.28	$6.76	$8.43	$7.36	$6.85

TABLE 4B

SHIPPING COST BREAKDOWN

MARKET: MOBILE, ALABAMA
PORT OF ORIGIN: SAN JUAN, PERU

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	5,900		5,900		5,900	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	437	984	407	1,288	358	1,671
Canal Transit/RT	36	40	36	57	40	93
Load and Unload	72	36	72	42	96	48
Delays	12	9	12	9	12	9
Total Hours/RT	557 Hrs.	1,069 LT	527 Hrs.	1,396 LT	506 Hrs.	1,821 LT
Total Days/RT	23.208 Days		21.958 Days		21.083 Days	
RT/Yr. (351 Operating Days)	15.124		15.985		16.648	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	410		555		770	
Cargo Dwt.	34,740		44,326		50,180	
Annual Average Cargo/Vessel	34,740		44,326		50,180	
Annual Cargo Tons/Vessel	525,407		708,551		835,396	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Mobile		Mobile		Mobile	
Bunker Cost/LT	$15.21		$15.21		$15.21	
T/C Ins. /Day	$30.00		$35,00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 29,706	$ 29,706	$ 29,706	$ 31,927	$ 31,927	$ 31,927	$ 35,609	$ 35,609	$ 35,609
T/C Ins. / RT	696	696	696	769	769	769	843	843	843
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Canal Zone/RT	2,200	2,200	2,200	2,600	2,600	2,600	3,000	3,000	3,000
Canal Tolls $1.62/RT	12,085	12,085	12,085	17,360	17,360	17,360	22,426	22,426	22,426
Bunkers	16,259	16,259	16,259	21,233	21,233	21,233	27,697	27,697	27,697
Total Operating/RT	63,946	63,946	63,946	77,389	77,389	77,389	93,575	93,575	93,575
Amortization and Interest	42,679	31,447	25,854	49,230	36,275	29,819	59,391	43,768	35,968
Total Cost/RT	$106,625	$ 95,393	$ 89,800	$126,619	$113,664	$107,208	$152,966	$137,343	$129,543
Net Cost/LT ore (US $)	$3.07	$2.75	$2.58	$2.86	$2.56	$2.42	$3.05	$2.74	$2.58
Net Cost/LT ore (Canadian $)	$3.31	$2.96	$2.78	$3.08	$2.76	$2.61	$3.29	$2.96	$2.78

TABLE 4C

SHIPPING COST BREAKDOWN

MARKET: MOBILE, ALABAMA
PORT OF ORIGIN: SEVEN ISLANDS, QUEBEC

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	5,276			5,276			5,276		
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	391		880	364		1,152	320		1,493
Load and Unload	72		36	72		42	72		36
Delays	12		9	12		9	12		9
Total Hours/RT	475 Hrs.		925 LT	448 Hrs.		1,203 LT	404 Hrs.		1,538 LT
Total Days/RT	19,791 Days			18.666 Days			16.833 Days		
RT/Yr. (351 Operating Days)	17.735			18.804			20.851		
Cargo Dwt.									
Dwt. Vessel	35,400			45,131			51,200		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	625			831			450		
Cargo Dwt. Summer	34,525			44,050			50,050		
Cargo Dwt. Winter	33,519			-			-		
Annual Average Cargo/Vessel	34,022			44,050			50,050		
Annual Cargo Tons/Vessel	603,380			828,316			1,052,975		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Mobile			Mobile			Mobile		
Bunker Cost/LT	$15.21			$15.21			$15.21		
T/C Ins./Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 25,332	$ 25,332	$ 25,332	$ 27,140	$ 27,140	$ 27,140	$ 28,431	$ 28,431	$ 28,431
T/C Ins./RT	594	594	594	653	653	653	673	673	673
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	14,069	14,069	14,069	18,298	18,298	18,298	23,392	23,392	23,392
Total Operating/RT	42,995	42,995	42,995	49,591	49,591	49,591	56,496	56,496	56,496
Amortization and Interest	36,395	26,817	22,047	41,849	30,836	25,348	47,719	34,945	28,717
Total Cost/RT	$ 79,390	$ 69,812	$ 63,042	$ 91,440	$ 80,427	$ 74,939	$104,215	$ 91,441	$ 85,213
Net Cost/LT ore (US $)	$2.33	$2.05	$1.85	$2.08	$1.83	$1.70	$2.06	$1.81	$1.69
Net Cost/LT ore (Canadian $)	$2.51	$2.21	$1.99	$2.24	$1.97	$1.83	$2.22	$1.95	$1.82

TABLE 4D

SHIPPING COST BREAKDOWN

MARKET: MOBILE, ALABAMA
PORT OF ORIGIN: PUERTO ORDAZ

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	4,854			4,854			4,854		
Voyage RT Time and Fuel	Time	Bunkers		Time	Bunkers		Time	Bunkers	
Travel	359	809		335	1,016		294	1,371	
Load and Unload	84	45		84	51		84	45	
Delays	12	9		12	9		12	9	
Total Hours/RT	455 Hrs.	863 LT		431 Hrs.	1,121 LT		390 Hrs.	1,425 LT	
Total Days/RT	18.958 Days			17.958 Days			16.250 Days		
RT/Yr. (351 Operating Days)	18.514			19.545			21.600		
Cargo Dwt.									
Dwt. Vessel	35,400			45,131			51,200		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	1,025			1,350			300		
Cargo Dwt.	34,125			43,531			50,650		
Annual Average Cargo/Vessel	34,125			43,531			50,650		
Annual Cargo Tons/Vessel	631,790			850,813			1,094,040		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Port of Spain			Port of Spain			Mobile		
Bunker Cost/LT	$13.88			$13.88			$15.21		
T/C Ins. /Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 24,266	$ 24,266	$ 24,266	$ 25,587	$ 25,587	$ 25,587	$ 27,446	$ 27,446	$ 27,446
T/C Ins. /RT	569	569	569	616	616	616	650	650	650
Port Charges: Origin	1,000	1,000	1,000	1,200	1,200	1,200	1,500	1,500	1,500
Port Charges: Trinidad	300	300	300	300	300	300	-	-	-
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	11,978	11,978	11,978	15,559	15,559	15,559	21,674	21,674	21,674
Total Operating/RT	40,113	40,113	40,113	45,762	45,762	45,762	54,270	54,270	54,270
Amortization and Interest	34,865	25,688	21,119	39,455	29,072	23,898	45,776	33,735	27,723
Total Cost/RT	$ 74,977	$ 65,801	$ 61,232	$ 85,217	$ 74,834	$ 69,660	$100,046	$ 88,005	$ 81,993
Net Cost/LT ore (US $)	$2.20	$1.93	$1.79	$1.96	$1.72	$1.62	$1.98	$1.74	$1.62
Net Cost/LT ore (Canadian $)	$2.37	$2.08	$1.93	$2.11	$1.85	$1.74	$2.13	$1.87	$1.74

TABLE 4E

SHIPPING COST BREAKDOWN

MARKET: MOBILE, ALABAMA

PORT OF ORIGIN: PORT ETIENNE, FRENCH WEST AFRICA

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	8,418			8,418			8,418		
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	624		1,404	580		1,836	510		2,380
Load and Unload	72		36	72		42	72		36
Delays	12		9	12		9	12		9
Total Hours/RT	708 Hrs.		1,449 LT	664 Hrs.		1,887 LT	594 Hrs.		2,425 LT
Total Days/RT	29.500 Days			27.666 Days			24.750 Days		
RT/Yr. (351 Operating Days)	11.898			12.687			14.181		
Cargo Dwt.									
Dwt. Vessel	35,400			45,131			51,200		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	885			1,171			450		
Cargo Dwt.	34,265			43,710			50,500		
Annual Average Cargo/Vessel	34,265			43,710			50,500		
Annual Cargo Tons/Vessel	407,684			554,548			716,140		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Mobile			Mobile			Mobile		
Bunker Cost/LT	$15.21			$15.21			$15.21		
T/C Ins. /Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 37,760	$ 37,760	$ 37,760	$ 40,226	$ 40,226	$ 40,226	$ 41,803	$ 41,803	$ 41,803
T/C Ins./RT	885	885	885	968	968	968	990	990	990
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	2,500	2,500	2,500
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	22,039	22,039	22,039	28,701	28,701	28,701	36,884	36,884	36,884
Total Operating/RT	64,684	64,684	64,684	74,895	74,895	74,895	85,177	85,177	85,177
Amortization and Interest	54,250	39,972	32,863	62,027	45,704	37,570	69,721	51,381	42,224
Total Cost/RT	$118,934	$104,656	$ 97,547	$136,922	$120,599	$112,465	$154,898	$136,558	$127,401
Net Cost/LT ore (US $)	$3.47	$3.05	$2.85	$3.13	$2.76	$2.57	$3.07	$2.70	$2.52
Net Cost/LT ore (Canadian $)	$3.74	$3.28	$3.07	$3.37	$2.97	$2.77	$3.31	$2.91	$2.71

TABLE 4F

SHIPPING COST BREAKDOWN

MARKET: MOBILE, ALABAMA
PORT OF ORIGIN: VITORIA, BRAZIL

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	10,208		10,208		10,208	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	756	1,701	704	2,229	619	2,888
Load and Unload	72	36	72	42	72	36
Delays	12	9	12	9	12	9
Total Hours/RT	840 Hrs.	1,746 LT	788 Hrs.	2,280 LT	703 Hrs.	2,933 LT
Total Days/RT	35.000 Days		32.833 Days		29.291 Days	
RT/Yr. (351 Operating Days)	10.028		10.690		11.983	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	1,035		1,371		450	
Cargo Dwt.	34,115		43,510		50,500	
Annual Average Cargo/Vessel	34,115		43,510		50,500	
Annual Cargo Tons/Vessel	342,105		465,121		605,141	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Mobile		Mobile		Mobile	
Bunker Cost/LT	$15.21		$15.21		$15.21	
T/C Ins. /Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 44,800	$ 44,800	$ 44,800	$ 47,740	$ 47,740	$ 47,740	$ 49,472	$ 49,472	$ 49,472
T/C Ins./RT	1,050	1,050	1,050	1,150	1,150	1,150	1,172	1,172	1,172
Port Charges: Origin	2,600	2,600	2,600	3,100	3,100	3,100	4,000	4,000	4,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	26,556	26,556	26,556	34,679	34,679	34,679	44,610	44,610	44,610
Total Operating/RT	77,006	77,006	77,006	89,169	89,169	89,169	102,254	102,254	102,254
Amortization and Interest	64,365	47,425	38,990	73,611	54,240	44,587	82,513	60,808	49,970
Total Cost/RT	$141,371	$124,431	$115,996	$162,780	$143,409	$133,756	$184,767	$163.062	$152,224
Net Cost/LT ore (U.S. $)	$4.14	$3.65	$3.40	$3.74	$3.30	$3.07	$3.66	$3.23	$3.02
Net Cost/LT ore (Canadian $)	$4.46	$3.93	$3.66	$4.03	$3.55	$3.31	$3.94	$3.48	$3.25

TABLE 5A

SHIPPING COST BREAKDOWN

MARKET: BALTIMORE, MARYLAND
PORT OF ORIGIN: HAINES, ALASKA

	RIO			NEPTUNE			NEW BUILDING		
Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (Mi.)	13,118			13,118			13,118		
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	972		2,188	904		2,863	795		3,709
Canal Transit/RT	36		40	36		57	40		93
Load and Unload	72		36	72		42	96		48
Delays	12		9	12		9	12		9
Total Hours/RT	1,092 Hrs.		2,273 LT	1,024 Hrs.		2,971 LT	943 Hrs.		3,859 LT
Total Days/RT	45.500 Days			42.666 Days			39.291 Days		
RT/Yr. (351 Operating Days)	7.714			8.226			8.933		
Cargo Dwt.									
Dwt. Vessel	35,400			45,131			51,200		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	1,300			670			915		
Cargo Dwt. Summer	33,850			44,211			50,035		
Cargo Dwt. Winter	32,844			-			-		
Annual Average Cargo/Vessel	33,347			44,211			50,035		
Annual Cargo Tons/Vessel	257,239			363,679			446,962		
Operating Costs									
Basis: Operating Cost/Day	$2,580			$2,844			$3,231		
Bunker Source	Baltimore			Baltimore			Baltimore		
Bunker Cost/LT	$14.24			$14.24			$14.24		
T/C Ins./Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$117,390	$117,390	$117,390	$121,342	$121,342	$121,342	$126,950	$126,950	$126,950
T/C Ins./RT	1,365	1,365	1,365	1,494	1,494	1,494	1,572	1,572	1,572
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Canal Zone/RT	2,200	2,200	2,200	2,600	2,600	2,600	3,000	3,000	3,000
Canal Tolls $ 1.62/RT	12,831	12,831	12,831	17,360	17,360	17,360	22,426	22,426	22,426
Bunkers	32,368	32,368	32,368	42,307	42,307	42,307	54,952	54,952	54,952
Total Operating/RT	170,154	170,154	170,154	190,103	190,103	190,103	214,900	214,900	214,900
Amortization and Interest	152,152	112,112	92,138	173,906	128,169	105,342	201,248	148,323	121,880
Total Cost/RT	$322,306	$282,266	$262,292	$364,009	$318,272	$295,445	$416,148	$363,223	$336,780
Net Cost/LT ore (US $)	$9.64	$8.44	$7.84	$8.23	$7.20	$6.68	$8.32	$7.26	$6.73
Net Cost/LT ore (Canadian $)	$10.38	$9.09	$8.44	$8.86	$7.75	$7.19	$8.96	$7.82	$7.25

TABLE 5B

SHIPPING COST BREAKDOWN

MARKET: BALTIMORE, MARYLAND
PORT OF ORIGIN; SAN JUAN, PERU

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (Mi.)	6,962		6,962		6,962	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	516	1,162	480	1,520	422	1,969
Canal Transmit RT	36	40	36	57	96	48
Load and Unload	72	36	72	42	96	48
Delays	12	9	12	9	12	9
Total Hours/RT	636 Hrs.	1,247 LT	600 Hrs.	1,628 LT	570 Hrs.	2,119 LT
Total Days/RT	26.500 Days		25.000 Days		23.750 Days	
RT/Yr. (351 Operating Days)	13.245		14.040		14.778	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	500		670		920	
Cargo Dwt.	34,650		44,211		50,030	
Annual Average Cargo/Vessel	34,650		44,211		50,030	
Annual Cargo Tons/Vessel	458,939		620,722		739,343	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Baltimore		Baltimore		Baltimore	
Bunker Cost/LT	$14.24		$14.24		$14.24	
T/C Ins. /Day	$30.00		$35.00		$40.00	

	RIO			NEPTUNE			NEW BUILDING		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 33,920	$ 33,920	$ 33,920	$ 36,350	$ 36,350	$ 36,350	$ 40,114	$ 40,114	$ 40,114
T/C Ins. /RT	795	795	795	875	875	875	950	950	950
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Canal Zone/RT	2,200	2,200	2,200	2,600	2,600	2,600	3,000	3,000	3,000
Canal Tolls $ 1.62/RT	12,085	12,085	12,085	17,360	17,360	17,360	22,426	22,426	22,426
Bunkers	17,757	17,757	17,757	23,183	23,183	23,183	30,174	30,174	30,174
Total Operating/RT	69,757	69,757	69,757	83,868	83,868	83,868	100,664	100,664	100,664
Amortization and Interest	48,733	35,907	29,521	56,050	41,300	33,950	66,763	49,201	40,432
Total Cost/RT	$118,490	$105,664	$ 99,278	$139,918	$125,168	$111,818	$167,427	$149,865	$141,096
Net Cost/LT ore (US $)	$3.42	$3.05	$2.87	$3.16	$2.83	$2.53	$3.35	$3.00	$2.82
Net Cost/LT ore (Canadian $)	$3.68	$3.28	$3.09	$3.40	$3.05	$2.72	$3.61	$3.24	$3.04

TABLE 5C

SHIPPING COST BREAKDOWN

MARKET: BALTIMORE, MARYLAND
PORT OF ORIGIN: SEVEN ISLANDS, QUEBEC

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	2,934		2,934		2,934	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	217	488	202	640	178	831
Load and Unload	72	36	72	42	72	36
Delays	12	9	12	9	12	9
Total Hours/RT	301 Hrs.	533 LT	286 Hrs.	691 LT	262 Hrs.	876 LT
Total Days/RT	12.541 Days		11.916 Days		10.916 Days	
RT/Yr. (351 Operating Days)	27.988		29.456		32.154	
Cargo Dwt.						
Dwt. Vessel	35,400		46,500		52,680	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	375		503		400	
Cargo Dwt. Summer	34,775		45,747		52,030	
Cargo Dwt. Winter	33,769		44,271		-	
Annual Average Cargo/Vessel	34,272		45,009		52,030	
Annual Cargo Tons/Vessel	959,204		1,325,785		1,672,972	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Baltimore		Baltimore		Baltimore	
Bunker Cost/LT	$14.24		$14.24		$14.24	
T/C Ins. /Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 16,052	$ 16,052	$ 16,052	$ 17,326	$ 17,326	$ 17,326	$ 18,437	$ 18,437	$ 18,437
T/C Ins. /RT	376	376	376	417	417	417	437	437	437
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	7,590	7,590	7,590	9,840	9,840	9,840	12,474	12,474	12,474
Total Operating/RT	27,018	27,018	27,018	31,083	31,083	31,083	35,348	35,348	35,348
Amortization and Interest	23,063	16,993	13,971	26,716	19,685	16,182	30,750	22,661	18,623
Total Cost/RT	$ 50,081	$ 44,011	$ 40,989	$ 57,799	$ 50,768	$ 47,265	$ 66,098	$ 58,009	$ 53,971
Net Cost/LT ore (US $)	$1.46	$1.28	$1.20	$1.28	$1.13	$1.05	$1.27	$1.12	$1.04
Net Cost/LT ore (Canadian $)	$1.57	$1.38	$1.29	$1.38	$1.22	$1.13	$1.37	$1.21	$1.12

TABLE 5D

SHIPPING COST BREAKDOWN

MARKET: BALTIMORE, MARYLAND
PORT OF ORIGIN: PUERTO ORDAZ

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	4,468			4,468			4,468		
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	330		742	308		975	270		1,259
Load and Unload	84		45	84		51	84		45
Delays	12		9	12		9	12		9
Total Hours/RT	426 Hrs.		797 LT	404 Hrs.		1,035 LT	366 Hrs.		1,313 LT
Total Days/RT	17.75 D.ys			16.833 Days			15.250 Days		
RT/Yr. (351 Operating Days)	19.774			20.851			23,016		
Cargo Dwt.									
Dwt. Vessel	35,400			45,131			51,200		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	960			1,261			1,300		
Cargo Dwt.	34,190			43,620			50,650		
Annual Average Cargo/Vessel	34,190			43,620			50,650		
Annual Cargo Tons/Vessel	676,073			909,520			1,165,760		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Port of Spain			Port of Spain			Baltimore		
Bunker Cost/LT	$13.88			$13.88			$14.24		
T/C Ins. /Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 22,720	$ 22,720	$ 22,720	$ 24,475	$ 24,475	$ 24,475	$ 25,757	$ 25,757	$ 25,757
T/C Ins. /RT	532	532	532	589	589	589	610	610	610
Port Charges: Puerto Ordaz	1,000	1,000	1,000	1,200	1,200	1,200	1,500	1,500	1,500
Port Charges: Trinidad	300	300	300	300	300	300	-	-	-
Port Charges: Baltimore	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	11,062	11,062	11,062	14,366	14,366	14,366	18,697	18,697	18,697
Total Operating/RT	37,614	37,614	37,614	43,430	43,430	43,430	49,564	49,564	49,564
Amortization and Interest	32,642	24,051	19,773	37,740	27,808	22,859	42,959	31,659	26,017
Total Cost/RT	$ 70,256	$ 61,665	$ 57,387	$ 81,170	$ 71,238	$ 66,289	$ 92,523	$ 81,223	$ 75,581
Net Cost/LT ore (US $)	$2.05	$1.80	$1.68	$1.86	$1.63	$1.52	$1.83	$1.60	$1.49
Net Cost/LT ore (Canadian $)	$2.21	$1.94	$1.81	$2.00	$1.76	$1.64	$1.97	$1.72	$1.60

TABLE 5E

SHIPPING COST BREAKDOWN

MARKET: BALTIMORE, MARYLAND
PORT OF ORIGIN: PORT ETIENNE, FRENCH WEST AFRICA

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	6,864		6,864		6,864	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	508	1,143	473	1,498	416	1,941
Load and Unload	72	36	72	42	72	48
Delays	12	9	12	9	12	9
Total Hours/RT	592 Hrs.	1,188 LT	557 Hrs.	1,549 LT	500 Hrs.	1,998 LT
Total Days/RT	24.666 Days		23.208 Days		20.833 Days	
RT/Yr. (351 Operating Days)	14.230		15.124		16.848	
Cargo Dwt.						
Dwt. Vessel	35,400		46,500		52,680	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	755		1,003		400	
Cargo Dwt.	34,395		45,247		52,030	
Annual Average Cargo/Vessel	34,395		45,247		52,030	
Annual Cargo Tons/Vessel	489,440		684,316		876,601	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Baltimore		Baltimore		Baltimore	
Bunker Cost/LT	$14.24		$14.24		$14.24	
T/C Ins./Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 31,572	$ 31,572	$ 31,572	$ 33,744	$ 33,744	$ 33,744	$ 35,187	$ 35,187	$ 35,187
T/C Ins./RT	740	740	740	812	812	812	833	833	833
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	2,500	2,500	2,500
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	16,917	16,917	16,917	22,058	22,058	22,058	28,451	28,451	28,451
Total Operating/RT	53,229	53,229	53,229	61,614	61,614	61,614	69,971	69,971	69,971
Amortization and Interest	45,360	33,422	27,477	52,032	38,340	31,516	58,687	43,249	35,541
Total Cost/RT	$ 98,589	$ 86,651	$ 80,706	$113,646	$ 99,954	$ 93,130	$128,658	$113,220	$105,512
Net Cost/LT ore (US $)	$2.87	$2.52	$2.35	$2.51	$2.21	$2.06	$2.47	$2.18	$2.03
Net Cost/LT ore (Canadian $)	$3.09	$2.71	$2.53	$2.70	$2.38	$2.22	$2.66	$2.35	$2.19

TABLE 5F

SHIPPING COST BREAKDOWN

MARKET: BALTIMORE, MARYLAND
PORT OF ORIGIN: VITORIA, BRAZIL

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	9,162		9,162		9,162	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	679	1,528	632	2,001	555	2,590
Load and Unload	72	36	72	42	72	36
Delays	12	9	12	9	12	9
Total Hours/RT	763 Hrs.	1,573 LT	716 Hrs.	2,052 LT	639 Hrs.	2,635 LT
Total Days/RT	31.791 Days		29.833 Days		26.625 Days	
RT/Yr. (351 Operating Days)	11.040		11.765		13.183	
Cargo Dwt.						
Dwt. Vessel	35,400		46,500		52,680	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	950		1,253		450	
Cargo Dwt.	34,200		44,497		51,980	
Annual Average Cargo/Vessel	34,200		44,497		51,980	
Annual Cargo Tons/Vessel	377,568		523,507		685,252	
Operating Costs						
Basis: Operating Cost/RT	$1,280		$1,454		$1,689	
Bunker Source	Baltimore		Baltimore		Baltimore	
Bunker Cost/LT	$14.24		$14.24		$14.24	
T/C Ins. /Day	$30.00		$35.00		$40.00	

	RIO			NEPTUNE			NEW BUILDING		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 40,692	$ 40,692	$ 40,692	$ 43,377	$ 43,377	$ 43,377	$ 44,970	$ 44,970	$ 44,970
T/C Ins. /RT	954	954	954	1,044	1,044	1,044	1,065	1,065	1,065
Port Charges: Origin	2,600	2,600	2,600	3,100	3,100	3,100	4,000	4,000	4,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	22,399	22,399	22,399	29,221	29,221	29,221	37,522	37,522	37,522
Total Operating/RT	$ 68,645	$ 68,645	$ 68,645	$ 79,242	$ 79,242	$ 79,242	$ 90,557	$ 90,557	$ 90,557
Amortization and Interest	58,463	43,076	35,415	66,886	49,284	40,513	75,003	55,274	45,422
Total Cost/RT	$127,108	$111,721	$104,060	$146,128	$128,526	$119.755	$165,560	$145,831	$135,979
Net Cost/LT ore (US $)	$3.72	$3.26	$3.04	$3.28	$2.89	$2.69	$3.19	$2.81	$2.62
Net Cost/LT ore (Canadian $)	$4.01	$3.51	$3.27	$3.53	$3.11	$2.90	$3.43	$3.03	$2.82

TABLE 6A

SHIPPING COST BREAKDOWN

MARKET: ROTTERDAM, NETHERLANDS
PORT OF ORIGIN: HAINES, ALASKA

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	19,063		19,063		19,063	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	1,412	3,178	1,315	4,164	1,156	5,393
Canal Transit/RT	36	40	36	57	40	93
Load and Unload	84	45	84	51	108	57
Delays	12	9	12	9	12	9
Total Hours/RT	1,544 Hrs.	3,272 LT	1,447 Hrs.	4,281 LT	1,316 Hrs.	5,552 LT
Total Days/RT	64.333 Days		60.292 Days		54.833 Days	
RT/Yr. (351 Operating Days)	5.456		5.821		6.401	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	1,065		500		515	
Cargo Dwt. Summer	34,085		44,381		50,435	
Cargo Dwt. Winter	33,079		-		-	
Annual Average Cargo/Vessel	33,582		44,381		50,435	
Annual Cargo Tons/Vessel	183,223		258,341		322,834	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1.689	
Bunker Source	Rotterdam/Aruba		Rotterdam/Aruba		Rotterdam/Aruba	
Bunker Cost/LT	$18.62/$13.00		$18.62/$13.00		$18.62/$13.00	
T/C Ins./Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 82,346	$ 82,346	$ 82,346	$ 87,665	$ 87,665	$ 87,665	$ 92,612	$ 92,612	$ 92,612
T/C Ins./RT	1,930	1,930	1,930	2,110	2,110	2,110	2,193	2,193	2,193
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Market	2,500	2,500	2,500	3,000	3,000	3,000	3,500	3,500	3,500
Port Charges: Aruba	300	300	300	300	300	300	400	400	400
Port Charges: Canal Zone	2,200	2,200	2,200	2,600	2,600	2,600	3,000	3,000	3,000
Canal Tolls $1.62/RT	12,085	12,085	12,085	17,360	17,360	17,360	22,426	22,426	22,426
Bunkers	51,727	51,727	51,727	67,685	67,685	67,685	87,777	87,777	87,777
Total Operating/RT	155,088	155,088	155,088	183,220	183,220	183,220	$214,908	$214,908	$214,908
Amortization and Interest	118,308	87,171	71,667	135,175	99,602	81,877	154,465	113,833	93,545
Total Cost/RT	$273,396	$242,259	$226,765	$318,395	$282,822	$265,097	$369,373	$328,741	$308,453
Net Cost/LT ore (US $)	$8.14	$7.21	$6.75	$7.17	$6.37	$5.97	$7.33	$6.52	$6.12
Net Cost/LT ore (Canadian $)	$8.76	$7.76	$7.27	$7.72	$6.86	$6.43	$7.90	$7.03	$6.59

TABLE 6B

SHIPPING COST BREAKDOWN

MARKET: ROTTERDAM, NETHERLANDS
PORT OF ORIGIN: SAN JUAN, PERU

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	12,907		12,907		12,907	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	956	2,152	891	2,821	783	3,653
Canal Transit/RT	36	40	36	57	40	93
Load and Unload	84	45	84	51	108	57
Delays	12	9	12	9	12	9
Total Hours/RT	1,088 Hrs.	2,246 LT	1,023 Hrs.	2,938 LT	9,431 Hrs.	3,812 LT
Total Days/RT	45,333 Days		42,625 Days		39,291 Days	
RT/Yr. (351 Operating Days)	7.743		8.234		8.933	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	1,285		500		515	
Cargo Dwt. Summer	33,865		44,381		50,435	
Cargo Dwt. Winter	-		-		-	
Annual Average Cargo/Vessel	33,865		44,381		50,435	
Annual Cargo Tons/Vessel	262,216		365,433		450,535	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Aruba/Rotterdam		Aruba/Rotterdam		Aruba/Rotterdam	
Bunker Cost/LT	$13.00/$18.62		$13.00/$18.62		$13.00/$18.62	
T/C Ins./Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 58,026	$ 58,026	$ 58,026	$ 61,977	$ 61,977	$ 61,977	$ 66,362	$ 66,362	$ 66,362
T/C Ins./RT	1,360	1,360	1,360	1,491	1,491	1,491	1,572	1,572	1,572
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,500	2,500	2,500	3,000	3,000	3,000	3,500	3,500	3,500
Port Charges: Aruba	300	300	300	300	300	300	400	400	400
Port Charges: Canal Zone	2,200	2,200	2,200	2,600	2,600	2,600	3,000	3,000	3,000
Canal Tolls $1.62/RT	12,085	12,085	12,085	17,350	17,350	17,350	22,426	22,426	22,426
Bunkers	35,509	35,509	35,509	46,450	46,450	46,450	60,267	60,267	60,267
Total Operating/RT	112,980	112,980	112,980	134,178	134,178	134,178	158,527	158,527	158,527
Amortization and Interest	83,362	61,426	50,500	95,565	70,417	57,885	110,682	81,568	67,030
Total Cost/RT	$196,347	$174,406	$163,480	$229,743	$204,595	$192,063	$269,209	$240,095	$225,557
Net Cost/LT ore (US $)	$5.80	$5.15	$4.83	$5.18	$4.61	$4.33	$5.34	$4.77	$4.48
Net Cost/LT ore (Canadian $)	$6.24	$5.55	$5.20	$5.58	$4.96	$4.66	$5.76	$5.14	$4.83

TABLE 6C

SHIPPING COST BREAKDOWN

MARKET: ROTTERDAM, NETHERLANDS
PORT OF ORIGIN: SEVEN ISLANDS, QUEBEC

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	6,290		6,290		6,290	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	466	1,049	434	1,374	381	1,778
Load and Unload	72	36	72	42	96	48
Delays	12	9	12	9	12	9
Total Hours/RT	550 Hrs.	1,094 LT	518 Hrs.	1,425 LT	489 Hrs.	1,835 LT
Total Days/RT	22.916 Days		21.583 Days		20.375 Days	
RT/Yr. (351 Operating Days)	15.316		16.262		17.227	
Cargo Dwt.						
Dwt. Vessel	35,400		50,343		64,920	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	710		943		400	
Cargo Dwt. Summer	34,440		49,150		64,270	
Cargo Dwt. Winter	33,434		47,674		-	
Annual Average Cargo/Vessel	33,937		48,412		64,270	
Annual Cargo Tons/Vessel	519,779		787,275		1,107,179	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Rotterdam		Rotterdam		Rotterdam	
Bunker Cost/LT	$18.62		$18.62		$18.62	
T/C Ins./Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 29,332	$ 29,332	$ 29,332	$ 31,382	$ 31,382	$ 31,382	$ 34,413	$ 34,413	$ 34,413
T/C Ins./RT	687	687	687	755	755	755	815	815	815
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,500	2,500	2,500	3,000	3,000	3,000	3,500	3,500	3,500
Bunkers	20,370	20,370	20,370	26,534	26,534	26,534	34,111	34,111	34,111
Total Operating/RT	53,889	53,889	53,889	62,671	62,671	62,671	73,839	73,839	73,839
Amortization and Interest	42,142	31,051	25,558	48,389	35,655	29,310	57,396	42,299	34,760
Total Cost/RT	$ 96,031	$ 84,940	$ 79,447	$111,060	$ 98,326	$ 91,981	$131,235	$116,138	$108,599
Net Cost/LT ore (US $)	$2.83	$2.50	$2.34	$2.29	$2.03	$1.90	$2.04	$1.81	$1.69
Net Cost/LT ore (Canadian $)	$3.05	$2.69	$2.52	$2.47	$2.19	$2.05	$2.20	$1.95	$1.82

TABLE 6D

SHIPPING COST BREAKDOWN

MARKET: ROTTERDAM, NETHERLANDS
PORT OF ORIGIN: PUERTO ORDAZ

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	8,552		8,552		8,552	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	633	1,424	589	1,865	518	2,416
Load and Unload	72	36	72	42	72	36
Delays	24	18	24	18	24	18
Total Hours/RT	729 Hrs.	1,478 LT	685 Hrs.	1,925 LT	614 Hrs.	2,470 LT
Total Days/RT	30.375 Days		28.541 Days		25.583 Days	
RT/Yr. (351 Operating Days)	11.555		12.298		13.720	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	800		251		345	
Cargo Dwt.	34,350		44,630		50,605	
Annual Average Cargo/Vessel	34,350		44,630		50,605	
Annual Cargo Tons/ Vessel	396,914		548,859		694,300	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Rotterdam/Barbados		Rotterdam/Barbados		Rotterdam/Barbados	
Bunker Cost/LT: Rotterdam	$18.62		$18.62		$18.62	
Bunker Cost/LT: Barbodos	$14.62		$14.62		$14.62	
T/C Ins. /Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 38,880	$ 38,880	$ 38,880	$ 41,499	$ 41,499	$ 41,499	$ 43,210	$ 43,210	$ 43,210
T/C Ins. /RT	911	911	911	999	999	999	1,023	1,023	1,023
Port Charges: Origin	1,000	1,000	1,000	1,200	1,200	1,200	1,500	1,500	1,500
Port Charges: Barbados	300	300	300	300	300	300	-	-	-
Port Charges: Market	2,500	2,500	2,500	3,000	3,000	3,000	3,500	3,500	3,500
Bunkers: Rotterdam	13,760	13,760	13,760	17,922	17,922	17,922	22,995	22,995	22,995
Bunkers: Barbados	10,804	10,804	10,804	14,072	14,072	14,072	18,055	18,055	18,055
Total Operating/RT	68,155	68,155	68,155	78,992	78,992	78,992	90,283	90,283	90,283
Amortization and Interest	55,859	41,158	33,837	63,989	47,150	38,759	72,067	53,110	43,645
Total Cost/RT	$124,014	$109,313	$101,992	$142,981	$126,142	$117,751	$162,350	$143,393	$133,928
Net Cost/LT ore (US $)	$3.61	$3.18	$2.97	$3.20	$2.83	$2.64	$3.21	$2.83	$2.65
Net Cost/LT ore (Canadian $)	$3.89	$3.42	$3.20	$3.45	$3.05	$2.84	$3.46	$3.05	$2.85

TABLE 6E

SHIPPING COST BREAKDOWN

MARKET: ROTTERDAM, NETHERLANDS
PORT OF ORIGIN: PORT ETIENNE, FRENCH WEST AFRICA

	RIO			NEPTUNE			NEW BUILDING		
Vessel Class									
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	4,538			4,538			4,538		
Voyage RT Time and Fuel	Time	Bunkers		Time	Bunkers		Time	Bunkers	
Travel	336	756		313	991		275	1,283	
Load and Unload	72	36		72	42		72	36	
Delays	12	9		12	9		12	9	
Total Hours/RT	420 Hrs.	801 LT		397 Hrs.	1,042 LT		359 Hrs.	1,328 LT	
Total Days/RT	17.500 Days			16.541 Days			14.958 Days		
RT/Yr. (351 Operating Days)	20.057			21.220			23.465		
Cargo Dwt.									
Dwt. Vessel	35,400			50,343			52,680		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	560			750			400		
Cargo Dwt.	34,590			49,343			52,030		
Annual Average Cargo/Vessel	34,590			34,590			34,590		
Annual Cargo Tons/Vessel	693,771			1,047,060			1,220,883		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Rotterdam			Rotterdam			Rotterdam		
Bunker Cost/LT	$18.62			$18.62			$18.62		
T/C Ins. /Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 22,400	$ 22,400	$ 22,400	$ 24,050	$ 24,050	$ 24,050	$ 25,264	$ 25,264	$ 25,264
T/C Ins. /RT	525	525	525	579	579	579	598	598	598
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	2,500	2,500	2,500
Port Charges: Market	2,500	2,500	2,500	3,000	3,000	3,000	3,500	3,500	3,500
Bunkers	14,914	14,914	14,914	19,402	19,402	19,402	24,727	24,727	24,727
Total Operating/RT	42,339	42,339	42,339	49,531	49,531	49,531	56,589	56,589	56,589
Amortization and Interest	32,182	23,712	19,495	37,085	27,326	22,463	42,137	31,053	25,518
Total Cost/RT	$ 74,521	$ 66,051	$ 61,834	$ 86,616	$ 76,857	$ 71,994	$ 98,726	$ 87,642	$ 82,107
Net Cost/LT ore (US $)	$2.15	$1.91	$1.79	$1.76	$1.56	$1.46	$1.90	$1.68	$1.58
Net Cost/LT ore (Canadian $)	$2.31	$2.06	$1.93	$1.89	$1.68	$1.57	$2.05	$1.81	$1.70

TABLE 6F

SHIPPING COST BREAKDOWN

MARKET: ROTTERDAM, NETHERLANDS
PORT OF ORIGIN: VITORIA, BRAZIL

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	10,078			10,078			10,078		
Voyage RT Time and Fuel	Time	Bunkers		Time	Bunkers		Time	Bunkers	
Travel	747	1,681		695	2,200		611	2,851	
Load and Unload	72	36		72	42		96	48	
Delays	12	9		12	9		12	9	
Total Hours/RT	831 Hrs.	1,726 LT		779 Hrs.	2,251 LT		719 Hrs.	2,908 LT	
Total Days/RT	34.625 Days			32.458 Days			29.958 Days		
RT/Yr. (351 Operating Days)	10.137			10.814			11.716		
Cargo Dwt.									
Dwt. Vessel	35,400			50,343			64,920		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	1,000			1,353			400		
Cargo Dwt.	34,150			48,740			64,270		
Annual Average Cargo/Vessel	34,150			48,740			64,270		
Annual Cargo Tons/Vessel	346,178			527,074			752,987		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Rotterdam			Rotterdam			Rotterdam		
Bunker Cost/LT	$18.62			$18.62			$18.62		
T/C Ins. /Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 44,320	$ 44,320	$ 44,320	$ 47,194	$ 47,194	$ 47,194	$ 50,599	$ 50,599	$ 50,599
T/C Ins. /RT	1,039	1,039	1,039	1,136	1,136	1,136	1,198	1,198	1,198
Port Charges: Origin	2,600	2,600	2,600	3,100	3,100	3,100	4,000	4,000	4,000
Port Charges: Market	2,500	2,500	2,500	3,000	3,000	3,000	3,500	3,500	3,500
Bunkers	32,138	32,138	32,138	41,914	41,914	41,914	54,146	54,146	54,146
Total Operating/RT	82,597	82,597	82,597	96,344	96,344	96,344	113,443	113,443	113,443
Amortization and Interest	63,675	46,916	38,572	72,770	53,621	44,078	84,392	62,193	51,108
Total Cost/RT	$146,272	$129,513	$121,169	$169,114	$149,965	$140,422	$197,835	$175,636	$164,551
Net Cost/LT ore (US $)	$4.28	$3.79	$3.55	$3.47	$3.08	$2.88	$3.08	$2.73	$2.56
Net Cost/LT ore (Canadian $)	$4.61	$4.08	$3.82	$3.74	$3.32	$3.10	$3.32	$2.94	$2.76

TABLE 7A

SHIPPING COST BREAKDOWN

MARKET: PIOMBINO, ITALY
PORT OF ORIGIN: HAINES, ALASKA

Vessel Class	RIO	NEPTUNE	NEW BUILDING
Deadweight Tonnage (LT)	35,400	50,343	69,000
Voyage Distance (mi.)	19,696	19,696	19,696

Voyage RT Time and Fuel	RIO Time	RIO Bunkers	NEPTUNE Time	NEPTUNE Bunkers	NEW BUILDING Time	NEW BUILDING Bunkers
Travel	1,459	3,284	1,359	4,302	1,193	5,566
Canal Transit R/T	36	40	36	57	40	93
Load and Unload	72	36	72	42	96	48
Delays	24	18	24	18	24	18
Total Hours/RT	1,591 Hrs.	3,378 LT	1,491 Hrs.	4,419 LT	1,353 Hrs.	5,725 LT
Total Days/RT	66.291 Days		62.125 Days		56.375 Days	
RT/Yr. (351 Operating Days)	5.295		5.649		6.226	

Cargo Dwt.	RIO Summer Load	RIO Winter Load	NEPTUNE	NEW BUILDING
Dwt. Vessel	35,400	34,390	45,131	51,200
C&S	150	150	150	150
F/W	100	100	100	100
Bunkers	1,065	1,065	500	515
Cargo Dwt.	34,085	33,079	44,381	50,435
Annual Average Cargo/Vessel	33,582		44,381	50,435
Annual Cargo Tons/Vessel	177,816		250,708	314,008

Operating Costs Basis:	RIO	NEPTUNE	NEW BUILDING
Operating Cost/Day	$1.280	$1,454	$1,689
Bunker Source	Piombino/Aruba	Piombino/Aruba	Piombino/Aruba
Bunker Cost/LT	$20.02 / $13.00	$20.02/ $13.00	$20.02 / $13.00
T/C Ins. /Day	$30.00	$35.00	$40.00

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 84,852	$ 84,852	$ 84,852	$ 90,330	$ 90,330	$ 90,330	$ 95,217	$ 95,217	$ 95,217
T/C Ins. /RT	1,989	1,989	1,989	2,174	2,174	2,174	2,255	2,255	2,255
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Aruba	300	300	300	300	300	300	400	400	400
Port Charges: Canal Zone/RT	2,200	2,200	2,200	2,600	2,600	2,600	3,000	3,000	3,000
Canal Tolls $1.62 RT	12,085	12,085	12,085	17,360	17,360	17,360	22,426	22,426	22,426
Bunkers	55,771	55,771	55,771	72,954	72,954	72,954	94,516	94,516	94,516
Total Operating/RT	161,197	161,197	161,197	190,718	190,718	190,718	223,814	223,814	223,814
Amortization and Interest	121,909	89,824	73,848	139,284	102,631	84,366	158,808	117,035	96,176
Total Cost/RT	$283,106	$251,021	$235,045	$330,002	$293,349	$275,084	$382,622	$340,849	$319,990
Net Cost/LT ore (US $)	$8.43	$7.47	$7.00	$7.44	$6.61	$6.20	$7.59	$6.76	$6.34
Net Cost/LT ore (Canadian $)	$9.08	$8.04	$7.54	$8.01	$7.12	$6.68	$8.18	$7.28	$6.83

TABLE 7B

SHIPPING COST BREAKDOWN

MARKET: PIOMBINO, ITALY
PORT OF ORIGIN: SAN JUAN, PERU

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	13,540		13,540		13,540	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	1,003	2,258	935	2,959	820	3,826
Canal Transit R/T	36	40	36	57	40	93
Load and Unload	72	36	72	42	96	48
Delays	24	18	24	18	24	18
Total Hours/RT	1,135 Hrs.	2,352 LT	1,067 Hrs.	3,076 LT	980 Hrs.	3,985 LT
Total Days/RT	47.291 Days		44.458 Days		40.833 Days	
RT/Yr. (351 Operating Days)	7.422		7.895		8.596	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	1,330		500		515	
Cargo Dwt.	33,820		44,381		50,435	
Annual Average Cargo/Vessel	33,820		44,381		50,435	
Annual Cargo Tons/Vessel	251,012		350,388		433,539	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Aruba/Piombino		Aruba/Piombino		Aruba/Piombino	
Bunker Cost/LT	$13.00/$20.00		$13.00/$20.00		$13.00/$20.00	
T/C Ins. /Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 60,534	$ 60,534	$ 60,534	$ 64,642	$ 64,642	$ 64,642	$ 68,967	$ 68,967	$ 68,967
T/C Ins. /RT	1,419	1,419	1,419	1,556	1,556	1,556	1,633	1,633	1,633
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Aruba	300	300	300	300	300	300	400	400	400
Port Charges: Canal Zone/RT	2,200	2,200	2,200	2,600	2,600	2,600	3,000	3,000	3,000
Canal Tolls $1.62/RT	12,085	12,085	12,085	17,360	17,360	17,360	22,426	22,426	22,426
Bunkers	38,831	38,831	38,831	50,785	50,785	50,785	65,788	65,788	65,788
Total Operating/RT	118,369	118,369	118,369	140,743	140,743	140,743	166,214	166,214	166,214
Amortization and Interest	86,968	64,079	52,682	99,679	73,445	60,374	115,027	84,769	69,661
Total Cost /RT	$205,337	$182,448	$171,051	$240,418	$214,188	$201,117	$281,241	$250,983	$235,885
Net Cost/LT ore (US $)	$6.07	$5.39	$5.06	$5.42	$4.83	$4.53	$5.58	$4.98	$4.68
Net Cost/LT ore (Canadian $)	$6.54	$5.80	$5.45	$5.84	$5.20	$4.88	$6.18	$5.43	$5.10

TABLE 7C

SHIPPING COST BREAKDOWN

MARKET: PIOMBINO, ITALY
PORT OF ORIGIN: SEVEN ISLANDS, QUEBEC

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	7,500		7,500		7,500	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	556 Hrs.	1,251	517	1,637	455	2,123
Load and Unload	72	36	72	42	96	48
Delays	12	9	12	9	12	9
Total Hours/RT	640 Hrs.	1,296 LT	601 Hrs.	1,688 LT	563 Hrs.	2,180 LT
Total Days/RT	26.666 Days		25.041 Days		23.458 Days	
RT/Yr. (351 Operating Days)	13.162		14.017		14.963	
Cargo Dwt.						
Dwt. Vessel	35,400		50,343		52,680	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	810		1,073		400	
Cargo Dwt. Summer	34,340		49,020		52,030	
Cargo Dwt. Winter	33,334		47,544		-	
Annual Average Cargo/Vessel	33,837		48,282		52,030	
Annual Cargo Tons/Vessel	445,362		676,768		778,525	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Piombino		Piombino		Piombino	
Bunker Cost/LT	$20.02		$20.02		$20.02	
T/C Ins. /Day	$30.00		$35.00		$40.00	

	RIO			NEPTUNE			NEW BUILDING		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 34,132	$ 34,132	$ 34,132	$ 36,410	$ 36,410	$ 36,410	$ 39,621	$ 39,621	$ 39,621
T/C Ins. /RT	800	800	800	876	876	876	938	938	938
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	25,946	25,946	25,946	33,794	33,794	33,794	43,643	43,643	43,643
Total Operating/RT	63,878	63,878	63,878	74,580	74,580	74,580	88,202	88,202	88,202
Amortization and Interest	49,039	36,132	29,706	56,142	41,368	34,006	66,081	48,699	40,019
Total Cost/RT	$112,917	$100,010	$ 93,584	$130,722	$115,948	$108,586	$154,283	$136,901	$128,221
Net Cost/LT ore (US $)	$3.34	$2.96	$2.77	$2.71	$2.40	$2.25	$2.97	$2.63	$2.46
Net Cost/LT ore (Canadian $)	$3.60	$3.19	$2.98	$2.92	$2.58	$2.42	$3.20	$2.83	$2.65

TABLE 7D

SHIPPING COST BREAKDOWN

MARKET: PIOMBINO, ITALY
PORT OF ORIGIN: PUERTO ORDAZ

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	9,059		9,059		9,059	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	671	1,510	625	1,978	548	2,557
Load and Unload	72	36	72	42	72	36
Delays	24	18	24	18	24	18
Total Hours/RT	767 Hrs.	1,564 LT	721 Hrs.	2,038 LT	644 Hrs.	2,611 LT
Total Days/RT	31.958 Days		30.041 Days		26.833 Days	
RT/Yr. (351 Operating Days)	10.983		11.684		13.080	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	850		251		345	
Cargo Dwt.	34,300		44,630		50,605	
Annual Average Cargo/Vessel	34,300		44,630		50,605	
Annual Cargo Tons/Vessel	376,716		521,456		661,913	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Piombino/Barbados		Piombino/Barbados		Piombino/Barbados	
Bunker Cost/LT - Piombino	$20.02		$20.02		$20.02	
Bunker Cost/LT- Barbados	$14.62		$14.62		$14.62	
T/C Ins./Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 40,906	$ 40,906	$ 40,906	$ 43,680	$ 43,680	$ 43,680	$ 45,320	$ 45,320	$ 45,320
T/C Ins./RT	959	959	959	1,051	1,051	1,051	1,073	1,073	1,073
Port Charges: Origin	1,000	1,000	1,000	1,200	1,200	1,200	1,500	1,500	1,500
Port Charges: Barbados	300	300	300	300	300	300	-	-	-
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers: Piombino	15,655	15,655	15,655	20,400	20,400	20,400	26,126	26,126	26,126
Bunkers: Barbados	11,432	11,432	11,432	14,898	14,898	14,898	19,093	19,093	19,093
Total Operating/RT	92,052	92,052	92,052	84,029	84,029	84,029	96,112	96,112	96,112
Amortization and Interest	58,770	43,303	35,601	67,352	49,628	40,796	75,589	55,705	45,777
Total Cost/RT	$150,822	$135,355	$127,653	$151,381	$133,657	$124,825	$171,701	$151,817	$141,889
Net Cost/LT ore (US $)	$4.40	$3.95	$3.72	$3.39	$2.99	$2.80	$3.39	$3.00	$2.80
Net Cost/LT ore (Canadian $)	$4.73	$4.25	$4.91	$3.65	$3.22	$3.01	$3.65	$3.23	$3.01

TABLE 7E

SHIPPING COST BREAKDOWN

MARKET: PIOMBINO, ITALY
PORT OF ORIGIN: PORT ETIENNE, FRENCH WEST AFRICA

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	3,968			3,968			3,968		
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	294		662	274		867	240		1,120
Load and Unload	72		36	72		42	96		48
Delays	12		9	12		9	12		9
Total Hours/RT	378 Hrs.		707 LT	358 Hrs.		918 LT	358 Hrs.		1,177 LT
Total Days/RT	15.750 Days			14.916 Days			14.916 Days		
RT/Yr. (351 Operating Days)	22.285			23.531			23.531		
Cargo Dwt.									
Dwt. Vessel	35,400			46,500			64,920		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	515			700			400		
Cargo Dwt.	34,635			45,550			64,270		
Annual Average Cargo/Vessel	34,635			45,550			64,270		
Annual Cargo Tons/Vessel	771,840			1,071,840			1,512,337		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1.689		
Bunker Source	Piombino			Piombino			Piombino		
Bunker Cost/LT	$20.02			$20.02			$20.02		
T/C Ins./Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 20,160	$ 20,160	$ 20,160	$ 21,688	$ 21,688	$ 21,688	$ 25,193	$ 25,193	$ 25,193
T/C Ins./RT	472	472	472	522	522	522	597	597	597
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	2,500	2,500	2,500
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers:	14,154	14,154	14,154	18,378	18,378	18,378	23,563	23,563	23,563
Total Operating/RT	38,786	38,786	38,786	45,588	45,588	45,588	54,853	54,853	54,853
Amortization and Interest	28,964	21,341	17,561	33,442	24,642	20,256	42,018	30,966	25,447
Total Cost/RT	$ 67,750	$ 60,127	$ 56,347	$ 79,030	$ 70,230	$ 65,844	$ 96,871	$ 85,819	$ 80,300
Net Cost/LT ore (US $)	$1.96	$1.74	$1.63	$1.74	$1.54	$1.45	$1.51	$1.34	$1.25
Net Cost/LT ore (Canadian $)	$2.11	$1.87	$1.76	$1.87	$1.66	$1.56	$1.63	$1.44	$1.35

TABLE 7F

SHIPPING COST BREAKDOWN

MARKET: PIOMBINO, ITALY
PORT OF ORIGIN: VITORIA, BRAZIL

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	9,592			9,592			9,592		
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	711		1,600	661		2,092	581		2,711
Load and Unload	72		36	72		42	72		36
Delays	12		9	12		9	12		9
Total Hours/RT	795 Hrs.		1,645 LT	745 Hrs.		2,143 LT	665 Hrs.		2,756 LT
Total Days/RT	33.125 Days			31.041 Days			27.708 Days		
RT/Yr. (351 Operating Days)	10.596			11.307			12.667		
Cargo Dwt.									
Dwt. Vessel	35,400			46,697			52,680		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	985			1,297			400		
Cargo Dwt.	34,165			45,150			52,030		
Annual Average Cargo/Vessel	34,165			45,150			52,030		
Annual Cargo Tons/Vessel	362,012			510,511			659,064		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Piombino			Piombino			Piombino		
Bunker Cost/LT	$20.02			$20.02			$20.02		
T/C Ins. /Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 42,400	$ 42,400	$ 42,400	$ 45,134	$ 45,134	$ 45,134	$ 46,798	$ 46,798	$ 46,798
T/C Inc. /RT	994	994	994	1,086	1,086	1,086	507	507	507
Port Charges: Origin	2,600	2,600	2,600	3,100	3,100	3,100	4,000	4,000	4,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	32,932	32,932	32,932	42,903	42,903	42,903	55,175	55,175	55,175
Total Operating/RT	80,926	80,926	80,926	94,723	94,723	94,723	109,480	109,480	109,480
Amortization and Interest	60,916	44,884	36,901	69,594	51,280	42,154	35,683	26,297	21,610
Total Cost/RT	$141,842	$125,810	$117,827	$164,317	$146,003	$136,877	$145,163	$135,777	$131,090
Net Cost/LT ore (US $)	$4.15	$3.68	$3.45	$3.64	$3.23	$3.03	$2.79	$2.61	$2.52
Net Cost/LT ore (Canadian $)	$4.47	$3.96	$3.71	$3.92	$3.48	$3.26	$3.00	$2.81	$2.71

TABLE 8A

SHIPPING COST BREAKDOWN

MARKET: PHILADELPHIA
PORT OF ORIGIN: SAN JUAN, PERU

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	77,052			77,052			77,052		
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	522		1,175	486		1,538	428		1,997
Canal Transit RT	36		40	36		57	40		93
Load and Unload	72		36	72		42	72		36
Delays	12		9	12		9	12		9
Total Hours/RT	642 Hrs.		1,260 LT	606 Hrs.		1,646 LT	552 Hrs.		2,147 LT
Total Days/RT	26.750 Days			25.250 Days			23.000 Days		
RT/Yr. (351 Operating Days)	13.121			13.900			15.260		
Cargo Dwt.									
Dwt. Vessel	35,400			45,131			51,200		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	505			680			935		
Cargo Dwt.	34,645			44,201			50,015		
Annual Average Cargo/Vessel	34,645			44,201			50,015		
Annual Cargo Tons/Vessel	454,577			614,393			763,228		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Philadelphia			Philadelphia			Philadelphia		
Bunker Cost/LT	$14.24			$14.24			$14.24		
T/C Ins. /Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 34,240	$ 34,240	$ 34,240	$ 36,714	$ 36,714	$ 36,714	$ 38,847	$ 38,847	$ 38,847
T/C Ins. /RT	802	802	802	884	884	884	920	920	920
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Port Charges: Canal Zone/RT	2,200	2,200	2,200	2,600	2,600	2,600	3,000	3,000	3,000
Canal Tolls $ 1.62 RT	12,085	12,085	12,085	17,360	17,360	17,360	22,426	22,426	22,426
Bunkers	17,942	17,942	17,942	23,439	23,439	23,439	30,573	30,573	30,573
Total Operating/RT	69,549	69,549	69,549	84,497	84,497	84,497	99,766	99,766	99,766
Amortization and Interest	49,193	36,246	29,799	56,611	41,713	34,290	64,791	47,748	39,238
Total Cost/RT	$118,742	$105,795	$ 99,348	$141,108	$126,210	$118,787	$164,557	$147,514	$139,004
Net Cost/LT ore (US $)	$3.43	$3.05	$2.87	$3.19	$2.86	$2.69	$3.41	$3.05	$2.88
Net Cost/LT ore (Canadian $)	$3.69	$3.28	$3.09	$3.43	$3.08	$2.90	$3.72	$3.32	$3.14

TABLE 8B

SHIPPING COST BREAKDOWN

MARKET: PHILADELPHIA
PORT OF ORIGIN: SEVEN ISLANDS, QUEBEC

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)		35,400			50,343			69,000	
Voyage Distance (mi.)		2,614			2,614			2,614	
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	194		437	180		570	158		737
Load and Unload	72		36	72		42	96		48
Delays	12		9	12		9	12		9
Total Hours/RT	278 Hrs.		482 LT	264 Hrs.		621 LT	266 Hrs.		794 LT
Total Days/RT		11.583 Days			11.000 Days			11.083 Days	
RT/Yr. (351 Operating Days)		30.303			31.909			31.670	
Cargo Dwt.									
Dwt. Vessel	35,400			50,343			58,800		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	350			463			300		
Cargo Dwt. Summer	34,800			49,630			58,250		
Cargo Dwt. Winter	33,794			48,154			-		
Annual Average Cargo/Vessel	34,297			48,892			58,250		
Annual Cargo Tons/Vessel	1,039,302			1,560,094			1,844,777		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Philadelphia			Philadelphia			Philadelphia		
Bunker Cost/LT	$14.24			$14.24			$14.24		
T/C Ins. /Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 14,826	$ 14,826	$ 14,826	$ 15,994	$ 15,994	$ 15,994	$ 18,719	$ 18,719	$ 18,719
T/C Ins./RT	347	347	347	385	385	385	443	443	443
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	6,864	6,864	6,864	8,843	8,843	8,843	11,306	11,306	11,306
Total Operating/RT	25,037	25,037	25,037	28,722	28,722	28,722	34,468	34,468	34,468
Amortization and Interest	21,301	15,695	12,903	24,662	18,172	14,938	31,221	23,008	18,908
Total Cost/RT	$ 46,338	$ 40,732	$ 37,940	$ 53,384	$ 46,894	$ 43,660	$ 65,689	$ 57,476	$ 53,376
Net Cost/LT ore (US $)	$1.35	$1.19	$1.11	$1.09	$ .96	$ .89	$1.13	$ .99	$ .92
Net Cost/LT ore (Canadian $)	$1.45	$1.28	$1.20	$1.17	$1.03	$ .96	$1.22	$1.07	$ .99

TABLE 8C

SHIPPING COST BREAKDOWN

MARKET: PHILADELPHIA
PORT OF ORIGIN: PUERTO ORDAZ

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	4,508		4,508		4,508	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	334	752	312	987	272	1,268
Load and Unload	72	36	72	42	72	36
Delays	24	18	24	18	24	18
Total Hours/RT	430 Hrs.	806 LT	408 Hrs.	1,047 LT	368 Hrs.	1,322 LT
Total Days/RT	17.916 Days		17.000 Days		15.333 Days	
RT/Yr. (351 Operating Days)	19.591		20.647		22.891	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	970		231		300	
Cargo Dwt.	34,180		44,650		50,650	
Annual Average Cargo/Vessel	34,180		44,650		50,650	
Annual Cargo Tons/Vessel	669,620		921,888		1,159,429	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Port of Spain		Port of Spain		Philadelphia	
Bunker Cost/LT	$13.88		$13.88		$14.24	
T/C Ins. /Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 22,932	$ 22,932	$ 22,932	$ 24,718	$ 24,718	$ 24,718	$ 25,897	$ 25,897	$ 25,897
T/C Ins. /RT	537	537	537	595	595	595	613	613	613
Port Charges: Origin	1,000	1,000	1,000	1,200	1,200	1,200	1,500	1,500	1,500
Port Charges: Trinidad	300	300	300	300	300	300	-	-	-
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	11,187	11,187	11,187	14,532	14,532	14,532	18,825	18,825	18,825
Total Operating/RT	37,956	37,956	37,956	43,845	43,845	43,845	49,835	49,835	49,835
Amortization and Interest	32,947	24,276	19,958	38,114	28,084	23,086	43,193	31,831	26,158
Total Cost/RT	$ 70,903	$ 62,232	$ 57,914	$ 81,959	$ 71,929	$ 66,931	$ 93,028	$ 81,666	$ 75,993
Net Cost/LT ore (US $)	$2.07	$1.82	$1.69	$1.84	$1.61	$1.50	$1.84	$1.61	$1.50
Net Cost/LT ore (Canadian $)	$2.23	$1.96	$1.82	$1.98	$1.73	$1.62	$1.98	$1.73	$1.62

TABLE 8D

SHIPPING COST BREAKDOWN

MARKET: PHILADELPHIA
PORT OF ORIGIN: PORT ETIENNE, FRENCH WEST AFRICA

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	6,702		6,702		6,702	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	496	1,116	462	1,463	406	1,894
Load and Unload	72	36	72	42	96	48
Delays	12	9	12	9	12	9
Total Hours/RT	580 Hrs.	1,161 LT	546 Hrs.	1,514 LT	514 Hrs.	1,951 LT
Total Days/RT	24.166 Days		22.750 Days		21.416 Days	
RT/Yr. (351 Operating Days)	14.524		15.428		16.389	
Cargo Dwt.						
Dwt. Vessel	35,400		50,343		58,800	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	740		983		450	
Cargo Dwt.	34,410		49,110		58,100	
Annual Average Cargo/Vessel	34,410		49,110		58,100	
Annual Cargo Tons/Vessel	499,770		757,669		952,200	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Philadelphia		Philadelphia		Philadelphia	
Bunker Cost/LT	$14.24		$14.24		$14.24	
T/C Ins. /Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/Day	$ 30,932	$ 30,932	$ 30,932	$ 33,079	$ 33,079	$ 33,079	$ 36,172	$ 36,172	$ 36,172
T/C Ins. /RT	725	725	725	796	796	796	857	857	857
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	2,500	2,500	2,500
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	16,532	16,532	16,532	21,559	21,559	21,559	27,782	27,782	27,782
Total Operating/RT	52,189	52,189	52,189	60,434	60,434	60,434	70,311	70,311	70,311
Amortization and Interest	44,430	32,736	26,914	51,006	37,583	30,895	60,329	44,460	36,536
Total Cost/RT	$ 96,619	$ 84,925	$ 79,103	$111,440	$ 98,017	$ 91,329	$130,640	$114,771	$106,847
Net Cost/LT ore (US $)	$2.81	$2.47	$2.30	$2.27	$2.00	$1.86	$2.25	$1.98	$1.84
Net Cost/LT ore (Canadian $)	$3.03	$2.66	$2.48	$2.44	$2.15	$2.00	$2.42	$2.13	$1.98

TABLE 8E

SHIPPING COST BREAKDOWN

MARKET: PHILADELPHIA
PORT OF ORIGIN: VITORIA, BRAZIL

Vessel Class	RIO			NEPTUNE			NEW BUILDING		
Deadweight Tonnage (LT)	35,400			50,343			69,000		
Voyage Distance (mi.)	9,108			9,108			9,108		
Voyage RT Time and Fuel	Time		Bunkers	Time		Bunkers	Time		Bunkers
Travel	675		1,519	628		1,988	552		2,576
Load and Unload	72		36	72		36	96		48
Delays	12		9	12		9	12		9
Total Hours/RT	759 Hrs.		1,564 LT	712 Hrs.		2,033 LT	660 Hrs.		2,633 LT
Total Days/RT	31.625 Days			29.666 Days			27.500 Days		
RT/Yr. (351 Operating Days)	11.098			11.831			12.763		
Cargo Dwt.									
Dwt. Vessel	35,400			50,343			58,800		
C&S	150			150			150		
F/W	100			100			100		
Bunkers	945			1,643			450		
Cargo Dwt.	34,205			48,450			58,100		
Annual Average Cargo/Vessel	34,205			48,450			58,100		
Annual Cargo Tons/Vessel	379,609			573,211			741,530		
Operating Costs									
Basis: Operating Cost/Day	$1,280			$1,454			$1,689		
Bunker Source	Philadelphia			Philadelphia			Philadelphia		
Bunker Cost/LT	$14.24			$14.24			$14.24		
T/C Ins./Day	$30.00			$35.00			$40.00		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 40,480	$ 40,480	$ 40,480	$ 43,134	$ 43,134	$ 43,134	$ 46,448	$ 46,448	$ 46,448
T/C Ins./RT	937	937	937	1,038	1,038	1,038	1,100	1,100	1,100
Port Charges: Origin	2,600	2,600	2,600	3,100	3,100	3,100	4,000	4,000	4,000
Port Charges: Market	2,000	2,000	2,000	2,500	2,500	2,500	3,000	3,000	3,000
Bunkers	22,271	22,271	22,271	28,950	28,950	28,950	37,493	37,493	37,493
Total Operating/RT	68,289	68,289	68,289	78,722	78,722	78,722	92,041	92,041	92,041
Amortization and Interest	58,158	42,851	35,230	66,511	49,008	40,286	77,468	57,090	46,915
Total Cost/RT	$126,447	$111,140	$103,519	$145,233	$127,730	$119,008	$169,509	$149,131	$138,956
Net Cost/LT ore (US $)	$3.70	$3.25	$3.03	$3.00	$2.64	$2.46	$2.92	$2.57	$2.39
Net Cost/LT ore (Canadian $)	$3.98	$3.50	$3.26	$3.23	$2.84	$2.65	$3.14	$2.77	$2.57

TABLE 9A

SHIPPING COST BREAKDOWN

MARKET: PHIL/MORRISVILLE
PORT OF ORIGIN: SAN JUAN, PERU

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	77,096		77,096		77,096	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	532	1,185	496	1,550	440	2,015
Canal Transit RT	36	40	36	57	40	93
Load and Unload	72	36	72	42	72	36
Delays	24	18	24	18	24	18
Total Hours/RT	664 Hrs.	1,279 LT	628 Hrs.	1,667 LT	576 Hrs.	2,174 LT
Total Days/RT	27.666 Days		26.166 Days		24.000 Days	
RT/Yr. (351 Operating Days)	12.687		13.414		14.625	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	505		680		935	
Cargo Dwt.	34,645		44,201		50,015	
Annual Average Cargo/Vessel	34,645		44,201		50,015	
Annual Cargo Tons/Vessel	439,541		592,912		731,469	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Philadelphia		Philadelphia		Philadelphia	
Bunker Cost/LT	$14.24		$14.24		$14.24	
T/C Ins./Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 35,412	$ 35,412	$ 35,412	$ 38,045	$ 38,045	$ 38,045	$ 40,536	$ 40,536	$ 40,536
T/C Ins./RT	830	830	830	916	916	916	960	960	960
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	3,000	3,000	3,000	3,500	3,500	3,500	4,000	4,000	4,000
Port Charges: Canal Zone RT	2,200	2,200	2,200	2,600	2,600	2,600	3,000	3,000	3,000
Canal Tolls $1.62 RT	12,085	12,085	12,085	17,360	17,360	17,360	22,426	22,426	22,426
Bunkers	18,212	18,212	18,212	23,738	23,738	23,738	30,957	30,957	30,957
Total Operating/RT	72,739	72,739	72,739	87,159	87,159	87,159	102,879	102,879	102,879
Amortization and Interest	50,877	37,487	30,819	58,664	43,226	35,533	67,608	49,824	40,944
Total Cost/RT	$123,616	$110,226	$103,558	$145,823	$130,385	$122,692	$170,487	$152,703	$143,823
Net Cost/LT ore (US $)	$3.57	$3.18	$2.99	$3.30	$2.95	$2.78	$3.41	$3.05	$2.88
Net Cost/LT ore (Canadian $)	$3.84	$3.42	$3.22	$3.55	$3.18	$2.99	$3.68	$3.29	$3.11

TABLE 9B

SHIPPING COST BREAKDOWN

MARKET: PHIL/MORRISVILLE
PORT OF ORIGIN: SEVEN ISLANDS, QUEBEC

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	2,658		2,658		2,658	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	204	447	190	582	170	755
Load and Unload	72	36	72	42	96	48
Delays	24	18	24	18	24	18
Total Hours/RT	300 Hrs.	501 LT	286 Hrs.	642 LT	290 Hrs.	821 LT
Total Days/RT	12.500 Days		11.916 Days		12.083 Days	
RT/Yr. (351 Operating Days)	28.080		29.456		29.049	
Cargo Dwt.						
Dwt. Vessel	35,400		50,343		58,800	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	350		463		300	
Cargo Dwt. Summer	34,800		49,630		58,250	
Cargo Dwt. Winter	33,794		48,154		-	
Annual Average Cargo/Vessel	34,297		48,892		58,250	
Annual Cargo Tons/Vessel	963,060		1,440,162		1,692,104	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Philadelphia		Philadelphia		Philadelphia	
Bunker Cost/LT	$14.24		$14.24		$14.24	
T/C Ins. /Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 16,000	$ 16,000	$ 16,000	$ 17,326	$ 17,326	$ 17,326	$ 20,408	$ 20,408	$ 20,408
T/C Ins. /RT	375	375	375	417	417	417	483	483	483
Port Charges: Origin	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Port Charges: Market	3,000	3,000	3,000	3,500	3,500	3,500	4,000	4,000	4,000
Bunkers	7,134	7,134	7,134	9,142	9,142	9,142	11,691	11,691	11,691
Total Operating/RT	27,509	27,509	27,509	31,385	31,385	31,385	37,582	37,582	37,582
Amortization and Interest	22,987	16,937	13,925	26,716	19,685	16,182	34,038	25,084	20,614
Total Cost/RT	$ 50,496	$ 44,446	$ 41,434	$ 58,101	$ 51,070	$ 46,567	$ 71,620	$ 62,666	$ 58,196
Net Cost/LT ore (US $)	$1.47	$1.29	$1.21	$1.19	$1.04	$ .97	$1.23	$1.08	$1.00
Net Cost/LT ore (Canadian $)	$1.58	$1.39	$1.30	$1.28	$1.12	$1.04	$1.32	$1.16	$1.08

TABLE 9C

SHIPPING COST BREAKDOWN

MARKET: PHIL/MORRISVILLE
PORT OF ORIGIN: PUERTO ORDAZ

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	4,552		4,552		4,552	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	344	762	322	999	284	1,286
Load and Unload	72	36	72	42	72	36
Delays	36	27	36	27	36	27
Total Hours/RT	452 Hrs.	825 LT	430 Hrs.	1,068 LT	392 Hrs.	1,349 LT
Total Days/RT	18.833 Days		17.916 Days		16.333 Days	
RT/Yr. (351 Operating Days)	18.637		19,591		21.490	
Cargo Dwt.						
Dwt. Vessel	35,400		45,131		51,200	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	970		231		300	
Cargo Dwt.	34,180		44,650		50,650	
Annual Average Cargo/Vessel	34,180		44,650		50,650	
Annual Cargo Tons/Vessel	637,012		874,738		1,088,468	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Port of Spain		Port of Spain		Philadelphia	
Bunker Cost/LT	$13.88		$13.88		$14.24	
T/C Ins. /Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 24,106	$ 24,106	$ 24,106	$ 26,050	$ 26,050	$ 26,050	$ 27,586	$ 27,586	$ 27,586
T/C Ins. /RT	565	565	565	627	627	627	653	653	653
Port Charges: Origin	1,000	1,000	1,000	1,200	1,200	1,200	1,500	1,500	1,500
Port Charges: Trinidad	300	300	300	300	300	300	-	-	-
Port Charges: Market	3,000	3,000	3,000	3,500	3,500	3,500	4,000	4,000	4,000
Bunkers	11,451	11,451	11,451	14,824	14,824	14,824	19,209	19,209	19,209
Total Operating/RT	40,422	40,422	40,422	46,501	46,501	46,501	52,948	52,948	52,948
Amortization and Interest	34,633	25,518	20,980	40,168	29,597	24,330	46,010	33,907	27,864
Total Cost/RT	$ 75,055	$ 65,940	$ 61,402	$ 86,669	$ 76,098	$ 70,831	$ 98,958	$ 86,855	$ 80,812
Net Cost/LT ore (US $)	$2.20	$1.93	$1.80	$1.94	$1.70	$1.59	$1.95	$1.72	$1.60
Net Cost/LT ore (Canadian $)	$2.37	$2.08	$1.94	$2.09	$1.83	$1.71	$2.10	$1.85	$1.72

TABLE 9D

SHIPPING COST BREAKDOWN

MARKET: PHIL/MORRISVILLE

PORT OF ORIGIN: PORT ETIENNE, FRENCH WEST AFRICA

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	6,746		6,746		6,746	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	506	1,126	472	1,475	418	1,912
Load and Unload	72	36	72	42	96	48
Delays	24	18	24	18	24	18
Total Hours/RT	602 Hrs.	1,180 LT	568 Hrs.	1,535 LT	538 Hrs.	1,978 LT
Total Days/RT	25.083 Days		23.666 Days		22.416 Days	
RT/Yr. (351 Operating Days)	13.993		14.831		15.658	
Cargo Dwt.						
Dwt. Vessel	35,400		50,343		58,800	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	740		983		450	
Cargo Dwt.	34,410		49,110		58,100	
Annual Average Cargo/Vessel	34,410		49,110		58,100	
Annual Cargo Tons/Vessel	481,499		728,350		909,729	
Operating Costs						
Basis: Operating Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Philadelphia		Philadelphia		Philadelphia	
Bunker Cost/LT	$14.24		$14.24		$14.24	
T/C Ins. /Day	$30.00		$35.00		$40.00	

	RIO			NEPTUNE			NEW BUILDING		
Payout Periods	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.	10 Yrs.	15 Yrs.	20 Yrs.
Operating Cost/RT	$ 32,106	$ 32,106	$ 32,106	$ 34,410	$ 34,410	$ 34,410	$ 37,861	$ 37,861	$ 37,861
T/C Ins. /RT	752	752	752	828	828	828	897	897	897
Port Charges: Origin	2,000	2,000	2,000	2,500	2,500	2,500	2,500	2,500	2,500
Port Charges: Market	3,000	3,000	3,000	3,500	3,500	3,500	4,000	4,000	4,000
Bunkers	16,803	16,803	16,803	21,858	21,858	21,858	28,166	28,166	28,166
Total Operating/RT	54,661	54,661	54,661	63,096	63,096	63,096	73,424	73,424	73,424
Amortization and Interest	46,127	33,987	27,942	53,059	39,096	32,138	63,146	46,536	38,242
Total Cost/RT	$100,788	$ 88,648	$ 82,603	$116,155	$102,192	$ 95,234	$136,570	$119,960	$111,666
Net Cost/LT ore (US $)	$2.93	$2.58	$2.40	$2.37	$2.08	$1.94	$2.35	$2.06	$1.92
Net Cost/LT ore (Canadian $)	$3.15	$2.78	$2.58	$2.55	$2.24	$2.09	$2.53	$2.22	$2.07

TABLE 9E

SHIPPING COST BREAKDOWN

MARKET: PHIL/MORRISVILLE
PORT OF ORIGIN: VITORIA, BRAZIL

Vessel Class	RIO		NEPTUNE		NEW BUILDING	
Deadweight Tonnage (LT)	35,400		50,343		69,000	
Voyage Distance (mi.)	9,152		9,152		9,152	
Voyage RT Time and Fuel	Time	Bunkers	Time	Bunkers	Time	Bunkers
Travel	685	1,529	638	2,000	564	2,594
Load and Unload	72	36	72	36	96	48
Delays	24	18	24	18	24	18
Total Hours/RT	781 Hrs.	1,583 LT	734 Hrs.	2,054 LT	684 Hrs.	2,660 LT
Total Days/RT	32.541 Days		30.583 Days		28.500 Days	
RT/Yr. (351 Operating Days)	10.786		11.476		12.315	
Cargo Dwt.						
Dwt. Vessel	35,400		50,343		58,800	
C&S	150		150		150	
F/W	100		100		100	
Bunkers	945		1,643		450	
Cargo Dwt.	34,205		48,450		58,100	
Annual Average Cargo/Vessel	34,205		48,450		58,100	
Annual Cargo Tons/Vessel	368,935		556,012		715,501	
Operating Costs						
Basis: Operaring Cost/Day	$1,280		$1,454		$1,689	
Bunker Source	Philadelphia		Philadelphia		Philadelphia	
Bunker Cost/LT	$14.24		$14.24		$14.24	
T/C Ins/Day	$30.00		$35.00		$40.00	

Payout Periods	RIO 10 Yrs.	RIO 15 Yrs.	RIO 20 Yrs.	NEPTUNE 10 Yrs.	NEPTUNE 15 Yrs.	NEPTUNE 20 Yrs.	NEW BUILDING 10 Yrs.	NEW BUILDING 15 Yrs.	NEW BUILDING 20 Yrs.
Operating Cost/RT	$ 41,652	$ 41,652	$ 41,652	$ 44,468	$ 44,468	$ 44,468	$ 48,137	$ 48,137	$ 48,137
T/C Ins./RT	976	976	976	1,070	1,070	1,070	1,140	1,140	1,140
Port Charges: Origin	2,600	2,600	2,600	3,100	3,100	3,100	4,000	4,000	4,000
Port Charges: Market	3,000	3,000	3,000	3,500	3,500	3,500	4,000	4,000	4,000
Bunkers	22,541	22,541	22,541	29,249	29,249	29,249	37,878	37,878	37,878
Total Operating/RT	70,769	70,769	70,769	81,387	81,387	81,387	95,155	95,155	95,155
Amortization and Interest	59,842	44,093	36,250	68,567	50,523	41,532	80,285	59,166	48,621
Total Cost/RT	$130,611	$114,862	$107,019	$149,955	$131,910	$122,919	$175,440	$154,321	$143,776
Net Cost/LT ore (US $)	$3.82	$3.36	$3.13	$3.10	$2.72	$2.54	$3.02	$2.66	$2.48
Net Cost/LT ore (Canadian $)	$4.11	$3.62	$3.37	$3.34	$2.93	$2.73	$3.25	$2.86	$2.67

SECTION IF-19-62

MEASURED: NIXON & STEELE
PLOTTED; NIXON
AIR PHOTO; A-12148-182
106F11

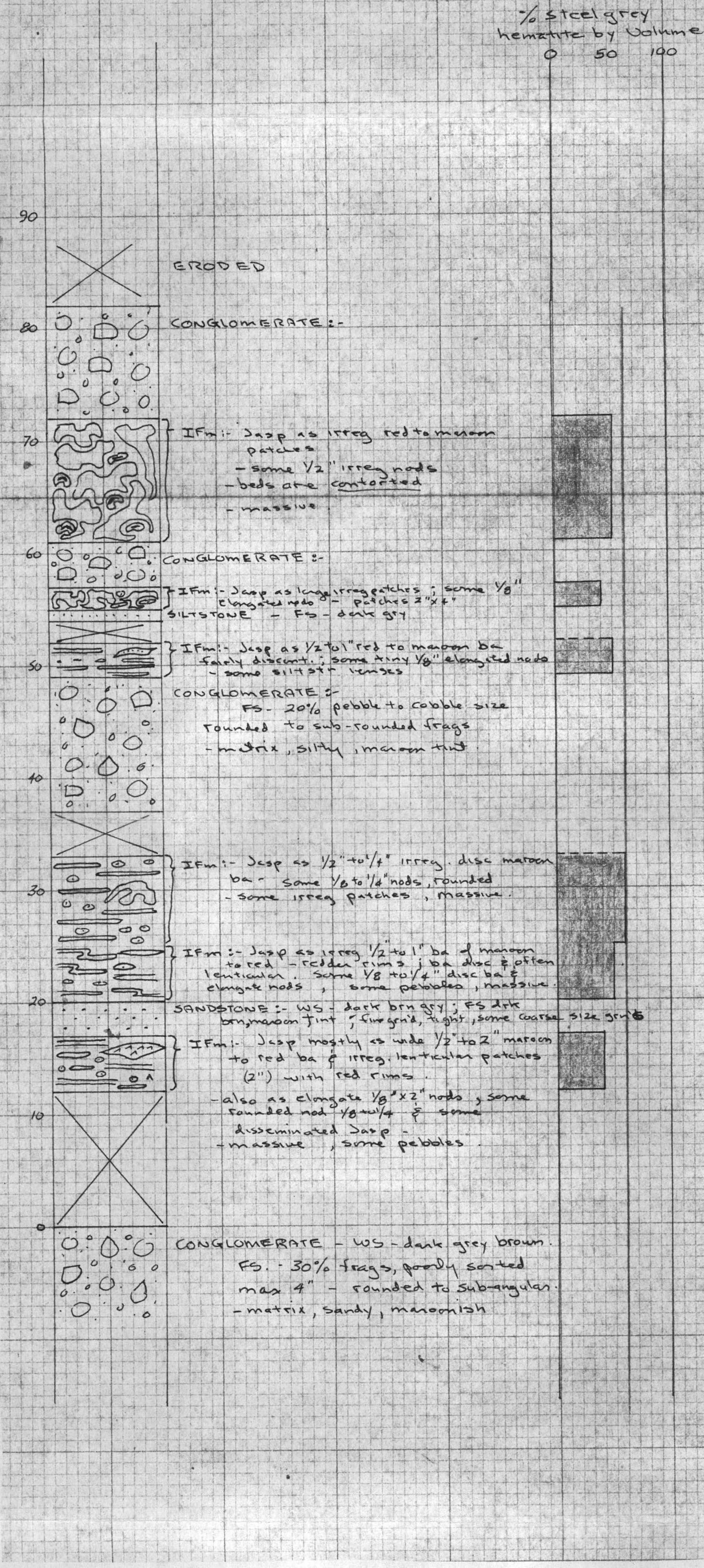
061478

"IF-25-62"

MEASURED - WILLIAMS & BRANDT
July 16/62

PLOTTED - WILLIAMS
JULY 24/62

PHOTO - #A-12148-181 flight 11



Drill hole

" D.D.H. #1 " IRON CREEK.


IF-6-62
plotted June 29/62
LEGEND
ba = bands
ba = continuous bands
nod = nodules
nod = "
nod = "
= birdseye texture
= disseminated jasper
CONGLOMERATE -@ 291'
ba's - red to maroon - 1" thick av. nods - occassionally - blocky
SANDSTONE: WS. - br gry FS. mar br-gry - silty, poorly sorted, fine grained - hem. matrix
ba's & corroded nod's - disseminated ba's - nods av. 1" diam.
nods - irregular ba's - mostly ba's av. 1" wide - maroon colour Shaley bands occassionally blocky to flaggy.
ba & nod = siderite centres - blocky
bа's - maroon. - hem = slight maroon tint - ghost by texture
nods, maroon ba's, - also nod. conc. in ba's - minute wavy bands - blocky to flaggy
flaggy
nod concentrated in ba's av. 6" wide
SILTSTONE: WS. - br gry FS - maroon gry-br - some sand size grains - hematite matrix - slatey fracture - multi coloured grains
ba 1/4" to 1/2" wide - maroon to red. - discontinuous
ba - av 1/2" wide - some ba of disseminated jas. - blocky
ba - red to maroon - average 1/2" wide - blocky
maroon bands - blocky
IF - maroon tint
siltstn lense - 1" wide
maroon jasp ba average 1" wide
occassional 2" to 3" ba of gry IF
nods 1/4" to 1/2" diam - blocky
chert jasper
SHALE ??
SHALE: WS - brick red FS - maroon - hematitic, 1/16" grains scattered thruout - looks like small scale conglomerate
maroon shaley lense
nods 1/2" x 1/4" max ba's 1/4 to 1/2 - blocky
ba - 1/4" wide max - discontinuous - massive to blocky
nod & dis - slatey to blocky - platey - 4" chert bed
by - 1/4" diam max & ba - maroon jasp - 1/4" wide max - blocky to massive
by & ba 1/8 to 1/4" wide
by siltstn lenses
disseminated jasper - massive to blocky
COVERED.
Channel samples
CHANNEL CHIP SAMPLE NO.'S
"CHANNEL" "CHIP"
0 50 100
% Hematite
SAMPLE INTERVAL
SAMPLE NO.
"IF-6-62"
Plotted June 29/62
R.M. Williams
measured - Williams & Nixon
SAMPLED - BRANDT & MOSS

IF-7-62

measured Williams & NIXON
plotted June 28/62 - RmWilliams
SAMPLED - KLASSEN & PORTIGAL.

LEGEND -
- ba = bands
- nod = nodules
- by = birdseye
- dis = disseminated

(ba, nod, by, dis: Textures of Jasper.)

- discontinuous bands
- continuous bands


IF-8-62
measured June 27/62 - Williams & Brandt
plotted June 29/62 - Williams
LEGEND
ba - bands - discontinuous
ba - " - continuous
nod - nodules
by - birdseye
dis - diseminated
JASPER TEXTURE
% HEMATITE
0 50 100
% IRON
0 50 69.9 100
360
CONGLOMERATIC S.S. & red HEMATITIC SHALE
IFm: ?? Jasper as sand sized angular grains scattered throughout hematite matrix - speckled texture - massive
350
340
330
IFm: Jasp mostly as ba (1/4"-1/2") also ba of by up to 9" wide - blocky to flaggy
320
SANDSTONE: WS - med brgry FS: greenmar to brgry Fine grn'd, tight, hem. matrix flaggy to slatey.
IFm: FS - steel gry Jasp mostly as ba 1/4" to 1" and large (1" diam) irregular nods - often faint maroon tint to hem.
310
300
IFm: FS - steel gry Jasp. mostly as ba 1/2 to 1" - very few nods - flaggy
290
IFm: FS - steel grey Jasp - red to maroon as ba 1/2" to 1" 4" max - blocky
2' sand lense
280
IFm: FS - steel grey Jasper as nod - (1/4" diam) c̄ siderite centres - occassional maroon ba 1/4" to 1"
270
IFm: FS - steel grey Jasper almost entirely ba (1/4" to 2") - hem as ba (1/4" to 2") - blocky
260
IFm: Jasper in ba Av 1/2" thick - flaggy.
IFm: FS - steel grey Jasp as occassional ba & nod. ghost by - occassional sand lense - massive to blocky
250
IFm: FS steel grey Jasp as maroon ba (1/8" to 1/2") - occassional nod.
240
IFm: FS - steel grey Jasp as occassional tiny nod or stringer - massive.
sand lense
IFm as @ 220-230'
argillaceous band
230
IFm: FS steel grey Jasp as nod c̄ siderite cores (1/8 to 1/4" diam) - occassional by & ba (1/4") also ghost by
220
Sand lenses & Argillaceous IFm
IFm - FS - steel grey Jasp - maroon as ba (1/4 to 1") hem as ba (1/4" to 2")
SANDSTONE: WS brown FS - dark maroon gry brn; fine grn'd; tight, subrounded, hem. matrix - FLAGGY - SAMPLE 207'
210
IFm: Jasp as dark maroon irregular ba & blobs intergrown 1/4" thick & indefinite length
200
IFm: FS - steel gry Jasp as ba (1/8" to 1/4") and elongated nods Av 1/4" diam
190
50/50 IFm & CONG - interlensed - Jasp as thick ba (4") & nod (1/4" to 1" diam) & by tex. - IFm - poor grade 30 to 40% steel gry hem
180
CONGLOMERATE: WS gry br FS - hematitic matrix - poorly sorted - frags Av 1/2 inch but 6" max - frags subrounded to sub angular greenstn, qtzite IFm etc.
170
160
150
IFm: FS - steel gry Jasp - maroon in ba 2" Av - two shaley 10" units - 148'-50' - flaggy Jasper 1/8 laminations
140
IFm: steel gry Jasp - mostly as nods often irregular - maroon c̄ red rim - 1/4" to 1/2" diam - occassional 2" band by - several sand lenses & one ss stringer six feet long - one lense @ 135' 18" x 3'
130
120
110
100
IFm: FS - steel gry Jasp mostly as irregular nod's 1" Av diam; maroon centre c̄ red rims - blocky to massive.
90
IFm - FS - steel grey Jasp mostly as nod 1/8" to 1/2" diam - massive to blocky
IFm: FS: steel grey Jasp as ba Av 1/4" spaced 1" to 4" apart. - nod (1/4" diam) between - blocky to massive
80
IFm: occassional Jasp stringer.
IFm: FS: steel grey Jasp - maroon in ba 4" thick - 3/4" otherwise nods 1/8" to 1/4" - sand lenses on bedding plane up to 1" thick
70
60
wavy bedding sand lense 1" wide & pebbles
50
IFm: FS: steel gry - Jasp as ba Av 1/2" - ghost by - massive to blocky
IFm: FS - steel gry Jasp as ba 1/8" to 1/2" also as nod and lenses 2" x 6" max.
40
IFm: FS: steel grey Jasper red to maroon as ba 1" thick & nod (1/4" diam) in hem.
IFm: FS: steel gry Jasp - red to maroon in ba 1/4" to 1/2" - fairly discontinuous
30
Qtzite cobble c̄ flow lines around it
20
10
IFm: FS: steel grey Jasp as ba 1/16" to 1"
0
CONGLOMERATE: WS - maroon brown FS: maroon matrix c̄ vari-coloured frags - poorly sorted - only occassional pebble & larger.
104' > 50% Fe
150' = or > 50% Fe = DIRECT SHIPPING ORE


"IF-9-62"
measured - July 7/62 - williams & Steele
Plotted - July 9/62 williams
LEGEND
nod - nodules
ba - bands (continuous & discontinuous)
by - birdseye texture
dis - disseminated
Jasper Textures
% Hematite by Volume
0
50
100
CONGLOMERATIC SHALE :-
-10% sand to small pebble size frags
- matrix - hematitic, argillaceous, sandy etc.
IFm - 90% Jasper
60% Hematite by Volume
S.S.
275
274
273
368
272
271
270
269
S.S.
268
267
266
265
264
263
262
261
260
259
258
257
TOTALS
"IF-9-62"

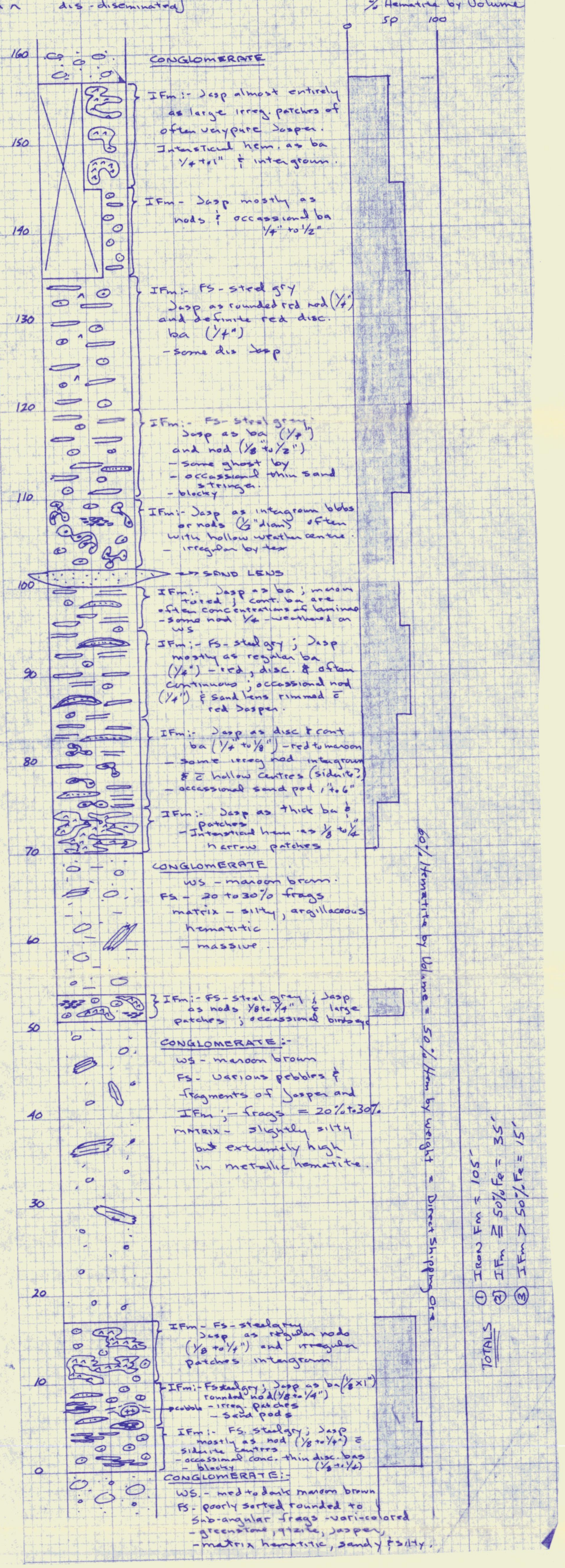
"IF-10-62"

measured - Williams & Brandt July 8/62
plotted - Williams - July 9/62
Photo # A 12056-351

LEGEND

- nod - nodules
- ba - bands
- by - birdseye
- blobs or Patches
- dis - diseminated

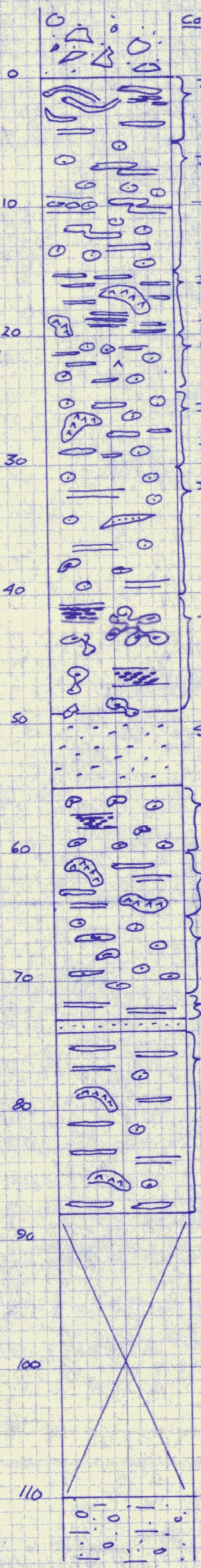
} JASPER TEXTURE



"IF-11-62"

measured - Williams & Brandt July 8/62
Plotted - Williams July 9/62
Photo # A12056-351 Fgt 9

% Hematite by Volume
0 50 100



CONGLOMERATE
70% frags - matrix hematitic

IFm:- Jasp mostly as ba
fairly cont, slightly contorted
1/8 to 1/4" -

IFm:- Jasp mostly as nods
(1/4") rounded ~~& irreg~~, ~~both~~;
- some irreg. ba
- often nod conc in ba
- some ghost by

IFm:- Jasp mostly as
tiny laminae - red to maroon
- also as large irregular
patches (2"-6")

IFm:- Jasp mostly as nods (1/4")
- some laminae
- some disseminated

IFm - Jasp as nods (1/4") red
rounded & red ba (1/4")
- also maroon irreg patches
& laminae

IFm -
Jasp as nods (1/8")
- occassionally irregular
- also " cont. ba of
Jasper (1") - maroon.
- irreg patches
- sand pods (1")

IFm:- Jasp as ba (1") of
conc by tex; also as
irreg network of irreg nod.
- often maroon tint to hem

SANDSTONE:- w.s. dark brownish gy
f.s. - greenish brown gry.; poorly
sorted various sized grains
- hematitic

IFm:- Jasp as (1/4") nod & conc
ba of by tex - mostly
nods are irreg.

IFm:- Jasp red to maroon ba (1/4 to 1")
also as irreg patches
- flaggy to blocky

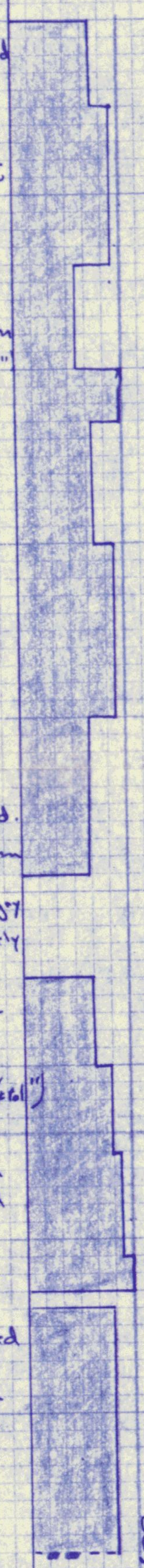
IFm:- Jasp as red to maroon
nods (1/4") mostly rounded
some elongated nods disc. ba.

IFm - Jasp as maroon 1" ba
- flaggy

S.S.

IFm:- Jasp as maroon & red
ba (1/4 to 1")
- some nod & larger
irreg patches
- flaggy

CONGLOMERATIC SHALE:-
- 10 to 20% grains
- matrix hematitic
& argillaceous



60% Hem by Vol = 50% Fe by Wt.

TOTALS
(1) IRON FM = 86'
(2) DIRECT SHIPPING ORE = 5'

"IF-12-62"

measured - Williams & Nixon
July 10/62

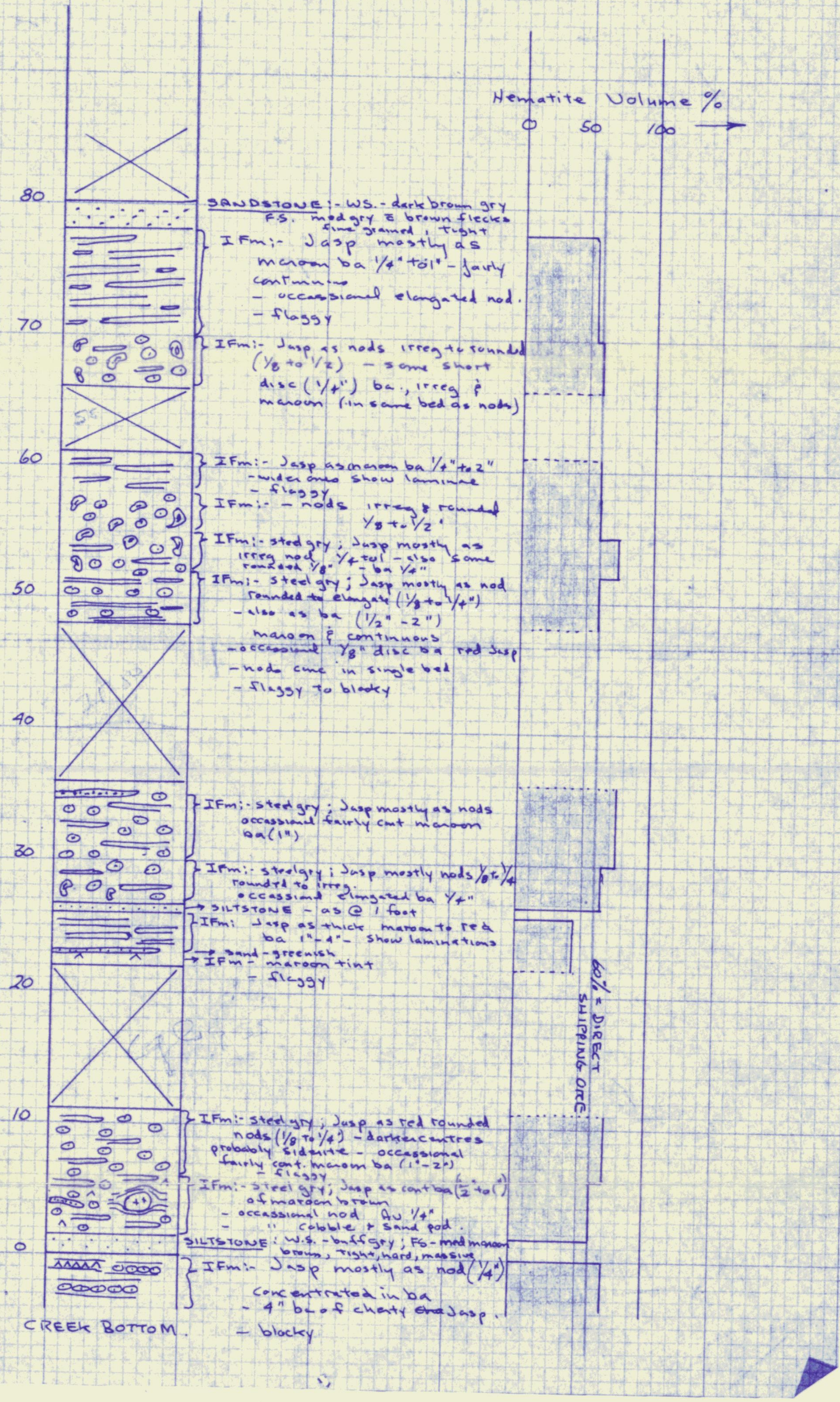
plotted - Williams
July 12/62

Photo No. A 12148-183 Flt-11

LEGEND

- nod - nodules
- ba - bands
- pa - patches
- by - birdseye
- dis - diseminated

(nod, ba, pa, by: JASPER TEXTURES)




IF-13-62
MEASURED: NIXON & WILLIAMS
PLOTTED ; NIXON
PHOTO ; A 12148 - 183
SAMPLED ; NIXON , SATTIN , DOKA
0 50 100
PERCENTAGE HEMATITE BY VOLUME
Channel samples
0
CONGLOMERATE W.S. dk rd bn F.S. bn-rd bn Submet. lustre in part matrix f-m.g. hematitic
CONGLOMERATE as above with more abundant and larger coarse clastics hematitic
10
20
I Fm Hem. st. gy elongate nods in upper pt bands lower part of variable thickness to 6"
I Fm Hem. st. gy alt. layers of jasp & hem 1"
I Fm Hem. st. gy
I Fm Hem st. gy platy
CONGLOMERATE ; jasper hematite
I Fm Hem. st. gy & maroon nods b.y. text.
SANDSTONE : conglomeratic W.S. ch. bn ; F.S. dk gy bn hem & rock frags to 1"
30
40
50
I Fm Hem. st. gy jasp. as irreg. lense like masses - and in layers with irregular contact with the hematite
60
SANDSTONE : W.S. Brown F.S. gy to bn gn gy : f.g. - equigranular
I Fm. jasp. in bands and in nodules concentrated in the upper and lower extremities of the unit
SANDSTONE : W.S. gn to gn bn F.S. , gn gy Inequigranular or finely conglomeratic 1/16" frags in bn gy matrix a large lens??
70
80
I Fm : Hem st. gy jasp
jasp. as distinct spheroidal masses long irregular tabulate masses bands
90
I Fm : similar to the above and with nods with irreg. outer boundaries and dk mineral (siderite ?) in the centre
I Fm : nods - bands of jasper containing streaks of st. gy hem
100
110
120
I Fm : Hem st. gy jasper bands irreg & discontinuous - ellipsoidal and irregular nods often with hematite in the centers
130
140
I Fm : Hem st. gy jasper - nodules with siderite ? & hematite centres - in layers to 6" thick silty layers
I Fm : Hem. st. gy : jasper Jasper in nods & irregular bands
I Fm : Hem. jasp. (banded) Platy
SANDSTONE : W.S. Brown F.S. gy . bn gy . f.g. equi
150
I Fm Hem. st. gy jasper nodules , elongate lenses - layers to 6"
160
I Fm Hem. st. gy jasper jasp. as bands 2" tk and flattened nodules
I Fm Hem. st. gy jasper jasp occurring predominately as small (1/4) in top 5' - with increasing downwards. in the interval
170
I Fm Hem. st. gy & maroon jasp. in bands, and in maroon hem. (klisp).
I Fm Hem st. gy jasper jasp as small nods with thin intermittent bands . Nodules have tendency to concentrate at top of thick beds (4 feet)
180
I Fm Hem. st. gy. jasper jasper as nods and bands.
SILTSTONE : cherty , hematitic
I Fm Hem st. gy jasper jasper as small nodules (1/2") and thin bands
190
SANDSTONE : W.S. Brown F.S. gr gy . f.g. eq thinly bedded ; conglomeratic at base
200
I Fm : Hem st. gy jasper nods to 2" - very irregular often interconnected masses and well defined bands to 2" tk
COVERED
210
220
230
240
250
FLOAT ??
I Fm :- Jasp red as 1/4" to 1/2" irreg nods & elongated nods - some patches of semi by tex.
- Jasp maroon as 1/4" to 1 or 2" fairly continuous to irreg ba's.
- red / maroon = 50/50
260
270
280
290
I Fm :- Jasp maroon patches & cont. ba.
I Fm :- scarce tiny red nods
I Fm :- Jasp as rounded nods - dark centres c red rims 1/8" to 1/4" - occassional 1/2" irreg red to brownish nod ; occassional 1" to 2" cont. maroon ba
I Fm :- Jasp mostly maroon to red 1/4" to 1/2" fairly continuous ba. - often irreg on their boundaries - some rounded to irreg red nods - massive
300
310
146
145
144
143
141
140
139
138
137
136
135
134
133
132
131
130
129
128
127
rubble
126
125
124
123
122
121
120
119
118
117
116
115
114
113
112
111
110
109
108
107
106
105
104
103
102
101
800
150
149
148
147

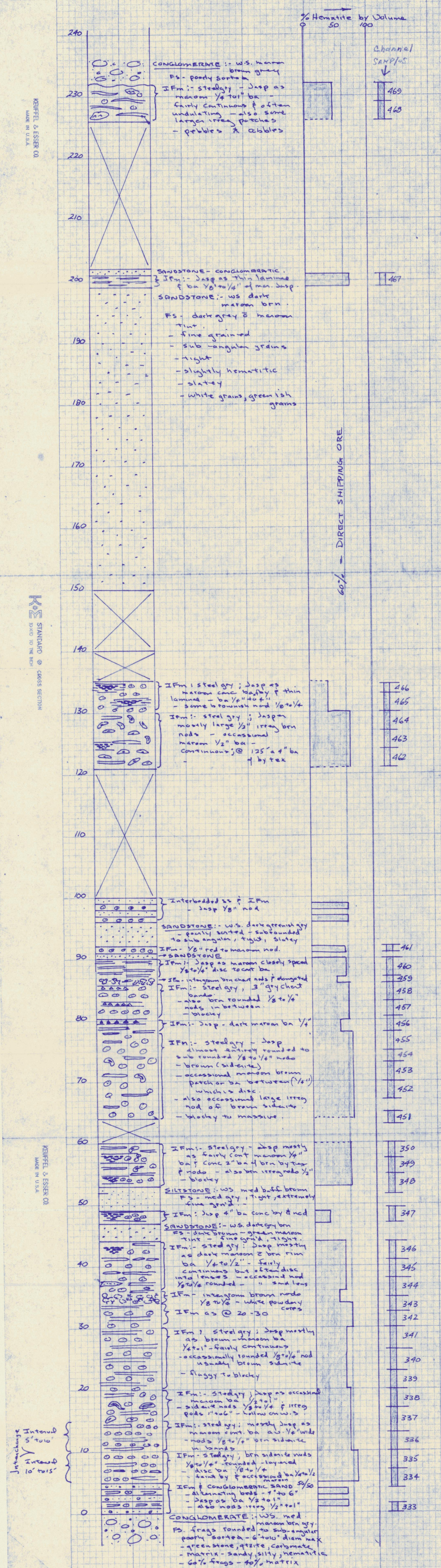
"IF- 14-62"

measured - Williams & Brandt
July 11/62

Plotted - Williams
July 12/62

Photo - A-12148-273 - Jit 13

LEGEND

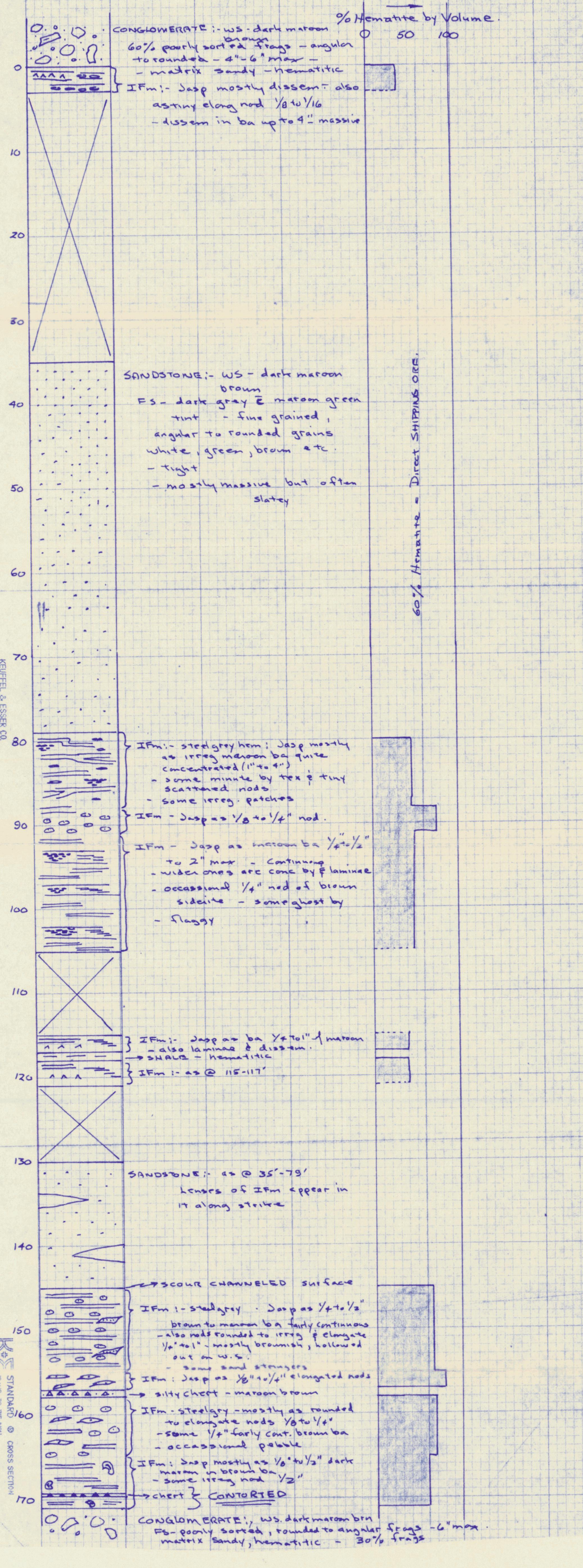


"IF-15-62"

measured by Williams & Brandt July 11/62

plotted by Williams July 12/62

Photo # A-12148-273 Jlt 13




IF - 16 - 62
MEASURED : NIXON & STEELE
PLOTTED ; NIXON
PHOTO ; A 12056 - 351
SAMPLED ; STEELE & SCURR.
0 50 100
PERCENTAGE HEMATITE BY VOLUME
Channel Sample
COVERED
I Fm : Hem. st. gy. ; jasp distinct f. lam (to 8" tk)
Minute by nods (1/16 - 1/8")
Thin nod. agg to 1" ; Thin 1/8" streaky bands at jasp in hem.
SANDSTONE : W.S. dk bn gy F.S. gy ; f.g., equi., v. thinly banded (1/4 - 1")
I Fm : Hem st. gy & jasp - distinct, or discreet (to 4" tk) bands
minute nodules
Thin nod agg's to 3", often in layers.
The whole, has a fine (2"-4") alt. layered aspect
@ 310' a 1" layer of platy hem and chert bands c ptc sandy lens (4" tk and 3" long)
CONGLOMERATE W.S. choco bn - bn blk F.S. br - br blk
Pbls & cobbls to 6"
I Fm : St. gy. jasp - as distinct Bands (2 to 4")
conglomerate bands (6" tk)
I Fm : Hem. st gy & jasp, - as distinct bands to 4" thick
- fine nodules (1/4" - 1/2")
I Fm : Hem st. gy & jasp abund. nod. layered agg to 4"
I Fm : Hem st gy jasp - abund. nod. layered agg (to 4")
- nods dispersed in thin (1/2 - 3/4") layers in hem
I Fm. Hem St. gy : jasp - thin (1/4" - 1/2") bands to 2' long
- occ sph & ellip nod to 3/4"
I Fm. Hem st gy : jasp. nods to 1" - nod agg layers 2"
- nodules rarely to 2" concentrated in layers (4" tk)
I Fm : Hem St gy jasp, in bands nodular & streaky to 6" tk nodules to 1/2"
I Fm : Hem. St gy jasper - nod. jasp layer 2" tk at base
layers of jasp to 6"
abundant small 1/8" nods
SANDSTONE (MARKER) W.S. bl - gy ; F.S. br - gy f.g. equi v. thinly bedded
conglomerate
I Fm . HEM st gy jasper in nods (1/2") & nodular layers (1/2" to 3")
← 2" sandstone layer
IFm. Hem St. gy : jasp as nods (1/2") and thin discontinuous nod bds (1/2")
CONGLOMERATE : abundant jasp - hem lense like nods Cobbles to 6"
HEMATITIC.
CONGLOMERATE : WS lt gy bn FS gy bn
I Fm : Hem st. gy : jasp as round nods to 1 1/2" - 4" & thin bands & nodular bands to 1/4" Nods from 1/32 to 1/4" abundant
CONGLOMERATE , W.S. ch. bn F.S. ch. bn gy - f grained silty matrix predominate.
I Fm : St. gy Hem : jasp abund nods (1/8 - 1/2) lg. lenses to 6"
CONGLOMERATE : W.S. choco. bn F.S. dk bn gy pbls - cobblles to 4". Eros. surface?
I Fm : Hem. st. gy jasp. in large lensoid aggs to 1 1/2' tk - abund. nods
I Fm : Hem st. gy jasp jasp in discreet nod layers to 4" tk abundant nods (1/4 - 1/2")
I Fm : Hem. st. gy jasper jasp. as irreg nodular bands to 6" with small (1/4") irreg & spheroidal nods - random in the hem
Occ layer of jasper 3" tk
I Fm : Hem. st. gy. - platy
I Fm ; Hem. st. gy jasper in bands to 6" - nods not too abund (to 1") Nods in irreg. inter layers
CONGLOMERATE WS : dk ch bn FS : lt bn to lt bn gy
Abund. coarse clastics. Cobbles concentrated in irregular layers.
Erosional Surfaces - stream channels?
CONGLOMERATE ; WS dk ch bn FS. lt bn to lt bn gy
Abund. pebbles cobbles & boulders to 5 feet across.
I Fm : Hem st. gy & maroon sub metallic & jasper nods & nodular layers - & int. in maroon hem.
I Fm : Hem st. gy & jasper bands to 2" - elongate nods - streak like
- abundant spheroidal nods
- nods (ellip) to 6"
IFm : Hem. st. gy jasper jasp: v. thin ba (2") : Nods sparse occur in bands 1/2" to 1 1/2', a conglomerate lens 2' long
CONGLOMERATE
inaccessible
covered
SAMPLE INTERVAL
SAMPLE NO.
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
291
290
289
288
287
286
285
284
283
282
281
280
279
278
277
276
175
174
173
172
171
170
169
168
167
166
165
164
163
162
161
160
159
158
157
156
155
154
153
152
151
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26

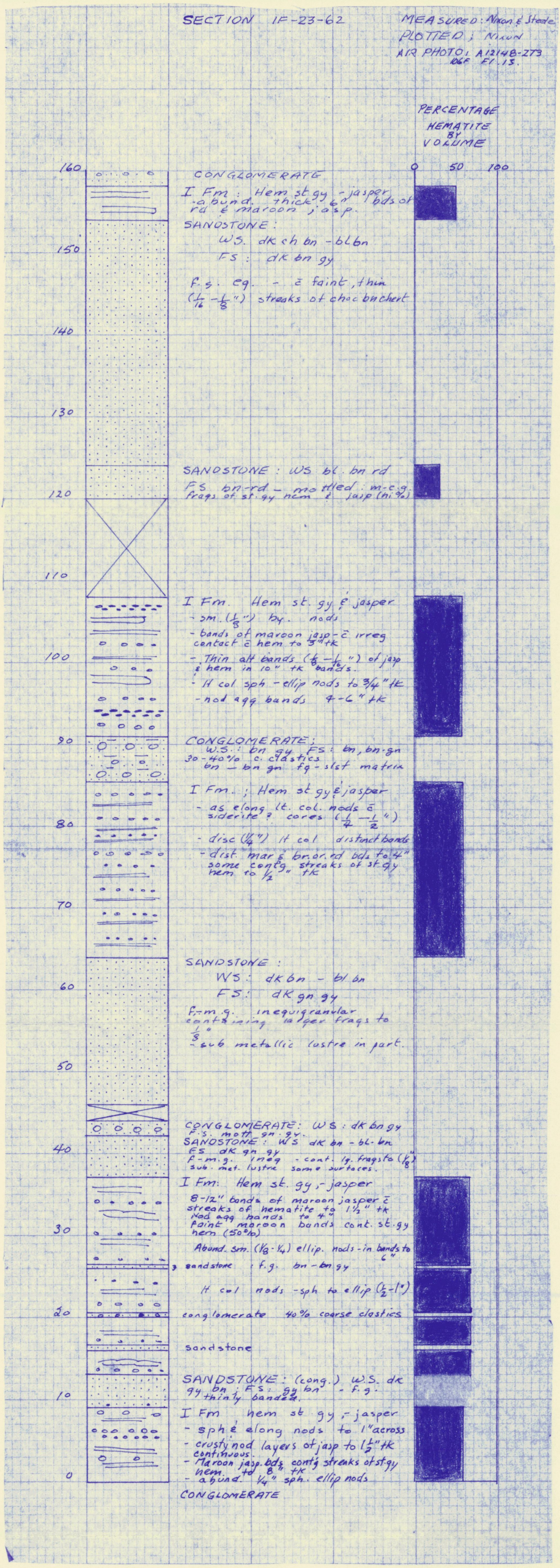
IF - 17-62
MEASURED ; NIXON & STEELE
PLOTTED ; NIXON
AIR PHOTO ; A-12056-351 106F
HEMATITE PERCENTAGE BY VOLUME
0 50 100
0 CONGLOMERATE
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
CONGLOMERATE :- shaly
Alt. bands of green and brown fissile shale - c cobbles & pbls.
I. Fm : Hem. st. gy & jasp
- jasp as dist bands contg some hem in faint stringers
bands to 6" tk
as nods - elongate - and thin 1/4" discontinuous bands
SANDSTONE : WS Br gy FS. gy - dk gn gy
f.g. eq. f. lam.
I. Fm. Hem. st. gy & jasper
- jasp as nod. agg. to 1"
- irreg nod. layers to 1' tk continuous
- fine (1/16" - 1/8) nods dispersed thru hematite.
CONGLOMERATE WS: gy bn - lt gy bn
FS. gy bn. : cob's to 2'
CONGLOMERATE W.S. bn gy
FS. bn - bn gy. : pbls cobbls
layers of f.g. f. lam ss.
1-3" layers of jasper
CONGLOMERATE
WS. dk ch. bn
FS. bn. gy.
lg. cobbles 1-2' - contg a 1' tk bds of I Fm.
I Fm Hem. st. gy. jasp
- nods sph to ellip -
- bands to 9" contg f. irreg bds of st gy hem.
- cong. lenses 6" tk; 3-6' long
- thin nod agg. bands to 2"
I Fm: Hem st gy - jasper - abundant sph. nodules to 3/4"
- distinct bands, thin, to 2"
- @ 98' 6" bd of by text.
I Fm Hem st gy & jasper
jasp as discontinuous thin 1/4" bands
- elongate nods
agg of sph. nods to 2" across
- as discreet bands & some hem
2" tk
- agg bds 2"
- min. by text. - conc in cherty bands to 1" tk
I Fm: Hem st gy & jasper
- nods to 1"
- elong agg bds to 1'
- some nods have weathered wh. centers - wh. qtz?
@ 128 platy hematite
- 6" bd by text.
SANDSTONE : W.S. bn. gy F.S. alt. gn - dk bn
I Fm: Hem. st. gy - jasp.
- nods - sub sph - ellip & elongate to 2"
- irreg nod. agg 3" across discon. along strike.
- discon jasp bands to 6"
← platy hem
CONGLOMERATE :
WS: bl - ch. bn
FS: bn gy mott
Pbls cobbls bldrs
some discordant boulders of I Fm.
I Fm : Hem st. gy, jasper
- sph to ellip nodules to 1 1/2"
- abund of discreet thin 1/4" discont. bands
I Fm : Hem. st. gy - jasp.
- Maroon Hematite
- Irreg. disc. nodules to 3"
I Fm : Hem st gy & jasper
- irreg. 1/8 bands to 1 1/2"
- nodules sph & ellip to 3/4"
- banded nod. agg, cont, 2" tk
- streak like, thin 1/4", distinct bands
- distinct jasper bands to 6"
- occ platy thin (4") layer of hem. st gy
CONGLOMERATE
WS: choco. brown - dk ch bn
FS: choco brown
Pebbles cobbles & boulders.
in f.g. ch bn matrix.
CONGLOMERATE
W.S. choc. bn - dk ch. bn
FS. choc. bn.
Pebbles, cobbles & boulders
in f.g. ch. bn matrix.
I Fm: hem st. gy
jasper : pred as bands 6" tk
& large by nods 1 1/2" long
← platy Hematite
← cong lens
cherty silst' w.s. dk bn gy F.S. ch. bn.

"IF-21-62"
Measured :- Williams & Brandt - July 14/62
Plotted :- Williams July 23/62
Photo # A-12106-315 flight 14
% by Volume of steelgry hematite
0 50 100
Channel Samples
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
CONGLOMERATE
IFm & SANDSTONE - some s.s. is green, some grey - interbedded 6" brds
IFm - maroon ba up to 2" also dis Jasper
SANDSTONE :- WS & FS - dark grey
427
426
SANDSTONE :- WS med greengry FS - very conglomeratic c pebbles up to 2" - matrix green.
IFm :- Jasp as 1" to 2" maroon ba, thicker ones are conc. by tex
325
SANDSTONE :- FS - greenish drkgry - less Jasp & hem as @ 194-202 - fine grn'd, tight, well indurated
214-219 - higher in Jasp & hem.
SANDSTONE :- WS - drk maroon brn FS - drk gry brn, med grn'd poorly sorted, high in Jasper grains - high in metallic hematite in matrix - tight - massive
IFm :- Jasp as 1/4" nod (red) & very occassional red 1" ba
324
SANDSTONE :- WS. maroon green FS. med green, finegrn'd. tight
IFm :- Jasp as maroon 1/8 to 1" ba - fairly cont. - thicker ones c reddish rims - some 1/2" irreg brownish nods - flaggy to blocky - some ba up to 4" wide of maroon Jasp
323
322
321
320
IFm :- siderite as 1/2" brownish irreg nods
319
SANDSTONE :- WS - dark brn gry FS - dark greenish gry, fine grained, tight, well indurated, hard, massive, weathers with conchoidal fractures.
IFm :- steel gry hem; Jasp almost entirely irreg to rounded brownish nods 1/4 to 1/2" - often dark in centre - last 3' 1/4 to 1/2 ba of maroon - continuous - red to brown rims
318
317
316
IFm :- steel gry hem: Jasp as ba 1" to 1/2" - one is very cherty & 1" - flaggy
315
SHALE :- hematitic
IFm :- Jasp as 1/2" cont. ba (maroon) & laminae
314
SANDSTONE - CONGLOMERATIC
IFm - 1/4" maroon ba & semi by tex
313
CONGLOMERATE
IFm :- Siderite as by tex & 1/4" ba also Jasp ba maroon.
312
IFm :- steel gry hem. Gangue as siderite as tiny 1/8" elongate nods & larger elongate nods 1/2" to 1/4 - flaggy to blocky
311
310
309
308
307
SILTSTONE - grey
CONGLOMERATE
IFm :- steel grey hem; Jasp as thin 1/4" maroon ba fairly cont. & as occassional irreg brown nod 1/2" - occassional pebble c flowlines around it
306
305
IFm :- Jasp as maroon ba 1" av fairly / disc. c red rims & irreg patches - flaggy to blocky
304
303
IFm :- Jasp as thin 1/8" disc ba almost laminae - also semi-by ghost tex
302
301
IFm :- Jasp as 1" av. maroon continuous ba & 1/2" irreg shaped maroon to brown nods
200
IFm & Conglomeratic S.S. 50/50 interbedded.
199
IFm :- Jasp as ba of maroon 1/2" to 1" - sandy - blocky to flaggy
198
CONGLOMERATE :- WS - dark gry brown. FS - poorly sorted, 75% frags are greenstone - rounded to sub angular - 18" max. - matrix sandy slightly greenish & hematitic, but more maroon in upper part of interval. - massive
CONGLOMERATE :- WS. drk gry brn FS - 60% frags - 18" max IFm frags - matrix greenish
IFm :- steelgry hem; Jasp as laminae - also as odd irreg 1/2" nod. & sand pod. - very occassional disc ba. 1/4" - flaggy
197
196
195
CONGLOMERATE :- W.S. dark greenish brown FS. - poorly sorted, frags rounded to sub-angular - various kinds - greenstone abundant matrix - sandy slightly hematitic " greenish

SECTION IF-22-62

MEASURED: NIXON & STEELE
PLOTTED: NIXON

AIR PHOTO: A-12148-273
(106F) FL. 13


SECTION IF-23-62
MEASURED: Nixon & Steele
PLOTTED; Nixon
AIR PHOTO; A12148-273
106F F1.13.
PERCENTAGE HEMATITE BY VOLUME
0 50 100
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
CONGLOMERATE
I Fm: Hem st gy - jasper
-abund. thick 6" bds of
rd ɛ maroon jasp.
SANDSTONE:
WS. dk ch bn - bl bn
FS: dk bn gy
f.g. eq. - c̄ faint, thin
(1/16 - 1/8") streaks of choc bn chert
SANDSTONE: WS bl. bn rd
FS bn-rd - mottled: m-c.g.
frags of st. gy hem ɛ jasp (hi %)
I Fm. Hem st. gy ɛ jasper
- sm. (1/8") by. nods
- bands of maroon jasp - c̄ irreg
contact c̄ hem to 3" tk
- Thin alt bands (1/8 - 1/16") of jasp
ɛ hem in 10" tk bands.
- lt col sph - ellip nods to 3/4" tk
- nod agg bands 4-6" tk
CONGLOMERATE;
W.S.: bn gy FS: bn, bn-gn
30-40% c. clastics
bn - bn gn fg - slst matrix
I Fm.; Hem st gy ɛ jasper
- as elong lt. col. nods c̄
siderite? cores (1/4 - 1/2")
- disc (1/4") lt col distinct bands
- dist. mar ɛ br.or.rd bds to 4"
some contg. streaks of st gy
hem to 1/2" tk
SANDSTONE:
WS: dk bn - bl bn
FS: dk gn gy
f-m.g. inequigranular
containing larger frags to
1/8"
- sub metallic lustre in part.
CONGLOMERATE: WS: dk bn gy
F.S. mott gn. gy.
SANDSTONE: WS dk bn - bl. bn
FS dk gn gy
f-m.g. ineq - cont. lg. frags to (1/8")
sub. met. lustre some surfaces.
I Fm: Hem st. gy, - jasper
8-12" bands of maroon jasper c̄
streaks of hematite to 1½" tk
Nod agg bands to 4"
faint maroon bands cont. st. gy
hem (50%)
Abund. sm. (1/8 - 1/4) ellip. nods - in bands to 6"
3 sandstone : f.g. bn - bn gy
lt col nods - sph to ellip (1/2 - 1")
conglomerate 40% coarse clastics
sandstone
SANDSTONE: (cong.) W.S. dk
gy bn; F.S.: gy bn - f.g.
thinly banded.
I Fm hem st gy, - jasper
- sph ɛ elong nods to 1" across
- crusty nod layers of jasp to 1½" tk
continuous.
- Maroon jasp. bds contg streaks of st. gy
hem. to 8" tk
- abund. 1/4" sph. ellip nods
CONGLOMERATE

IF-26-62

MEASURED: NIXON & STEELE
PLOTTED: NIXON
PHOTO: A12148-214
106F12


IF-27-62
MEASURED: NIXON & STEELE
PLOTTED: NIXON
PHOTO: A 12198-272
106F-13
PERCENTAGE HEMATITE BY VOLUME
0 50 100
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
SANDSTONE: WS: bn gy FS: gy c bn strks
IFm: Hem st. gy jasp
SANDSTONE: WS: dk gy FS: gy gn
f-m.g., equi, in part calcareous
IFm: Hem st. gy jasper
- as distinct cont. bds to 4" tk
- nod agg bands to 1/2"
- lg (1/2-2' tk) lense like irreg masses of maroon jasp disont, c wh. calcite strgers
- 301-303 lens of sheared green rock.
SILT: ch. bn.
CONGLOMERATE: (SANDY)
CONGLOMERATE: WS: ch bn - blk bn FS: ch bn
c. clastics 30% sand-silt matrix
IFm: Hem st. gy
- distinct mottled or-rd maroon bands contg streaks and irreg masses of st. gy hem to 3/4" tk
?- CONGLOMERATE
- deep mar. nod agg bds to 18" tk
thin distinct discont. (1/4" tk) bands of deep maroon jasper
sph & ellip or-rd nods to 1/3" tk
8-14" bds of 1/8" tk by. shaped nods
SILT: cherty mar-gy
SILT CHERTY (BN-MAR)
CONGLOMERATE:
WS: ch bn gy - blk bn
FS: ch bn
Hematitic
Coarse clastics 10-20%
50-60% in shown heavy conc. int
Clastics to blder size
silty-sandy matrix
IFm: hem st. gy jasper
- in lower 8' of this interval many sandy cong bds
- jasp. sph-ellip nods to 1/2"
- faint 4" bands deep maroon jasp. c streaks of hem to 1/2"
- nod agg bds to 5"
CONGLOMERATE
W.S. ch bn - bn blk
FS: ch bn
5-10% coarse clastics to boulder size
silty-sandy matrix
SANDSTONE:
WS: bn gy - blk
FS: Mottled gy-gn & ch. bn.
f. mg. - equi - with irreg patches & streaks outlined by bn gy silt.
CONGLOMERATE:
WS: ch bn - bn blk
FS: ch. bn
C. clastics to boulder size (10-15%) of lt gy ls. gn carb rock dk gy ls.
in ch bn silty to fine sandy matrix
Contains irreg angular and some rounded frags of hematite (to 1" across)
- jnt & bdg surfaces c sub metallic lustre
- Continuous or-pink carbonate stringers to 3/4"
SANDSTONE:
WS: dk ch. bn
FS: gy to ch. bngy (streaked)
f.g. equi.
freshly broken surface gy-gy bn streaks of ch. bn. silt.
sub. met. lustre in part.
IFm: Hem. st. gy jasper
- in discreet bands to 4" contg streaks of hem to 3/4"
- fine (1/16 - 1/8") ellip sph nodules
- thin discon bands 1/4"
- large elong nods 1 1/2" tk & 13" long; cong lens?
CONGLOMERATE:
W.S. bn gy - ch bn gy
FS. ch bn - ch bn gy
silty matrix

"IF-28-62"

MEASURED :- Williams & Stuart
July 20 & 21/62

PLOTTED :- Williams
July 24/62

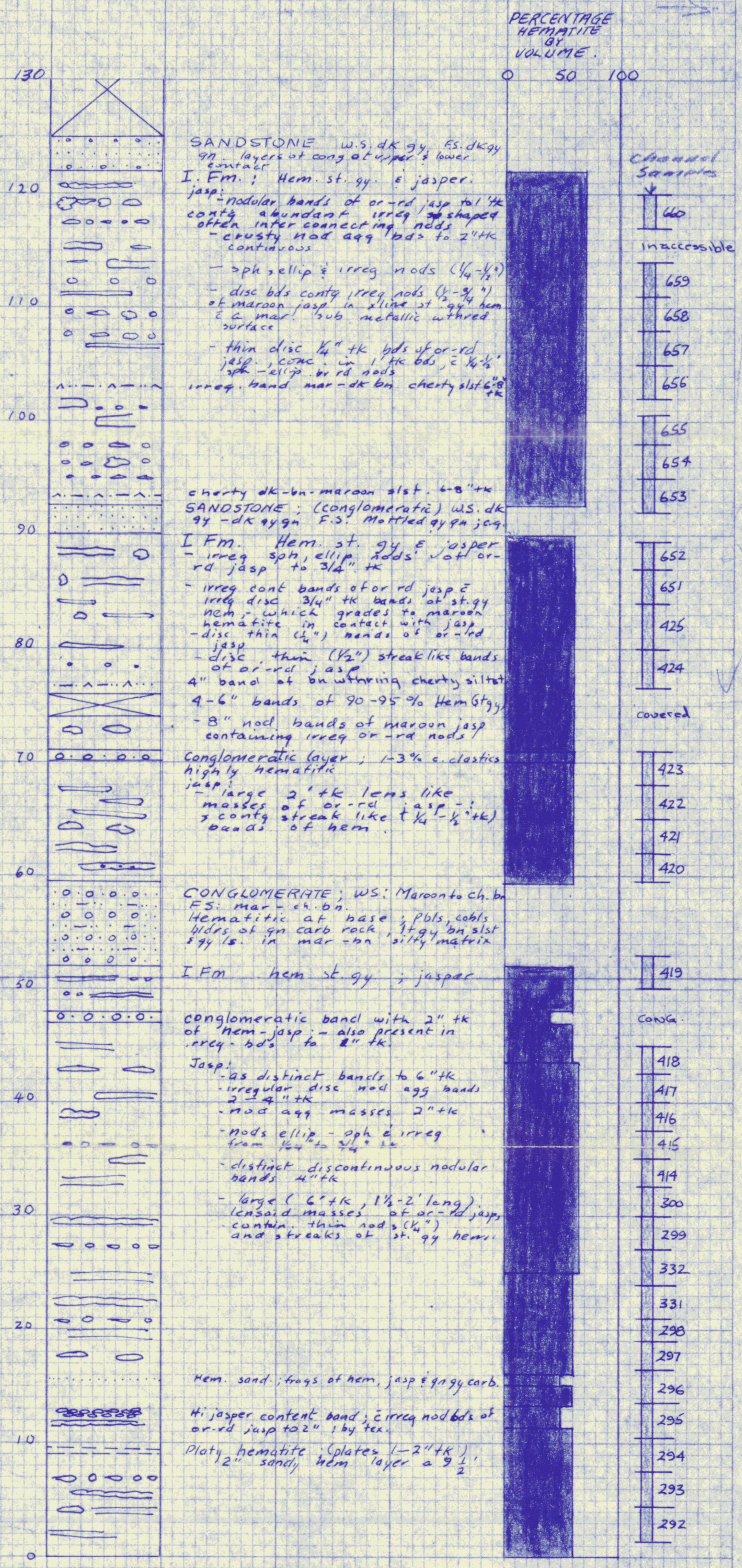
PHOTO NO A-12148-185
flight 11

IF-29-62

MEASURED ; NIXON & STEELE

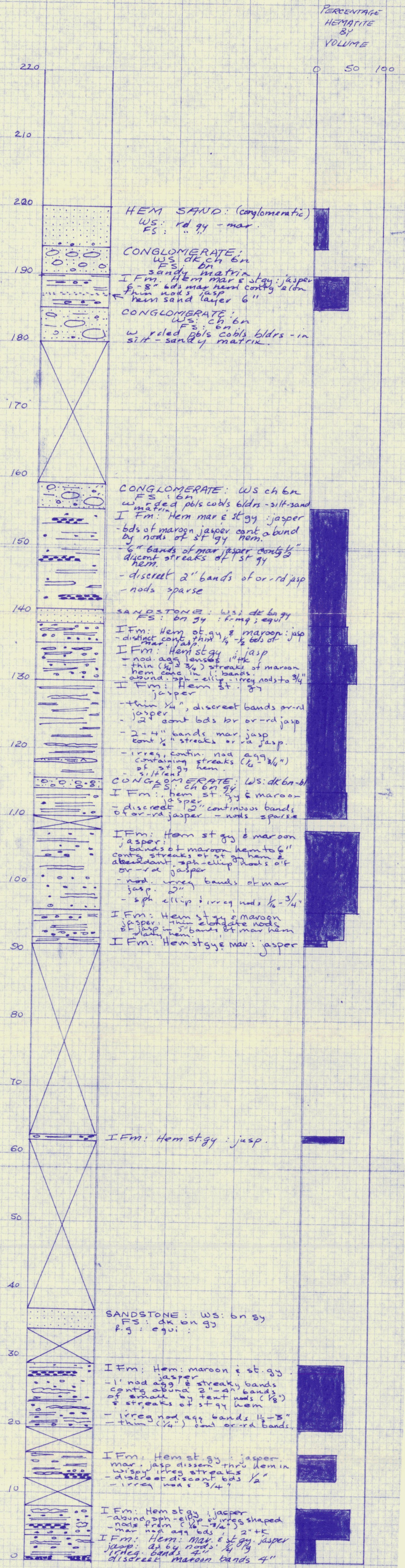
PLOTTED ; NIXON

AIR PHOTO ; A-12056-283



IF-30-62

MEASURED: NIXON
PLOTTED: NIXON
PHOTO: A-12056-286
106F (10)²



IF-31-62
MEASURED: Nixon & Williams
PLOTTED: Nixon
PHOTO: A-12056-286
PERCENTAGE HEMATITE BY VOLUME
0 50 100
CONGLOMERATE
I Fm: Hem. st. gy: jasp.
- mar crusty nod agg 3/4
- elong mar nods to 3/4
SANDSTONE: (hematitic)
WS: red - maroon - blk
FS: maroon - gy
- sub. met. lustre. in part
HEMATITIC SILTSTONE:
I Fm: Hem. st. gy:
- crusty nod agg 1½" tk
- abund. nods 1/8 - 1/4"
IFm: Hem. st. gy: jasp.
- abund. dissem. sm to ½" nods.
IFm. Hem. st. gy: jasp
- abund sph-ellips-irreg nods. (to 3/4")
- crusty nod agg bds-2"- continuous.
IFm: Hem. st gy: jasp
- abund. sph ellip irreg nods to 3/4"
- mar nod agg bds to ½"
IFm: Hem. st. gy: jasp.
- abund sph-ellip-irreg nods to 3/4"
- nod agg bds 3/4-3"
I Fm: Hem. st. gy: jasp
- disc. thin ¼" bds 3/4
- nods. elong
IFm: Hem. st. gy: jasp
- nod agg layers
- disc or'td bands
CONGLOMERATE
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

measured - Williams & Stuart
July 21/62

"IF-32-62"

plotted - Williams
July 25/62

PHOTO # A 12056-352
flight 9

CONGLOMERATE :- WS - drk brn gry
FS 20% frags poorly sorted - 6" max
- lts of Jasper - matrix sandy

CONGLOMERATE :- W.S. - dark gry
FS - 40% poorly sorted frags - Jasper
qtzite, etc.
- matrix high in metallic hem.
- some IFmd lenses

IFm :- Jasp as red 1/2" irreg nods
- occassional ba of (?') conc by tex
& very occassional large irreg patch of Jasp.
- 2 (6" x 2") sand lenses

IFm - as @ 81-92' but with some
red to maroon 1/4" ba - fairly cont.
- massive.

IFm :- Jasp as rounded to irreg
1/2" nods & irreg 1/4 to 1/8" nods
- massive

IFm :- 2/10 red Jasp as 1/2" irreg nods
& 1/2" to 1" fairly cont. ba & laminae
2/10 maroon Jasp as 1/4" to 2" ba
- massive.

IFm :- 2/10 red Jasp - 1/4" to 1" ba fairly cont.
4/10 maroon Jasp as ba fairly cont

SILTSTONE - ws dark brown

IFm :- 2/10 red Jasp as 1/4" to 1/8" disc ba.
5/10 maroon Jasp as 1/2" to 1" ba
fairly cont

IFm :- 3/10 red Jasp as large irreg patches
also one 2' bed filled c nods 1/4" to 1/2"
3/10 maroon Jasp throughout as
irreg patches
1/10 sand & cobbles (⊕)
CONTORTED

CONGLOMERATE :- WS - dark brown maroon
FS - 20% poorly sorted angular to
subrounded frags - matrix sandy.

IFm :- Jasp red 1/8" rounded nods. - 6" ba @ 37'
- some 2" disc ba also 1/4" disc ba
- some sil hem.

IFm - 1/2 Jasp red 1/4" nods, ba, patch ; 1/2 maroon Jasp or sil hem

CONGLOMERATE :- WS - dark maroon brn
FS 20% pebbles & cobbles ; maroonish matrix

IFm :- 4/10 Jasp red as irreg nods & patches
3/10 " maroon as nod centres & "
- odd band siliceous hem.

IFm :- Jasp red as 1/8 to 1/4" rounded nods
occassionally conc into a ba 1" to 2" wide
- occassional sand stringer
- 10% siliceous hem.
- some irreg patches 1" x 4"

IFm :- 3/10 Jasp red as rounded to irreg
1/4" to 1/2" nods & occassional fairly
continuous 1/4" to 1/2" red ba - some ghost by-
- touch of pale maroon hem.
- some sand stringers
- massive

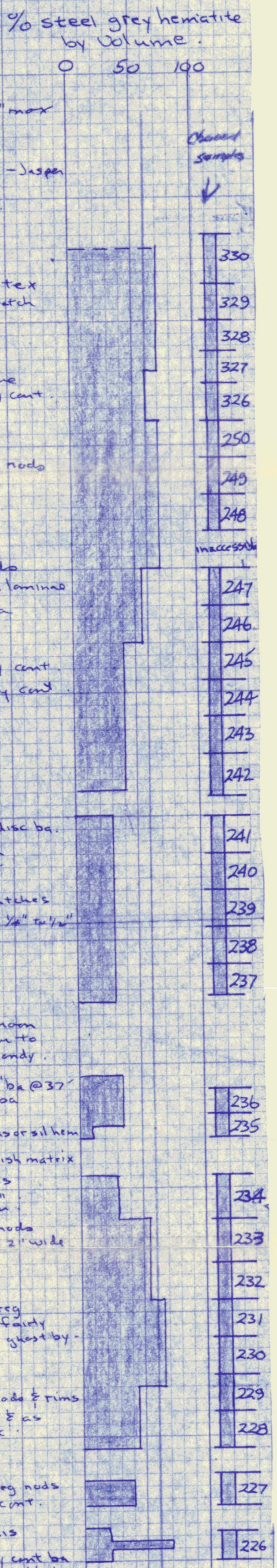
IFm :- 2/10 Jasp as red rounded 1/4" nods & rims
2/10 " as maroon nod centres & as
ba 1/2" to 1" disc
1/10 dis Jasp.

IFm :- Jasp red 1/8 to 1/4" rounded to irreg nods
- also maroon Jasp 1/2" to 1" ba - cont.

by tex - also tiny elongate nods & dis
nods only

IFm - 1/10 red Jasp as 1/4 to 1/2" fairly cont ba
- some rounded to irreg nod. (1/4")
- two dark maroon Jasp ba 2" to 4"
- two 2" sand stringers

CONGLOMERATE :- WS dark maroon brn.
FS - 30% frags - angular to sub rounded
poorly sorted, matrix hematitic.



KEUFFEL & ESSER CO.
MADE IN U.S.A.

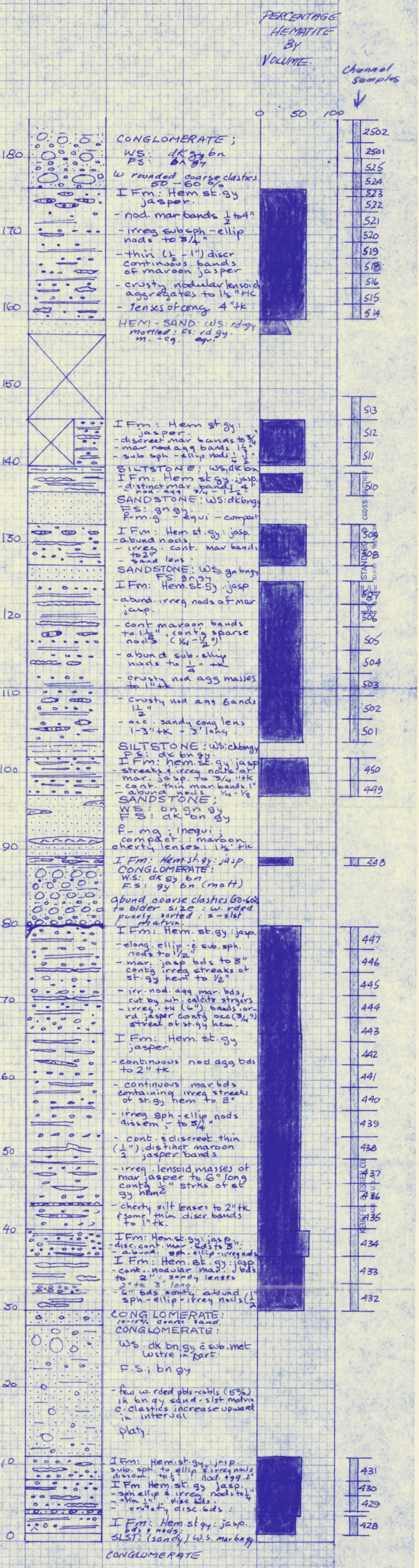
K+E STANDARD ⊕ CROSS SECTION
10 X 10 TO THE INCH

IF-33-62

MEASURED: NIXON & HOUEDBU

PLOTTED: NIXON

PHOTO: A 12148-273
106F (13)²



"IF-34-62"

measured - Williams Aug 1/62 & Aug 2/62

plotted - Williams Aug 5/62

Photo A12148-182 Flight 11

% steel grey hematite by ~~weight~~ volume

0 50 100

CONGLOMERATE

IRON FORMATION

SANDSTONE c̄ metallic hematite matrix

SANDSTONE

SANDSTONE:- WS - drk brn gry
FS - finegrn'd, tight

IFm:- Jasp mostly as red to brown nods - irreg 1/4 to 1/2"
- often in ba (cmc) with maroon matrix
- some nods are maroon with red rims.

shaley - recessive.

IFm:- Jasp mostly rounded to irreg nod 1/4 to 1/2" - often in ba

IFm:- Jasp mostly as maroon to red ba 1/4 to 1/2 fairly cont. - some nods rounded to irreg
- some sand pods

SHALE

IFm:- Jasp red ba 1/2" to 2" - fairly cont - also irreg patches

SAND & SHALE - recessive

IFm:- as @ 254-5

IFm:- Jasp as 1/2" to 2" cont ba

SANDSTONE

IFm:- Jasp red as rounded 1/4" nods & 1/4" ba fairly disc.

IFm:- Jasp mostly as red nods rounded 1/8" to 1/4" with darker centres - often elongated
- Some 1/2" ba of conc. laminae or irreg nod.
- occas. sand pod.

IFm as below

IFm:- Jasp mostly maroon to red ba 1/2" to 2" - cont.
- few elongated 1/8" nods

IFm Jasp as irreg patches & laminae - blocky

SILTSTONE:-

IFm:- 1/2 of Jasp. is red as rounded to irreg. nods 1/4" to 1/2" - often conc in ba
- also ba of by tex.
1/2 maroon Jasp - 1/2" to 1" reg to irreg ba - fairly cont.
- some dis
- also 4" ba @ top (conc laminae)

IFm:- Jasp as 1/8 to 1/4" maroon fairly disc ba
- sand stringer

IFm Jasp as nods - also occassional patch of by tex. & conc ba of 1/8" elongated nods

IFm:- Jasp mostly red as nods rounded to irreg. occass elongated 1/8" to 1/2"
- often larger ones conc in ba 1/2"
- some maroon brown fairly cont ba 1/4"

SANDSTONE:- WS. dark brn gry
FS. drk brn gry, fine grn'd, tight, slatey.

IFm:- Jasp as red & maroon nods elongated to irreg. c̄ red rims 1/8 to 1/4" - some conc in ba.

IFm:- Jasp red - mostly as 1/2" irreg nods & regular 1/8 to 1/4" nods
- occassional conc ba of by tex.

IFm:- Jasp as maroon elongated patches & ba 1/2" to 1" c̄ red rims

IFm:- Jasp as maroon elongated patches & ba 1/2" to 1" c̄ red rims

IFm:- Jasp as 1/2" to 2" ba & conc. patches of nods

CONGLOMERATE

IFm:- Jasp as red to maroon cont. ba 1/4" to 1"
- occass. disc ba
- " sand pod

CONGLOMERATE:- WS - dark brown grey
FS. 80% poorly sorted angular to sub-rounded frags. - of siltstn, SS, Jasper, carb, greenstone,
- mostly pebble size
- sandy brownish matrix

CUTS ACROSS BASAL CONTACT WITH SCOUR CHANNEL.

IFm:- Jasp as red to maroon ba 1/8" to 1" - often disc. & lensoid - some penecontemp frac.
- some by tex in ba
- " irreg maroon ba with red rims 1/2"
- a few irreg to rounded nods

IFm:- Jasp - red - nods rounded to elongate 1/8" to 1/4" - brownish
- maroon Jasp as irreg nods 1/2" c̄ by tex & red rims
- nods in ba up to 2"
- occassional sand stringer

CONGLOMERATIC SHALE:-
- maroon.

IFm:- Jasp mostly dark maroon irreg ba 1/2" with reddish rims - also elongated patches.

IFm - Jasp as 1/8 to 1/4" red rounded nod
- dark centres

IFm:- Jasp. mostly maroon as 1/4" ba & irreg 1/2" nod c̄ red rims - also as by tex
- occassional sand stringer
- some rounded 1/4 to 1/2" nod

IFm:- Jasp as tiny nods 1/16 to 1/8
Some maroon 1/8 to 1/4" ba near bottom - cont.
- sand pods & by tex

IFm:- Jasp. red to maroon - as ba 1/8 to 1" - some cont & disc.
- also disc ba of maroon about 1/4", with brown rims
- some rounded nods 1/8 to 1/4
- some irreg. patches @ 49'
- few sand lenses 1"x3"

→ Argillaceous IFm

IFm:- Jasp red to maroon - 1/8 to 1/2" ba - disc & cont; some rounded nod 1/8 to 1/4; some irreg patches

IFm:- Jasp. red to maroon - mostly as ba. 1/8" to 1/4" - disc & cont.
- also occassional conc 1" ba of by tex.
- some nods 1/8 to 1/4
- sand stringers. - occass. pebble

IFm:- 10% red Jasp. 1/8 to 1/4" - rounded nodes & occassional disc. ba.
40% maroon Jasp. as contin ba 1/4" to 1/8" & occas. irreg. nod. - massive

IFm:- Jasp red to maroon as conc. ba of tiny nods & by tex. ba 1/8" to 1/2"
ws. - nods raised on surface

IFm - argillaceous; FS. dark maroon
slight metallic lustre, faint disc ba & sandy lenses 1/8" x 1"

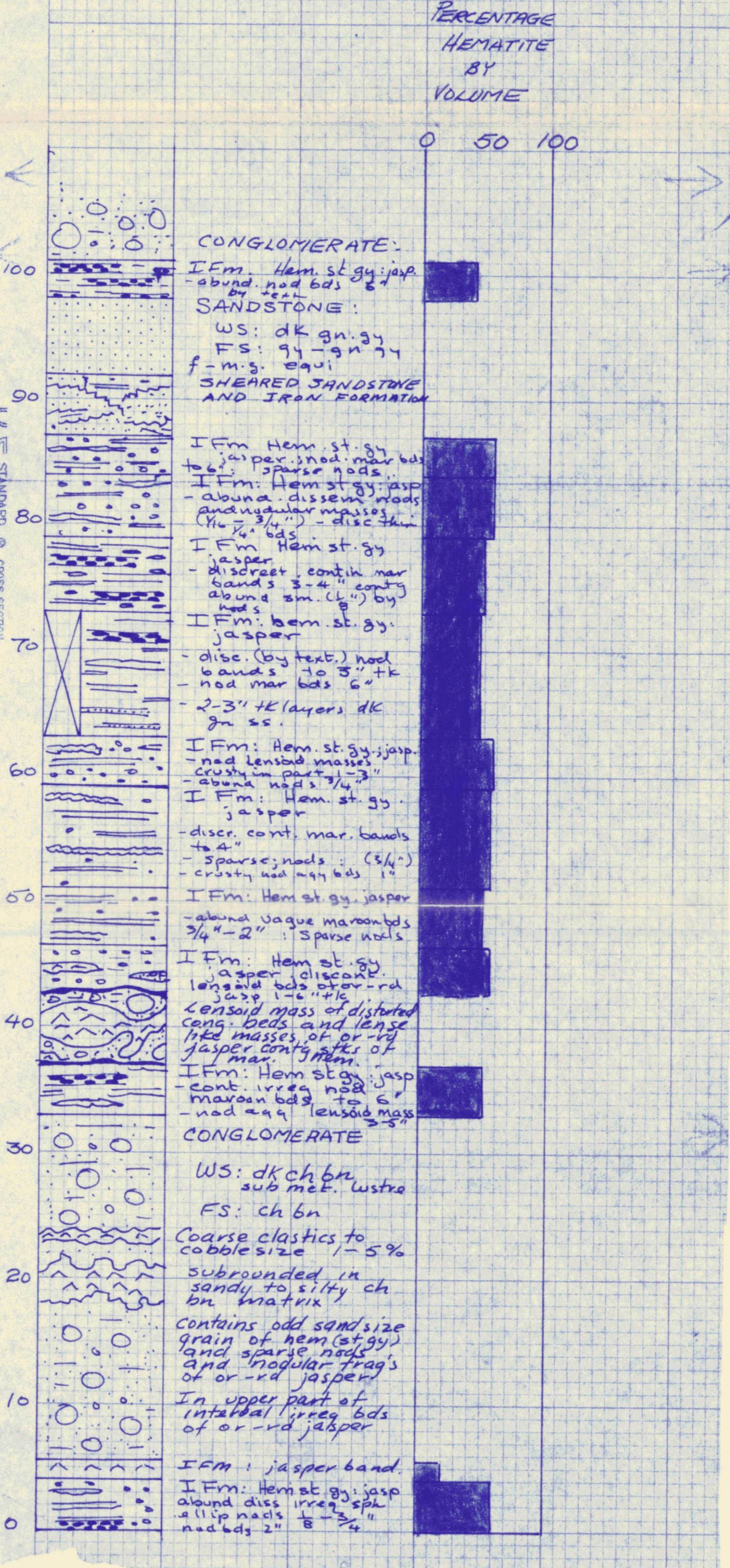
CONGLOMERATE:- W.S. med to dark maroon brown
FS - 40% poorly sorted frags 4" max - hematitic, sandy matrix

IF 36

IF-36-62

MEASURED : NIXON & HAMILTON
PLOTTED : NIXON

PHOTO : A 12056-284
106F — (10)²

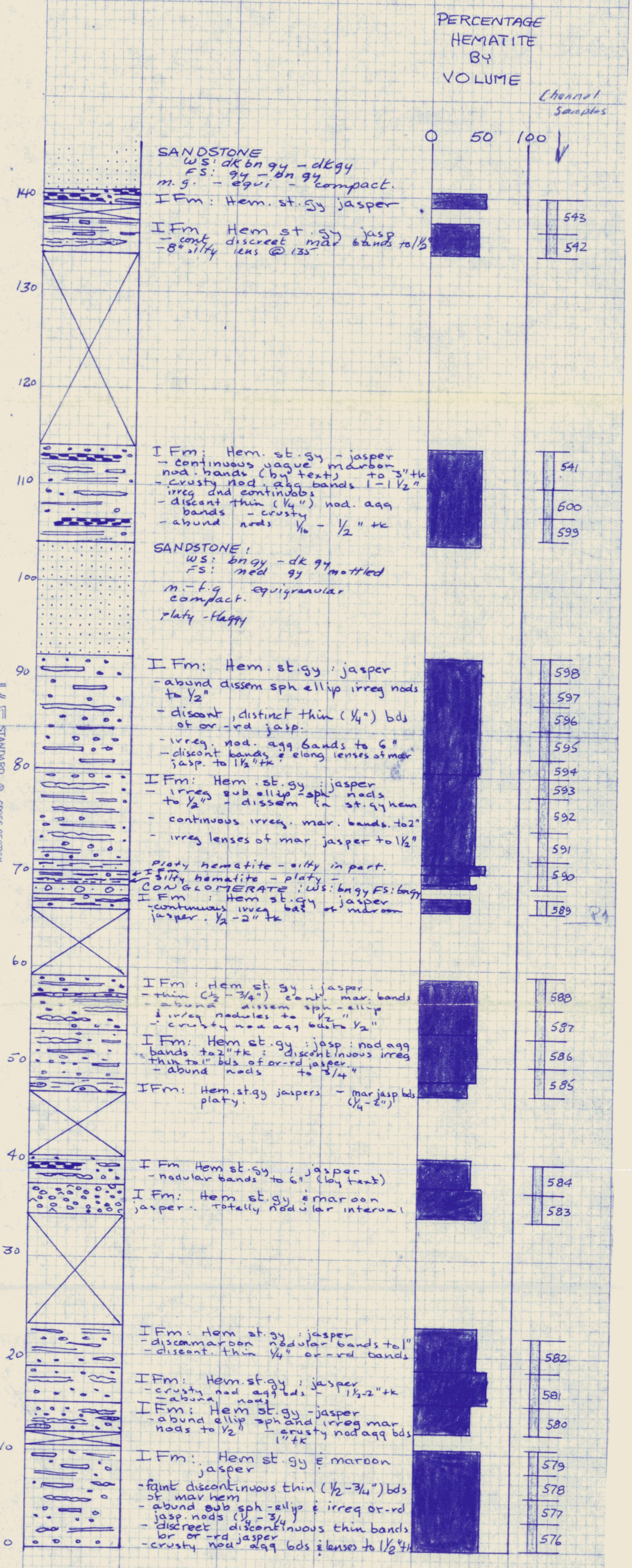



IF-37-62
MEASURED: Nixon & HOVEDBO
PLOTTED: NIXON
PHOTO: A 12148 - 18²
106F - (11)²
PERCENTAGE HEMATITE BY VOLUME
0 50 100
Channel samples
410
CONGLOMERATE
HEMATITE SAND.
W.S. mar-rd.gy
F S mar gy
submetallic
m-c.g. equi
compact
823
822
821
400
CONGLOMERATE; HEMATITIC.
W.S. ch.bn
F S. mar-st.gy
Well rounded c. clastics to cobblesize
390
380
370
360
SANDSTONE
350
CONGLOMERATE
340
330
320
CONGLOMERATE
310
300
290
280
270
260
250
240
SANDSTONE
230
CONGLOMERATE
220
210
200
CONGLOMERATE
190
180
SANDSTONE
170
160
150
CONGLOMERATE
140
130
120
110
100
90
80
70
CONGLOMERATE
60
50
40
30
20
CONGLOMERATE
10
0

IF-38-62

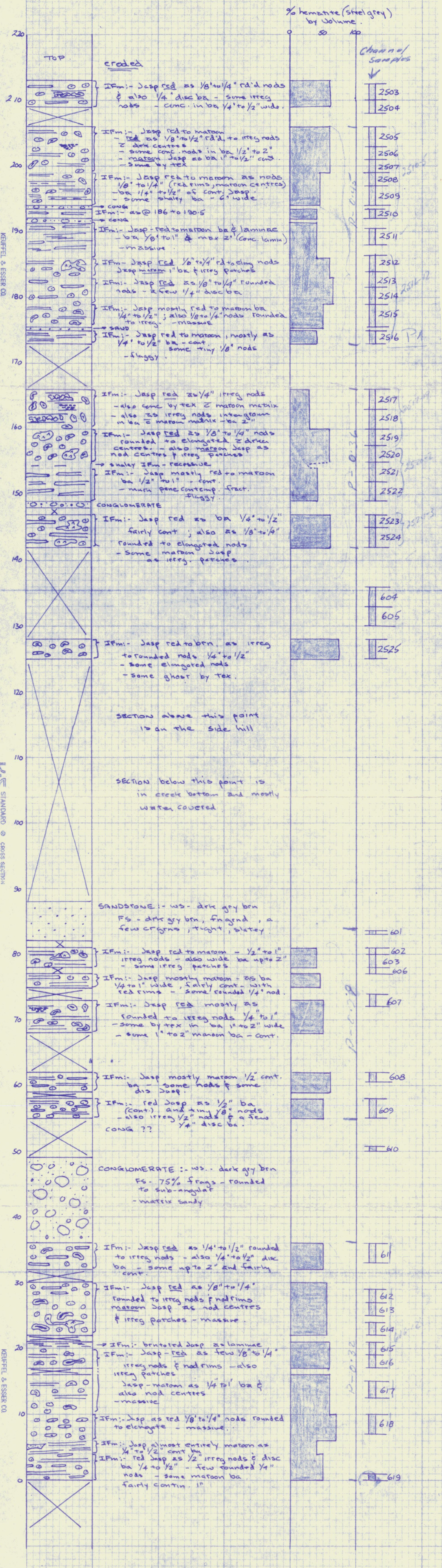
MEASURED: NIXON W.H.
PLOTTED: NIXON W.H.

PHOTO: A-12148-184
(106F-11) - 2



IF-39-62

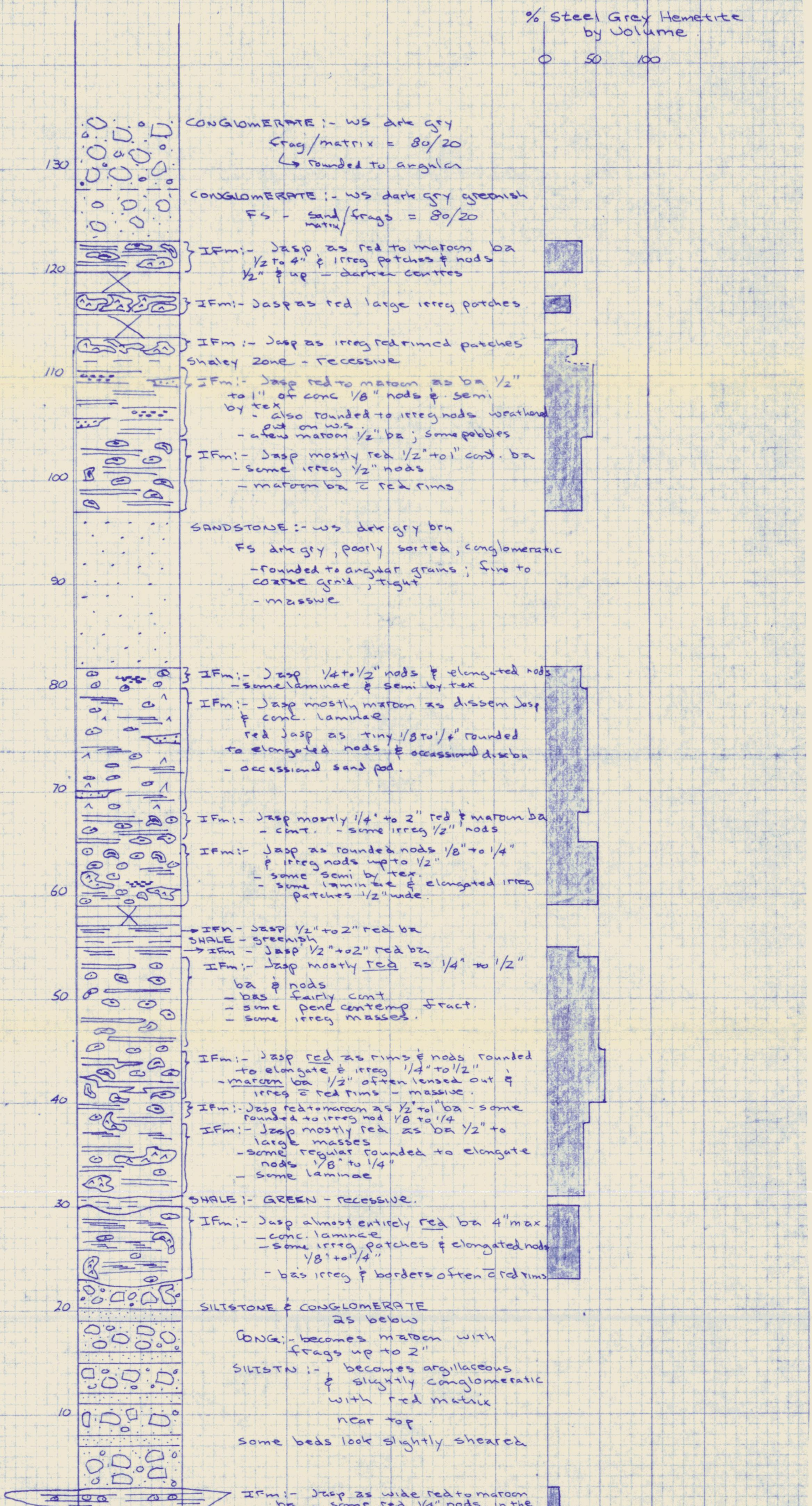
measured - Williams & Nixon Aug 16/62
plotted - Williams Aug 23/62
Photo A-12148-210 flight 12



"IF-40-62"

MEASURED - AUG-19/62
WILLIAMS - HAMILTON.
PLOTTED - WILLIAMS
- AUG-23/62

PHOTO - A 12148-210 flight 12.



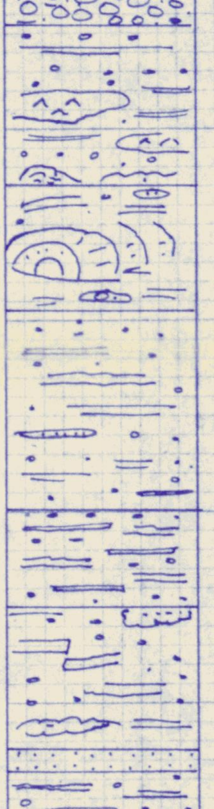
IF-41-62

Measured: Nixon & Brandt

Plotted: Nixon

Photo: A 12056-351
106F 9[3]

PERCENTAGE HEMATITE BY VOLUME



Conglomerate: WS: gngy - bngy
F.S: gn-gy mott. - 60-70%
c. clastics

I Fm: Hem st. gy
- continuous nodular bands to 4"
- contin mar. bds 1-2" tk
- sph ellip - irreg nods to 1/2"
@ 78' drag folds - bds contorted.

I Fm: Hem st. gy, jasp.
- irreg cont. or-rd bds 2"
- nod. lensoid masses to 1'
- cong lenses 6" to 1'
- 72-75 drag folds!!

I Fm: Hem st. gy : jasper
- sm. dissem nod's (1/10 - 1/8) conc in bands to 2"
- contin bands or-rd jasp - contg few elong 1/4"-1/2" nods - bands 1-4" tk
- cont. maroon bands 1-6" tk

I Fm. Hem st. gy : jasper
- dissem elong nods 1/8 - 1/2" tk
- cont. nod. bds 1-3" tk

I Fm: Hem st. gy : jasp.
- cont. striked mar bds to 4"
cont faint 1/8 - 1/16" strks of st gy hem.
- sparse dissem nods : elong ; subsph to 1/2"
- crusty nod agg masses 2-6" tk

Sandstone: WS bn - dkbngy : FS: gy
f-m.g. equi

I Fm: Hem. st. gy & mar. jasper.
- elong or-rd nods - dissem (to 1/2")
- discont - lensoid masses contg strks of st. gy hem (1/4 - 1/2" tk)
lenses to 1 1/2' tk.
- nod rd mar bands to 4"
- nods to 1/2"

Sandstone: (cong) WS: gy gn - gy bn

I Fm: Hem st. gy : jasp. : cont 1 1/2 - 3" bds by text. nod bds.

Sandstone; conglomeratic
WS: gy-gn to gybn FS: gn to dkbn mott

I Fm: Hem. st. gy, jasp.
- cont. bands mar. jasp. 1-4" tk
- elong nods, - irreg. patches of mar. jasp. (1/4 - 1")
- thin 1/4 - 1/2" discont. bands

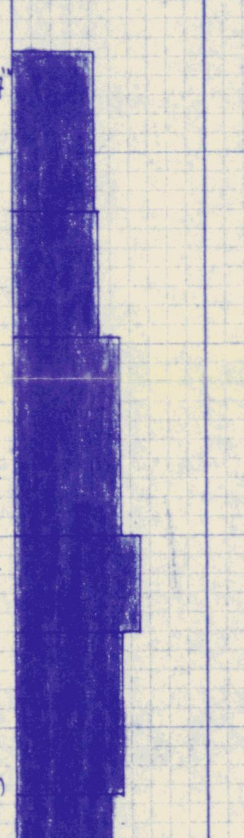
I Fm: Hem. st. gy - & jasper
- discont. irreg. br. or-rd bds in part. nodular (nods 1/2")
bands 2" tk : cong. lens.

I Fm: Hem. st. gy & jasp.
- contin. abundant. mar. bds 2" tk
- elong or-rd nods to 4" tk

Conglomerate: WS: dk gy - dk gn
F.S. gy-gn - blk

I Fm: Hem. st. gy & jasper
Hem. maroon!
- br. or-rd nodular massive layer - contg streaks & irreg masses of st. gy & mar. hematite 1/2 - 1 1/2"
- cont. br. rd. nods 1/8 - 1/4

I Fm: Hem. st. gy : jasper
- irreg. lensoid bds rd. jasp. - 8"
- nod. mar bds. : nods sparse



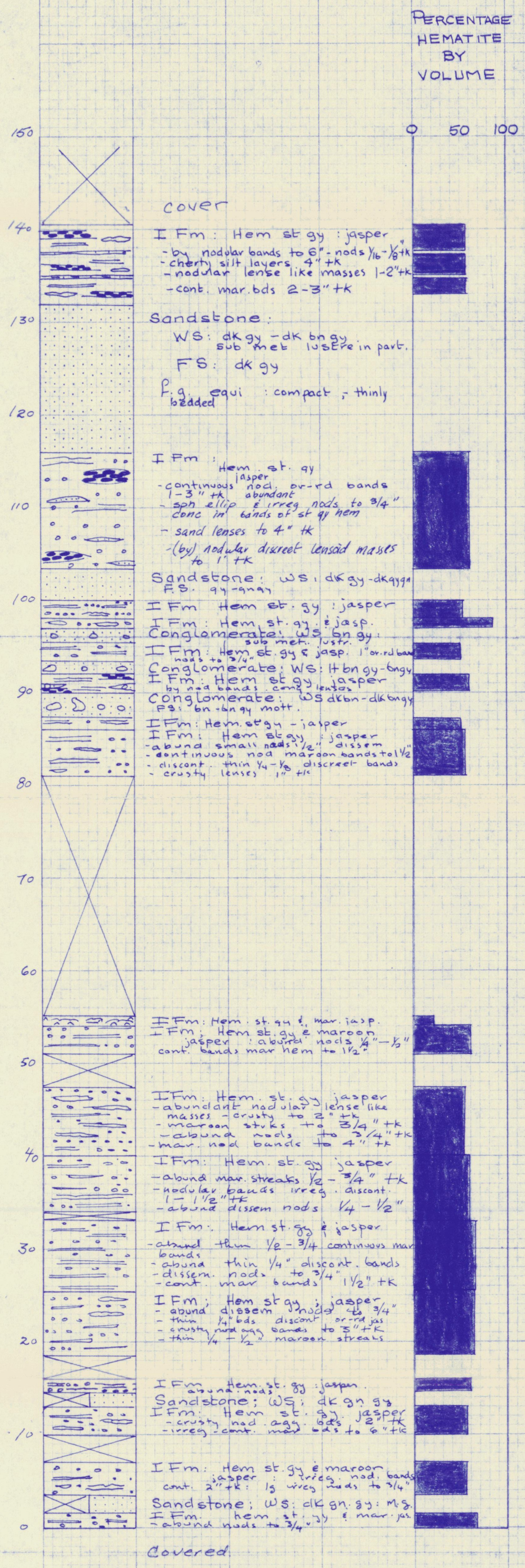
IF - 42 - 62

Measured ; Nixon & Spear

Plotted ; Nixon

Photo ; A-12148-212

106F - 12[3]

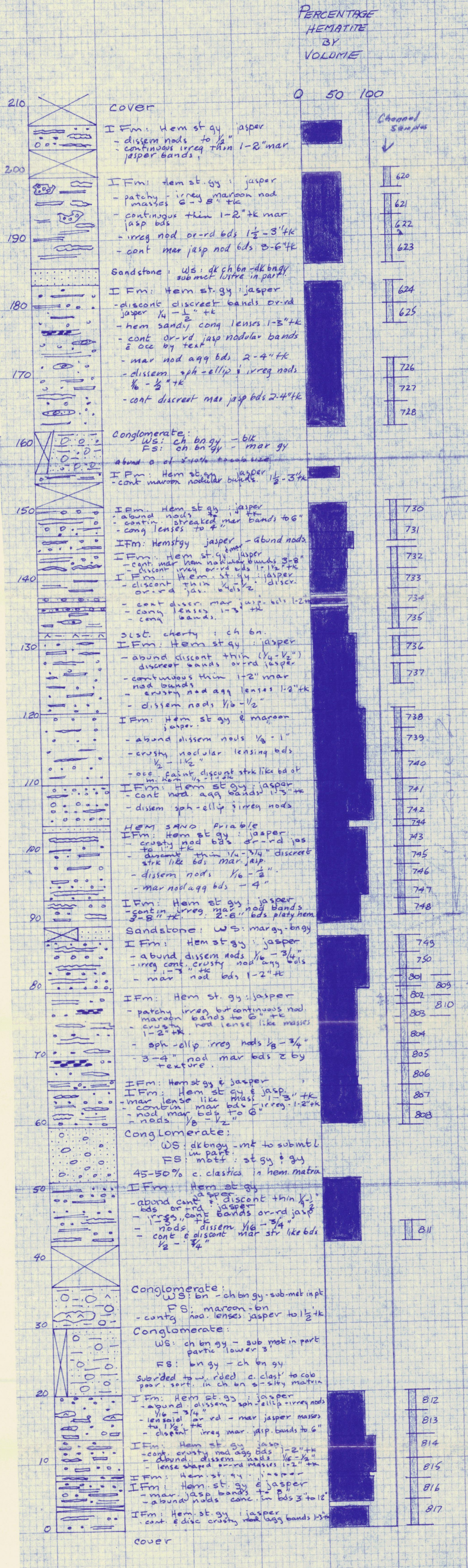


IF-43-62

Measured; Nixon & Brandt
Plotted; Nixon
Photo; A-12056-351
106F - 9³

IF-44-62

Personnel: Nixon
Plotted: Nixon
Photo: A 12056-285
106 F-10[2]



SECTION IF-45-62

Measured: Nixon
Plotted: Nixon
Photo: A-12148-185
106 F - 11