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REPORT ON ECONOMIC EVALUATION OF IRON ORE DEPOSITS, DUNCAN LAKE AREA

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ECONOMIC EVALUATION

of the

IRON ORE DEPOSITS OF THE DUNCAN LAKE AREA

QUEBEC

for

DUNCAN RANGE IRON MINES LIMITED
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by

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ECONOMIC EVALUATION OF THE IRON ORE

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SUMMARY

The purpose of this report is to present an economic evaluation on an enterprise involving the mining, beneficiating, and shipping of iron ore from the deposits of the Duncan Lake area in Quebec to the world markets.

Two types of product are considered — concentrates and pellets. Most of the report deals with the former because there is a big demand today for high-grade concentrates for the purpose of producing self-fluxing sinter, a material that is becoming increasingly popular among blast-furnace operators during the last decade. Concentrates have the additional advantage in that a substantial saving in the capital investment of the enterprise can be made since the pelletizing plant is a major item in the construction costs. On the other hand, if the necessary funds can be raised for plant construction, pellets have the advantage over concentrates in that greater profits can be made due to a higher grade of product because of lower moisture content, lower losses on shipping, and a higher selling price.

The evaluation made in this report is based on three rates of production, namely, 1,000,000 tons, 2,500,000 tons and 5,000,000 tons annually. These three rates are designated throughout the report as Plan A,

Plan B, and Plan C, respectively. This was considered necessary in order to determine the minimum production rate required to make the enterprise profitable.

There are three alternative routes possible for shipping the ore from Duncan Lake to the market area. These are designated throughout the report as the Hudson Route, the Moosonee Route, and the Chibougamau Route. A Maritime shipping expert is of the opinion that it is not unreasonable to ship 1,000,000 tons annually to Europe by way of Hudson Strait. Therefore, only this route is considered for Plan A. Larger quantities could be moved through Hudson Strait provided a trans-shipping port is built in Greenland or Newfoundland so that all the mine's production could be moved through the Strait within the period of the short Hudson Bay shipping season. The cost of this port would have to be borne by the mining company.

The Moosonee Route would consist of moving the ore to Moosonee by barge, to a port on the Great Lakes by rail, and by lake carriers to the market area in the United States. However, it is considered when using this route, that at least 1,000,000 tons would still go through Hudson Strait directly to Europe. This route would require an extra capital expenditure in a fleet of tugs and barges and an ore dock at Moosonee.

The Chibougamau Route is premised on the contingency that the Canadian National Railway would extend their rail line from Chibougamau to Duncan Lake. This alternative would require the least capital expenditure on the part of the mining company. By this route the ore would be shipped to Port Alfred on the Saguenay River, and by ocean carriers to markets in Europe or the United States.

For the purpose of this report, the two market areas considered are the Ruhr district of Germany and the Cleveland, Ohio district of the United States. The present prices for concentrates are calculated to be $14.83 per ton and $13.53 per ton in these two areas, respectively. The corresponding prices for pellets are $17.66 and $15.91 per ton. Since there has been a steady increase in ore prices during recent years, it is estimated that these prices would be $16.32, $14.88, $19.43 and $17.50 per ton about the time that the Duncan Range operation reaches the production stage. Since the report is premised on the idea of selling at least 1,000,000 annually in Europe even though the remainder would be sold in the United States, this means that the average price of the ore would be higher than the United States price, namely $15.46 per ton for Plan B and $15.76 per ton of concentrates for Plan C.

The study shows that the highest profits would be made when the product is sold in Europe after being shipped to the market area by the Hudson Route. These amount to $2.27 per ton of concentrates and $3.07 per ton of pellets when the capital investment is amortized over a period of twenty years, and when producing at the rate of 5,000,000 annually. Higher profits could be made if the investment were written off in thirty or forty years, but it is questionable if financing under these conditions is attractive. Lower profits are made when shipments are made by the Moosonee or Chibougamau Routes, and there is little to choose between them.

Production at the rate of 1,000,000 tons per year is economically unsound. There would be sufficient income to pay the operating costs and it would be feasible to produce at this rate for a short period while expanding the plant to large rates of production.

Production at the rate of 2,500,000 per year is economical under certain conditions, but not all. Therefore, it is recommended that the plant should be built with a production rate of at least 5,000,000 tons in mind. An enterprise of this magnitude would require a capital investment according to the shipping route and form of product adopted as follows:

Shipping Route	Concentrates	Pellets
Chibougamau Route	$ 114,200,000	$ 142,200,000
Hudson Route	126,200,000	154,200,000
Moosonee Route	147,600,000	175,600,000

No attempt is made in this investigation to recommend that either concentrates or pellets should be the final form of the product made. This will depend upon a large number of factors which cannot be fully assessed at this early stage, not the least of which is the nature of the contract which would be made between the mining company and any prospective customer. In all probability, it will be found advantageous to sell both types of product at times.

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ECONOMIC EVALUATION OF THE IRON ORE

DEPOSITS OF THE DUNCAN LAKE AREA, QUEBEC

INTRODUCTION

This report has been prepared by H. U. Ross, Metallurgical Engineer of Toronto, Ontario, herein referred to as the "Engineer" for the Duncan Range Iron Mines Limited, also of Toronto, herein referred to as "Duncan Range." The purpose of the report is to present an economic evaluation on an enterprise involving the mining, beneficiating, and shipping of iron ore from the deposits of the Duncan Lake area in Quebec to the world markets.

This evaluation includes an estimation of the capital investment required to bring the Duncan Range mining property into production and an estimation of the operating and shipping costs to produce and deliver saleable iron concentrates or pellets at a point of consumption where the accepted selling price is known so that the economic potential of this enterprise can be determined.

In an earlier study of this type, the Engineer estimated the cost of producing iron ore pellets delivered in the market area. However, in recent years there has been an increase in the demand for concentrates rather than pellets because of the recent swing towards the use of high-grade self-fluxing sinter. This material is made by mixing limestone with the ore before the latter is sintered, rather than mixing them in the blast furnace. Thus, instead of charging the furnace with ore, coke, and limestone, as was the older practice, the modern method is to charge the furnace with self-fluxing sinter and coke only. This change has resulted in an increase of about 25 per cent in the furnace capacity and has greatly lowered the cost of pig iron production. In order to take full advantage of this modification, it is necessary to use high-grade concentrates instead of direct-shipping ores. This has greatly increased the demand for concentrates and has accounted for the development of large enterprises such as those in the Wabush Lake, Carol Lake, and Lac Jeannine areas of Labrador and Quebec. For this reason, this economic evaluation is based on the sale of concentrates as well as on pellets. For convenience, the investigation in this report is primarily for the production of concentrates, then the extra costs and profits for pellets are determined.

Also in the earlier study, an estimation was made of the cost of producing pig iron from the Duncan Range pellets. In this report, this estimate is omitted as the demand for iron is much smaller than that for concentrates or pellets and, in addition, the cost of constructing a suitable smelting plant to handle even a reasonable fraction of the anticipated Duncan Range production is prohibitive.

The estimates are made using the following methods of mining and concentrating: mining would be carried out by open-pit methods in which the ore would be drilled, blasted, and loaded into trucks for transporting to a centrally located crushing and concentrating plant. Concentrating would be carried out by conventional methods of crushing, grinding, and magnetic concentration.

There are three potential routes to move the ore from Duncan Lake to the world markets. The first route would be to ship the concentrates to Fort George on James Bay where it would be loaded in ships and transported to ports in Europe or the Eastern United States. This is referred to as the Hudson Route. The second alternative would be to move the concentrates by barge to Moosonee and then by existing railroads to either Michipicoten Harbour on Lake Superior or to Parry sound on Georgian Bay whence it would be shipped to the Great Lakes industrial areas by lake carrier. This is designated as the Moosonee Route. The third suggested route would be provided by the extension of the railroad north from Chibougamau to Duncan Lake so that the concentrates could be moved by rail all the way from the mine to Port Alfred on the Saguenay River. This is called the Chibougamau Route.

Because the Hudson Route is the cheapest, it is assumed that at least 1,000,000 tons annually would be shipped out this way regardless of whether either of the other two routes is used for the remaining production.

Inasmuch as the costs of production to be obtained will depend to a large extent upon the size of the operation, it is felt that a more complete picture can be obtained only if the cost estimates are based on three different rates of production; namely, 1,000,000, 2,500,000, and 5,000,000 tons* of concentrates annually. These three operations are referred to throughout this report as Plan A, Plan B, and Plan C, respectively.

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*All "tons" shown in this report are gross tons of 2240 pounds each, unless otherwise specified.

The scheme developed to show the economic potential of this enterprise as follows: the capital cost for the mine plant and other facilities necessary for the production of concentrates is estimated in Section Two. A description of these facilities is given in Section One. In Section Three, the operating costs for producing the concentrates is determined up to the point where the concentrates are loaded on board ship at Fort George. All possible ways of shipping the product to the markets are considered in Section Four and the shipping costs for each possible way are determined. In Section Five, the probable selling price of the concentrates and pellets is calculated and in Section Six the economic potential is determined from the estimated selling prices and costs.

SECTION ONE

DESCRIPTION OF PLANT FACILITIES

For convenience in describing the plant facilities, the basic plant can be divided into four parts: the mining plant, the crushing plant, the concentrator, and the power plant. Before these facilities can be described in detail, it is necessary to mention a few important factors about the Duncan Range orebody. The geology of the range has been fully described by Dr. W. N. Ingham, Consulting Geologist, and the following data are taken from his report of 18th November 1958.

DUNCAN RANGE IRON-ORE DEPOSITS

The Duncan Range iron-ore deposits are located in the south-western section of the Ungava District of Northern Quebec. They cover the eastern end of Duncan Lake. This lake is 475 feet above sea level, and is located about 60 miles in an easterly direction from Fort George, a Hudson Bay Company's post on James Bay. The location can be clearly seen on the map which accompanies this report. The iron deposits extent over a distance of fifteen miles. For classification they are divided into six main orebodies, designated No. 1 to No. 6. Four of these lie along a general northern belt of iron formation and two, No. 5 and No.6, are part of a southern belt. The No. 1 and No. 2 orebodies constitute an iron-bearing horizon traced continuously for a length of nine miles but only the sections of length that are over 100 feet wide are classified as ore.

At one point, No. 1 orebody is 1300 feet wide. This orebody is the biggest of the six and it is likely that mining would begin on it.

The No. 1 orebody is divided into a north and a south band; the former is estimated to contain 608,000 tons per vertical foot with an average width of 400 feet, while the latter contains 654,000 tons per vertical foot with an average width of 600 feet. If the ore persists to depths, as is expected from the geological nature of the deposit, and if open-pit mining is carried out to a depth of 600 feet which is the average width of the south band, then nearly 400,000,000 tons of ore are available in this south band of No. 1 orebody, alone. Should the ore not persist to the depths expected, the exploitation of the north band of No. 1, or any of the other orebodies, will assure an adequate supply of ore. Therefore, for the purposes of this report, it is assumed that all of the ore will come from No. 1 orebody.

Metallurgical testing on samples taken from No. 1 orebody shows that a concentrate containing 66.73 per cent iron (dry), 6.10 per cent silica, 0.039 per cent phosphorous, 0.020 per cent sulphur, and 0.120 per cent titanium dioxide can be made magnetically at a ratio of concentration of 2.1 to 1 and with an iron recovery of 92.29 per cent. At this ratio of concentration, it would require the mining of 10,500,000 tons of ore per annum to produce 5,000,000 tons of dry concentrates. At this rate of mining there would appear to be at least 40 years' supply of ore in No. 1 orebody alone, which is sufficient to justify the capital investment required.

Since it is assumed that open-pit mining would be carried to a depth equal to the width of the deposit, it is reasonable to assume that an equal volume of wallrock will have to be removed to maintain a safe slope to the pit wall. Although the rock will have a somewhat lower specific gravity than the ore, it is assumed in this report that a ton of waste must be removed for each ton of ore mined.

Figure 1 is a map showing No. 1 orebody and its relation to Duncan and other lakes in the vicinity. The site chosen for the crushing plant and concentrator are indicated at a point near the shore of Duncan Lake and directly south of the west end of Almond Island. This location was chosen so that the haulage of ore to the crushing plant could be kept to a minimum distance from the major sections of the orebody.

MINING PLANT

The open-pit mine would be laid out and operated generally in accordance with methods now practised on the Mesabi Iron Range, and other iron mines. In increasing production from 1,000,000 to 2,500,000 tons and eventually to 5,000,000 tons annually, it would be necessary only to add more drills, shovels, trucks, and bulldozers to the equipment already on hand. Shops and other facilities would be built with ultimate expansion in mind so that additions to these would be just of a minor nature. Buildings in the mining plant would include a major repair shop for trucks and other equipment, a warehouse for operating supplies, fuel storage, a welfare building for personnel and office. The mining equipment would include drills, a fleet of 32-ton diesel trucks, electric shovels, diesel compressors, bulldozers, road-building machines, and smaller trucks, shovels, and drills.

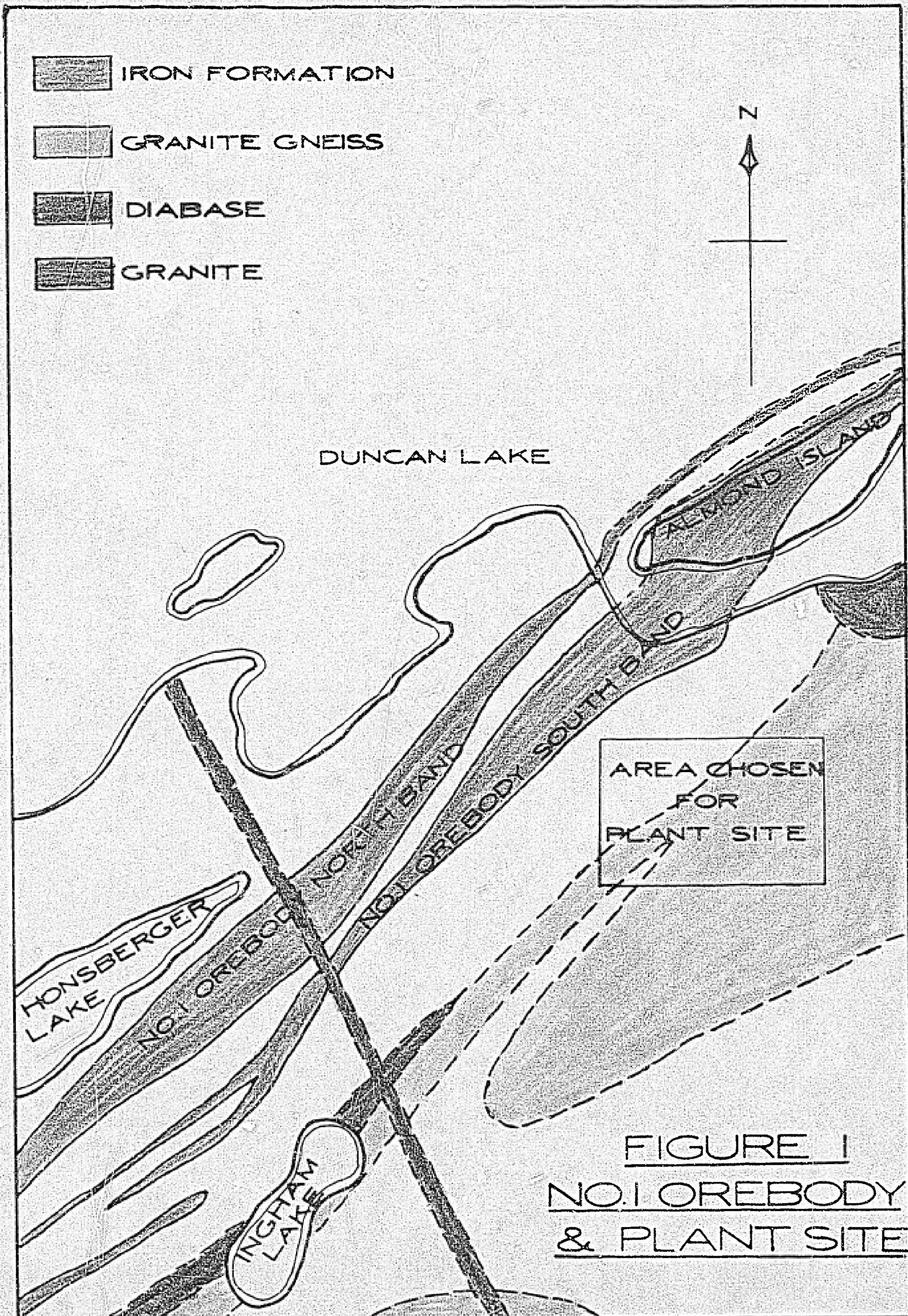

FIGURE I
NO. I OREBODY
& PLANT SITE

Ore would be drilled, broken by blasting, loaded into trucks, and transported to the crushing plant.

CRUSHING PLANT

The crushing equipment would consist of a primary crusher and secondary crushers. Screens would be installed to remove ore crushed sufficiently fine from the feed to the secondary crusher. As the ore trucked from the mine to the crusher would be in very large pieces, the maximum size of primary crusher would be required even for low rates of production. Hence, no further additions to this part of the plant would be required when expanding the size of the mine. For the secondary crushers, additional equipment would be required as the production rate was increased.

When the ore arrived at the crusher in the trucks, it would be discharged into a hopper equipped with an apron feeder and grizzly to feed the ore to the primary crusher and to remove fines. Belt conveyors would transfer the crushed ore to the concentrator.

CONCENTRATOR

Ore from the crusher would be stored in large bins of sufficient capacity to maintain a steady feed to the concentrator over the weekends when the mine and crushing plant were idle. From these bins, the ore would be fed to rod mills which would grind the ore to a size suitable for the primary magnetic separators. These units would separate the ore into a rough concentrate and a tailing. The latter would be thickened to conserve water and then pumped to a suitable pond for disposal. The rough concentrate would be ground further in ball mills and then classified in cyclones to remove oversized material which would be returned to the mill for further grinding. From the cyclones the fine material would go to the secondary magnetic separators where the final separation of magnetite and tailing would be made. The final operation on the concentrates would be thickening and filtering to lower the moisture content to about 10 per cent. It would be difficult to lower the moisture to a lower value. In any event, about this amount is necessary to insure that there would be no dusting losses during shipments. The presence of moisture in the concentrates has the effect of lowering the iron content. With 10 per cent moisture, the iron would be 60.06 per cent and the silica 5.49 per cent.

POWER PLANT

The Ingham Report mentions an adequate supply of hydro-electric power along the 30-mile stretch of the Fort George River about 15 miles north of the Duncan Range. A power plant and dam would be required to be built on the river and there would also need to be a power-line and access road between the river and the property.

TOWNSITE

As the Duncan Range project would be an entirely new development in an area remote from any established settlement, a complete townsite would have to be constructed with all conveniences for the comfortable living of the mine's personnel. Provision should be made for dormitories for single men, several apartment blocks for families, a shopping centre, recreational building, hospital, school and restaurant. It is estimated that Plan A would require a staff of 500; Plan B, 700; and Plan C, 1000 men.

TRANSPORTATION AND COMMUNICATIONS

It is assumed that all materials for the construction will come in through Fort George on James Bay. This will require a 60-mile access road to be built to the property and an adequate service dock for unloading supplies. It has been reported by a competent shipping authority conversant with navigational conditions in Hudson Bay, that it is not unreasonable to expect the movement of 1,000,000 tons of ore through Hudson Strait based on a shipping season of 90 days commencing the end of July and terminating the end of October, and upon the use of ore carriers of 20,000 tons carrying capacity average. There is little doubt that this would be the cheapest means of shipping the concentrates to the world markets and it is assumed for the purposes of this report that in Plan A, all the production will be shipped out this way, while for Plans B and C, 1,000,000 tons annually will be moved through Hudson Strait and the remainder by other means of transportation. It will be necessary then to build a 60-mile railroad from Duncan Lake to Fort George and modern loading docks at the harbour so that ore carriers can be loaded and despatched quickly. Stock-piling facilities would be required for the storage of the ore during the season when the bay is closed to navigation.

Fuel oil and other mine supplies would be brought in by way of Fort George. Therefore, there would need to be warehouses, offices and oil-storage tanks constructed there, as well as living accommodation for about seventy people.

PRODUCTION SCHEDULES

In order to calculate the quantities of ore to be mined, crushed, concentrated, and shipped, it is necessary to start with the finished product to be sold and work back to the ore in the ground, making suitable allowance for moisture content of concentrates, oxidation of pellets, shipping losses and ratio of concentration. For this purpose, the following premises are used:

(1) Moisture content of concentrates is 10 per cent

(2) Shipping losses amount to 2 per cent

(3) There is an increase in weight of 2 per cent during pelletizing due to the oxidation of magnetite

(4) Ratio of concentration is 2.1:1 on dry basis.

It is also necessary to draw up an operating schedule for the mine, crusher, concentrator, and pelletizing plant. For the purposes of this report, it is assumed that the mine and crushing plants would be worked in two eight-hour shifts for five days per week, and the concentrator and pelletizing plant would be operated on the basis of 24 hours per day for seven days per week throughout the year. To allow for holidays, breakdowns and repairs, it is assumed that the mill operates for about 330 days annually. On these bases, the production schedule is as shown in Table I.

TABLE I

PRODUCTION SCHEDULES

	PLAN A	PLAN B	PLAN C
Concentrates Sold Annually, Tons	1,000,000	2,500,000	5,000,000
Concentrates Shipped Annually, Tons	1,020,000	2,550,000	5,100,000
Dry Concentrates Milled Annually, Tons	918,000	2,295,000	4,590,000
Dry Concentrates Milled Daily, Tons	2,790	6,975	13,950
Ore Milled Daily, Tons (7 days/week)	5,850	14,625	29,250
Ore Mined Daily, Tons (5 days/week)	8,180	20,450	40,900
Ore Mined Annually, Tons	1,927,800	4,819,500	9,639,000
Pellets Sold Annually, Tons	1,000,000	2,500,000	5,000,000
Pellets Shipped Annually, Tons	1,020,000	2,550,000	5,100,000
Dry Concentrates Required for Pelleting, Tons	1,000,000	2,500,000	5,000,000
Ore Mined Annually for Pelletizing, Tons	2,100,000	5,250,000	10,500,000

When pelletizing there is an increase in weight due to the oxidation of the magnetite. This results in a decrease in iron concentration from 66.73 per cent in the concentrates to 64.30 per cent in the pellets. The losses in weight during shipping are not likely to be so high with pellets as with concentrates, but it is assumed for the purposes of this report that the weight of pellets sold is equal to the weight of concentrates made. Thus the loss in shipping would be offset by the increase in weight due to pelletizing. Because the pellets contain more iron and less moisture than the concentrates, it will require more ore to produce a ton of pellets for sale than a ton of concentrates. Thus it can be seen from Table I that it requires 1.9278 tons of ore to make one ton of concentrates but 2.1000 tons of ore to make one ton of pellets for sale.

ADDITIONAL FACILITIES

Besides the basic facilities just described for the production of concentrates, additional facilities may be required depending upon the route chosen for transporting the product to market and upon whether it is desired to produce pellets instead of concentrates. These additional facilities include: a trans-shipping port in Greenland, should it be desired to ship all the production by the Hudson Route; a fleet of tugs and barges and an unloading dock at Moosonee, should the Moosonee Route be preferred and a pelletizing plant should it be desired to produce pellets instead of concentrates. An earlier study showed that the best location for a pelletizing plant would be at Duncan Lake along with the concentrator.

SECTION TWO

CONSTRUCTION COST ESTIMATES

Construction cost estimates are made based on the facilities described in Section One. This plan does not represent, necessarily, the final choice. When further data become available from field studies, diamond drilling, and metallurgical testing, it will become clear that certain alternatives merit further careful consideration.

An accurate construction cost estimate would require a study and survey of the land chosen for the mine, plant, railroad and dock locations, and a set of engineering drawings of the proposed plant. As none of these is available, it is necessary for the Engineer to make his estimates based on similar projects built in the past. In view of these circumstances, only a rough estimate can be made at this time. At some future date, when more detailed information is available, a closer estimate will be possible. Undoubtedly, the opportunity for substantial savings in construction costs will be found. On the other hand, instances will occur where the costs will be higher than estimated herein. To some degree these differences will be compensatory so that the estimate made in this report will probably be within plus or minus five per cent of the ultimate construction cost.

Table II on the following page shows the construction cost estimates, together with additional items for working capital and

TABLE II

CONSTRUCTION COST ESTIMATES

	PLAN A	PLAN B	PLAN C
Mine Equipment	$ 1,500,000	$ 2,800,000	$ 5,000,000
Crushing Plant and Concentrator	5,000,000	8,000,000	13,000,000
Shop and Maintenance Equipment	500,000	700,000	900,000
Townsite at Duncan Lake	4,500,000	6,300,000	9,900,000
Road and Airport	1,500,000	1,500,000	1,500,000
Power and Heating Plants	6,300,000	9,000,000	10,800,000
Railroad to Fort George	22,000,000	26,000,000	33,000,000
Ore Docks at Fort George and Equipment	6,000,000	6,300,000	6,500,000
Service Dock	1,800,000	1,800,000	1,800,000
Oil Storage	200,000	300,000	400,000
Townsite at Fort George	1,400,000	1,800,000	2,000,000
	$ 50,700,000	$ 64,500,000	$ 84,800,000
Engineering and Contingencies	5,070,000	6,450,000	8,480,000
Total Construction Costs	$ 55,770,000	$ 70,950,000	$ 93,280,000
Working Capital	5,220,000	5,220,000	5,220,000
Total Capital Cost Estimate	$ 60,990,000	$ 76,170,000	$ 98,500,000
Earned Interest	5,610,000	9,510,000	15,700,000
Total Capital Investment	$ 66,600,000	$ 85,680,000	$ 114,200,000

earned interest which must be added to the construction cost in order to determine the total capital investment required to bring the mine into production. The working capital is a sum of money set aside to pay expenses in the production of concentrates which must be paid during the first few months of the mine's operation before any income from the sale of the product becomes available to pay these expenses. This item is calculated from the operating cost shown in Section Three of the report and the assumption that no income is available for the first twelve months of the mine's operation. In the case of Plans B and C, it is assumed that these are really expansions of Plan A so that production will be underway and income available before the completion of construction. Therefore, no additional funds will be required for working capital.

Earned interest is defined as interest charges on money borrowed prior to the time that the mine gets into production. For the calculation of this item, it is assumed that the interest rate is six per cent; that Plan A requires two years for construction and half of the required capital is borrowed at the beginning of each year; that Plan B requires three years for building and one-third of the capital is borrowed at the beginning of each year; and that Plan C requires four years to construct and one-quarter of the capital is borrowed at the beginning of each year. In Plan B and Plan C, it is assumed that production would get underway at the rate of 1,000,000 tons per year after the first two years of construction, and at the rate of 2,500,000 tons after three years of construction. This item of cost might be reduced considerably if the necessary funds are raised by the sale of stock instead of bonds. However, this possibility is not considered in this report because the sums required are rather large to be raised from the sale of stocks alone, and, in addition, no allowance is made in Table II for exploration, testing, and other pre-production expenses because it is assumed that the cost of these items is borne by the shareholders.

Not included in the estimates in Table II are the capital costs for equipment and facilities required for the transportation of ore to the markets and for a pelletizing plant. Items in this category are considered in greater detail in Section Four. Should any of these facilities be required, the total capital investment will be as shown in Table III. These extras are not required if shipments of concentrates are made by the Chibougamau Route.

TABLE III

TOTAL CAPITAL INVESTMENT

Not Including Pelletizing Plant

	PLAN A	PLAN B	PLAN C
Basic Plant (Table II)	$ 66,600,000	$ 85,680,000	$114,200,000
Dock in Greenland		10,000,000	12,000,000
Totals	$ 66,600,000	$ 95,680,000	$126,200,000
Basic Plant (Table II)	$ 66,600,000	$ 85,680,000	$114,200,000
Tugs, Barges, Moosonee Dock		20,800,000	33,400,000
Totals	$ 66,600,000	$106,480,000	$147,600,000
Including Pelletizing Plant			
Basic Plant (Table II)	$ 78,600,000	$101,680,000	$142,200,000
Dock in Greenland		10,000,000	12,000,000
Totals	$ 78,600,000	$111,680,000	$154,200,000
Basic Plant (Table II)	$ 78,600,000	$101,680,000	$142,200,000
Tugs, Barges, Moosonee Dock		20,800,000	33,400,000
Totals	$ 78,600,000	$122,480,000	$175,600,000

SECTION THREE

OPERATING COST ESTIMATES

The operating costs, estimated to mine, process and move the concentrates or pellets to the ships at Fort George, are shown in Table IV.

The figures shown are per ton of product sold. The costs of ore delivered to crusher were first determined per ton of ore and then multiplied by 1.9278 in order to determine the mining costs per ton of concentrates and by 2.1000 to determine the mining costs of pellets.

These figures include labour, supervision, maintenance and repairs, electric energy, and general office overhead. They do not include depreciation on renewable equipment nor any amortization of invested capital.

AVERAGE OPERATING COSTS

When all the ore is shipped out through Fort George, the operating costs will be as shown in Table IV. However, if part of the ore is shipped out by the Chibougamau Route, then the operating costs will be a little lower because the costs to move the ore to Fort George are not required. Therefore, for this case, it is necessary to calculate an average operating cost and for this purpose, it is assumed that the first 1,000,000 tons will always be shipped via Fort George and the Hudson Strait;

TABLE IV

OPERATING COST ESTIMATES

	COST PER TON OF CONCENTRATES		
	PLAN A	PLAN B	PLAN C
Cost of Ore Delivered to Crusher	$ 2.40	$ 2.20	$ 1.90
Primary Crushing	.27	.22	.18
Secondary Crushing and Grinding	.93	.84	.77
Concentration and Filtering	.50	.44	.40
Cost of Concentrates at Duncan Lake	$ 4.10	$ 3.70	$ 3.25
Transporting to Fort George	.80	.60	.50
Stockpiling	.07	.07	.07
Loading	.15	.13	.12
Cost of Concentrates on Board Ship	$ 5.12	$ 4.50	$ 3.94
Additional Cost for Pelletizing, Mining	.47	.43	.37
Pelletizing	1.65	1.55	1.45
Cost of Pellets on Board Ship	$ 7.24	$ 6.48	$ 5.76

the remainder (1,500,000 tons for Plan B, and 4,000,000 tons for Plan C) would be shipped by the alternative Chibougamau Route. On this basis, the average operating costs per ton of product sold are:

	Concentrates	Pellets
Plan A	$5.12 per ton (as in Table IV)	$7.24
Plan B	4.02 per ton	6.00
Plan C	3.39	5.21

DEPRECIATION

Many pieces of equipment used in mining and metallurgical operations will last almost indefinitely, provided the usual running repairs and maintenance are kept up. The cost of such maintenance is already included in the operating costs. Other pieces of equipment, such as drills, shovels, trucks, bulldozers, pumps, tugs, and barges, will have to be renewed from time to time. For this purpose, a certain amount of money must be put aside each year for the purchase of new equipment when required. This fund is called depreciation and has been estimated to amount to $0.25 per ton for Plan A, $0.23 per ton for Plan B, and $0.20 per ton for Plan C.

AMORTIZATION OF INVESTMENT

A quick and simplified way to show whether a mining enterprise is profitable is to assume that all the invested capital has been borrowed at a given rate of interest and that the repayment of principal and interest is made annually in equal instalments for a given number of years.

The calculations made in this report are based on No. 1 orebody which has an estimated reserve of over 400,000,000 tons. This orebody alone has a life of over 40 years, when mined to produce 5,000,000 tons of concentrates annually. The addition of the other orebodies would extend the life of the entire range for many years more. Thus, repayment of capital could be made over a period of 10, 20, 30 or even 40 years. The interest rate is assumed to be six per cent and the payments are to be made annually. Under these conditions, the annual repayments on invested capital and the repayments per ton of finished product would be as shown in Table V on the following page.

TABLE V

CAPITAL INVESTMENT AND AMORTIZATION

(Payments made Annually)

	PLAN A	PLAN B	PLAN C
Capital Investment for Basic Plant	$ 66,600,000	$ 85,680,000	$ 114,200,000
Capital Investment for Pelletizing Plant	12,000,000	16,000,000	28,000,000
ANNUAL REPAYMENTS FOR BASIC PLANT			
In 10 years at 6% (13.585%)	$ 9,047,610	$ 11,639,628	$ 15,514,070
In 20 years at 6% (8.718%)	5,806,188	7,469,582	9,955,956
In 30 years at 6% (7.264%)	4,837,824	6,223,795	8,295,488
In 40 years at 6% (6.646%)	4,426,236	5,694,293	7,589,732
REPAYMENTS PER TON OF PRODUCT			
In 10 years at 6%	$ 9.05	$ 4.66	$ 3.10
In 20 years at 6%	5.81	2.99	1.99
In 30 years at 6%	4.84	2.49	1.66
In 40 years at 6%	4.43	2.28	1.52
ADDITIONAL REPAYMENTS FOR PELLETIZING PLANT			
In 10 years at 6%	$ 1.63	$ 0.87	$ 0.76
In 20 years at 6%	1.05	.56	.49
In 30 years at 6%	.87	.46	.41
In 40 years at 6%	.80	.42	.37

SECTION FOUR

ORE TRANSPORTATION COSTS

It is necessary to treat the transportation costs separately from other costs because there are three basic alternative routes possible which must be considered individually. These are:

1. The Hudson Route
2. The Moosonee Route
3. The Chibougamau Route.

The Hudson Route can be treated in two ways: one way would be to gather together as many ships as possible to move the ore to its destination in the short season of navigation. This would be possible only in the case of Plan A. The other would be to use a smaller number of ships to move the ore to some ice-free trans-shipping point in Greenland or Newfoundland during the Hudson Bay season of the year and to use these same ships to take the ore to its destination during the remainder of the year. This method would be essential for Plans B and C. Likewise, the Moosonee Route can be treated two ways depending upon whether the ore is moved by rail to a port on Georgian Bay or to a port on Lake Superior.

In order to determine the economic potential of the Duncan Range enterprise, it is necessary to calculate the cost of the concentrates delivered to market areas in which the selling price of iron ore is established. The two areas selected to make these studies are the Ruhr district of Germany, and the Lower Lake Ports of Lake Erie (Cleveland, Ohio) in the United States.

THE HUDSON ROUTE

The Engineer was able to obtain information on shipping into Hudson Bay from three shipping companies: one in Canada, one in the United States, and one in England. The opinions expressed by these people are based partially on their own experience with the grain shipments from Churchill, Manitoba to Europe. The season of navigation commences about the end of July and terminates the end of October. Thus, there are from 75 to 90 operational days each year. One authority expressed the opinion that it would be possible to move 1,000,000 tons in this period provided carriers of 20,000 tons carrying capacity were used. One of the others thought that much larger tonnages could be shipped provided the freight rate offered is adequate to attract tonnage for this trade. With sufficient attraction, ship-owners would build new and special ships for it. At the present time, there are only about 75 bulk carriers with capacities of 20,000 or higher. It is understood that ships with capacities up to 60,000 tons are being built at the present time.

The freight rate that might prevail is also based on the Churchill grain trade because of the competition from this area. During the 1960 season, the ocean freight on grain was at the rate of about $3.50 per ton f.i.o. This is quite low and it is stated that the rates that are ruling are not economical, and are being subsidized out of shipowners' past profits. A desirable rate from the shipowners' point of view is thought to be $6.00 to $7.50 f.i.o. per ton in big ships. When the demand for shipping increases, it is natural to expect an increase in price. Therefore, a reasonable figure might be the average between the two extremes, i.e. $5.50.

According to reports, there is a trans-shipping charge of $0.27 per ton at Rotterdam and a shipping charge of $0.74 per ton for the movement of ore to the Ruhr district of Germany in Rhine River barges.

To the freight rate, there must be added the cost of insurance, which might be $0.35 per ton, or even higher, for the Hudson Bay trade. The summary of the shipping costs via Hudson Strait to Europe would be:

Ocean freight	-	$5.50 per ton
Insurance	-	.38
Unloading	-	.27
Rhine River freight	-	.74
Total		$6.89 per ton

HUDSON ROUTE WITH TRANS-SHIPMENT PORT

If it were planned to move more than 1,000,000 tons per season out through Hudson Strait, it would be necessary to build a trans-shipping port in an ice-free harbour in Greenland or Newfoundland. The cost of such a port, suitable for the storage of about 2,500,000 tons of ore, would be approximately $10,000,000, and for the storage of about 5,000,000 tons of ore, $12,000,000. When these harbour facilities are amortized over a period of 20 years, the capital cost becomes $0.58 and $0.26 per ton, respectively. Corresponding figures can be calculated for amortizing the investment over 10, 30, and 40 years.

For the purpose of this study, a port in Greenland is considered because this port would be more or less directly on the route between Hudson Strait and Europe. A port in Newfoundland would be farther away from Fort George, and, furthermore, the length of the trip to Europe would be greatly increased. It is estimated that the approximate distance from Fort George to Greenland is 1650 miles and to Europe, 3800 miles. If the total freight rate to Rotterdam is assumed to be $5.50 f.i.o. per ton, then on this basis, the estimated freight from Fort George to Greenland would be $3.00 per ton; and from Greenland to Rotterdam, $2.50 per ton. An additional cost involved would be for trans-shipping and stockpiling at Greenland, trans-shipping at Rotterdam and the Rhine River barge freight. The total estimated ore transportation costs to the Ruhr district of Germany are calculated as shown in Table VI.

Since the first 1,000,000 tons of ore can be shipped directly to Europe at a cost of $6.89, the other costs in Table VI apply to the ore in excess of 1,000,000 tons. It is necessary to calculate the average freight rate which will apply to the overall product from the mine. These average freights are summarized in Table VII. It will be noted that they vary with the number of years required to amortize the capital investment.

TABLE VI

ESTIMATED ORE TRANSPORTATION COSTS

HUDSON ROUTE

(20 Years Amortization)

	Costs per Ton		
	PLAN A	PLAN B	PLAN C
Freight from Fort George	$ 5.50	$ 3.00	$ 3.00
Insurance	.38	.35	.35
Trans-shipping at Greenland	-	.60	.60
Freight from Greenland	-	2.50	2.50
Insurance	-	.03	.03
Trans-shipping at Rotterdam	.27	.27	.27
Rhine River Freight	.74	.74	.74
Amortization of Capital	-	.58	.26
Totals	$ 6.89	$ 8.07	$ 7.75

TABLE VII

SUMMARY OF AVERAGE TRANSPORTATION COSTS

HUDSON ROUTE

	AVERAGE COST PER TON	
	PLAN B	PLAN C
Repayments Amortized over 10 Years	$ 7.79	$ 7.70
Repayments Amortized over 20 Years	7.60	7.58
Repayments Amortized over 30 Years	7.54	7.55
Repayments Amortized over 40 Years	7.51	7.53

MOOSONEE ROUTE

A study was made by the Dravo of Canada Limited on the possibilities of shipping iron ore by barges from Fort George to Moosonee. This port is the northern terminal of the Ontario Northland Railway. The scheme would require an unloading dock at Moosonee and a fleet of five tugs and 12 barges for the haulage of 2,500,000 tons of ore and 10 tugs and 24 barges for 5,000,000 tons. The total capital investment on these facilities amounts to $20,800,000 for Plan B, and $33,400,000 for Plan C. Amortized over a period of 20 years, this amounts to $1.21 and $0.72 per ton, respectively. Again, this could be amortized over 10, 30 or 40 years.

Shipping from Fort George to Moosonee would be carried on for seven months of each year. Stockpiling at Moosonee would have to be provided for. Rail haulage to Michipicoten Harbour on Lake Superior or to Parry Sound on Georgian Bay could take place throughout the year, but this would be at the discretion of the railways. The distance to Lake Superior is 365 miles and to Georgian Bay is 490 miles. It is assumed that the railways would provide their own loading docks and storage yards, if required. The cost of rail freight is estimated to be one cent per ton/mile.

For purposes of comparison, the shipping costs by the two alternative routes on the Great Lakes to Cleveland, Ohio, are calculated. From Michipicoten to Cleveland, the rate is $1.80, while from Georgian Bay, the rate is $1.00 per ton.

The total cost of shipping ore from Fort George to Cleveland by the Moosonee Route is as shown in Table VIII.

It will be noted that the costs through Michipicoten Harbour are the lower. It is highly likely that the Ontario Northland Railway would lower their rate to meet this competition. Therefore, only the lower transportation cost figures are used throughout the remainder of this report.

It is again necessary to average the transporation costs in view of the fact that part of the production will go to Europe by the Hudson Route and only the remainder will be shipped in the United States by the Moosonee Route. The summary of these average costs is shown in Table IX.

CHIBOUGAMAU ROUTE

The possibility of shipping iron concentrates or pellets from Duncan Lake to Port Alfred on the Saguenay River is subject to the premise that the Canadian National Railways would extend their line from Chibougamau to Duncan Lake. The total distance would be 540 miles from Duncan Lake to Port Alfred. There are good indications that this possibility might develop since there are other mining properties in the same area that would be served by this railroad. Its construction also has the support of the Quebec Government.

In line with the original premises made for this study, 1,000,000 tons of ore (Plan A) would still be shipped via the Hudson Route,

TABLE VIII

ESTIMATED ORE TRANSPORATION COSTS

MOOSONEE ROUTE

(20 Years Amortization)

	COST PER TON			
	PLAN B		PLAN C	
	Lake Superior	Georgian Bay	Lake Superior	Georgian Bay
Barge Costs, Fort George to Moosonee	$ 0.60	$ 0.60	$ 0.60	$ 0.60
Unloading and Stockpiling at Moosonee	.21	.21	.21	.21
Loading	.10	.10	.10	.10
Rail Freight	3.65	4.90	3.65	4.90
Trans-shipping (to Vessel on Great Lakes)	.19	.19	.19	.19
Lake Freight	1.80	1.00	1.80	1.00
Unloading to Rail of Vessel, Lower Lake Ports	.28	.28	.28	.28
Amortization of Tugs, Barges, etc.	1.21	1.21	.72	.72
Depreciation on Tugs and Barges	.37	.37	.25	.25
Totals	$ 8.41	$ 8.86	$ 7.80	$ 8.25

TABLE IX

SUMMARY OF AVERAGE TRANSPORTATION COSTS

MOOSONEE ROUTE

	AVERAGE COST PER TON	
	PLAN B	PLAN C
Repayments Amortized over 10 Years	$ 8.21	$ 7.95
Repayments Amortized over 20 Years	7.80	7.63
Repayments Amortized over 30 Years	7.68	7.53
Repayments Amortized over 40 Years	7.63	7.48

leaving 1,500,000 tons in Plan B and 4,000,000 tons in Plan C to be shipped via Port Alfred. It is assumed that the railway would provide the ore docks at Port Alfred and no further capital investment is required. The freight rate from Port Alfred to Rotterdam is anticipated to be the same as from Greenland. The freight rate from Port Alfred to Cleveland is estimated to be $2.54 per ton which includes a toll of $0.54 for the St. Lawrence Seaway. On these bases, the transportation costs for the Chibougamau Route are shown in Table X. The summary of the average transportation costs is shown in Table XI.

TABLE X

ESTIMATED ORE TRANSPORATION COSTS

CHIBOUGAMAU ROUTE

	COST PER TON	
	Ruhr District Germany	Cleveland, Ohio United States
Rail Freight from Duncan Lake	$ 5.40	$ 5.40
Trans-shipping to Vessel at Port Alfred	.30	.30
Ocean or Lake Freight	2.50	2.54
Trans-shipping or Unloading	.27	.28
Rhine River Freight	.74	-
Insurance	.03	-
Totals	$ 9.24	$ 8.52

TABLE XI

SUMMARY OF AVERAGE CONCENTRATION COSTS

CHIBOUGAMAU ROUTE

DESTINATION	AVERAGE COST PER TON PLAN B	AVERAGE COST PER TON PLAN C
Ruhr District, Germany	$ 8.30	$ 9.17
Cleveland, Ohio, U.S.A.	7.87	8.19

SECTION FIVE

ESTIMATED SELLING PRICES

The selling price of iron ore in the Cleveland, Ohio district is established by the American Iron Ore Association. From their figures, published in the 29th December 1960 issue of Iron Age, the value of concentrates containing 60.06 per cent iron natural is calculated to be $13.53 per ton at the rail of the vessel at the Lower Lake ports and the value of pellets containing 64.30 per cent iron natural is calculated to be $15.91 per ton.

The European selling price is subject to uncertainty and is not so easy to determine. The N.V. International Ertshandel Wombersie of Rotterdam are of the opinion that a price per unit of iron of $0.21 to $0.23 may be considered as reasonable at this moment. Bicker and Company A.G. of Essen report that the Ruhr works bought Malmberget pellets from Sweden, analyzing 68.85 to 69.20 per cent iron at a top price of $0.2738 per unit of iron c.i.f. They feel that, for a long-term contract, prices in the vicinity of $0.2510 per unit of iron might be possible.

Actual Ruhr district prices, quoted in 1957, which are considered to be a good gauge for future long-term contracts, were reported to the Engineer as shown in Table XII. From these figures and from a knowledge of the characteristics of the various ores named in this Table, it may be concluded that a unit price of $0.2468 for Sydvaranger concentrates, which are similar in all respects to the concentrates

TABLE XII

1957 RUHR DISTRICT ORE PRICES

Name	Per Cent Iron		Price per	
	Dry	Natural	Iron Unit	Gross Ton
Brazilian Lump	68	67.3	$ 0.3525	$ 23.73
Labrador	58	52.5	.2929	15.51
Indian	58	57.5	.3055	17.54
Luxembourg	25	22.6	.1998	4.50
Wabana	51	50.3	.2350	11.80
Sydvaranger Concentrates	65	60.4	.2468	14.90
Rio Tinto Cinder	60	49.0	.2350	11.50
Spanish (Average)	55	53.9	.2820	15.20
Kiruna D	60	59.4	.2350	13.96
Venezuelan	64	59.6	.2702	16.11

anticipated from Duncan Range, is not an unreasonable one. This would make the price of Duncan Range concentrates equal to $14.83 per ton. Similarly, the unit price of $0.2738 for Malmberget pellets is reasonable and, from this, the Duncan Range pellets would be worth $17.66 per ton laid down in the Ruhr district.

There has been a small but steady increase in prices for iron ores for years and it is not unreasonable to expect that the prices for concentrates and pellets would increase by as much as 10 per cent by the time the Duncan Range enterprise gets into production. This would make the Lower Lake price equal to $14.88 per ton and the Ruhr district price equal to $16.32 per ton for concentrates and $17.50 and $19.43 per ton, respectively, for pellets.

Because at least 1,000,000 tons are sold in Europe and the remainder can be sold in the United States, it is necessary to average the selling prices in the same way as was done for the transportation. When this is done, the average selling prices for each of the three plans are as follows:

		Concentrates	Pellets
Plan A	-	$ 16.32 per ton	$ 19.43
Plan B	-	15.46 per ton	18.27
Plan C	-	15.17 per ton	17.89

SECTION SIX

ECONOMIC POTENTIAL

The economic potential is determined from the difference between the selling price of the ore and the cost delivered to the point of sale. The figure so obtained can vary considerably depending upon the set of conditions, enumerated in previous Sections, which prevail. Table XIII shows a sample calculation of the economic potential for the case in which shipments of concentrates are made through Hudson Strait and in which the invested capital is amortized over twenty years. Table XIV is a summary of profits on concentrates using all the combinations of transportation and amortization previously discussed. Table XV is a similar table for pellets.

Table XIV shows that the Hudson Route is to be preferred over the other choices and that Europe is the better market area. The Table shows also that Plan A, in which the annual production amounts to 1,000,000 is not economical in itself. However, the size of the ore deposits on the Duncan Range is so large that it warrants a much larger operation than that indicated in Plan A. There is no reason why the mine could not be started at the lowest rate of production and continued as such for a few years. There would be sufficient income to pay the operating costs during this period. However, production should be stepped up to the highest rate as quickly as the facilities and markets permit.

TABLE XIII

SAMPLE CALCULATION OF ECONOMIC POTENTIAL

HUDSON ROUTE

(Invested Capital Amortized over 20 Years)

	PER TON OF CONCENTRATES		
	PLAN A	PLAN B	PLAN C
Operating Costs	$ 5.12	$ 4.50	$ 3.94
Depreciation	.25	.23	.20
Selling Expense	.34	.34	.34
Transportation Costs	6.89	7.60	7.58
Amortization of Invested Capital	5.81	2.99	1.99
Total Cost of Product Delivered	$18.41	$15.66	$14.05
Selling Price	16.32	16.32	16.32
Net Profit before Taxes	$-2.09	$ 0.66	$ 2.27

TABLE XIV

SUMMARY OF PROFIT CALCULATIONS FOR THE SALE OF CONCENTRATES

	PER TON OF CONCENTRATES		
	PLAN A	PLAN B	PLAN C
HUDSON ROUTE (European Sales)			
Amortization in 10 Years	$-5.33	$-1.20	$ 1.04
Amortization in 20 Years	-2.09	.66	2.27
Amortization in 30 Years	-1.12	1.22	2.63
Amortization in 40 Years	-0.71	1.46	2.79
MOOSONEE ROUTE (U. S. Sales)			
Amortization in 10 Years		$-2.42	$ -0.36
Amortization in 20 Years		-0.42	1.07
Amortization in 30 Years		.22	1.50
Amortization in 40 Years		.48	1.69
CHIBOUGAMAU ROUTE (European Sales)			
Amortization in 10 Years		$-1.23	$ 0.12
Amortization in 20 Years		.44	1.23
Amortization in 30 Years		.94	1.56
Amortization in 40 Years		1.15	1.70
CHIBOUGAMAU ROUTE (U. S. Sales)			
Amortization in 10 Years		$-1.66	$-0.05
Amortization in 20 Years		.01	1.06
Amortization in 30 Years		.51	1.39
Amortization in 40 Years		.72	1.53

TABLE XV

SUMMARY OF PROFIT CALCULATIONS

FOR THE SALE OF PELLETS

	PER TON OF PELLETS		
	PLAN A	PLAN B	PLAN C
HUDSON ROUTE (European Sales)			
Amortization in 10 Years	$-5.97	$-0.94	$ 1.57
Amortization in 20 Years	-2.15	1.23	3.07
Amortization in 30 Years	-1.00	1.89	3.51
Amortization in 40 Years	-0.52	2.17	3.71
MOOSONEE ROUTE (U. S. Sales)			
Amortization in 10 Years		$-2.62	$-0.22
Amortization in 20 Years		-0.13	1.48
Amortization in 30 Years		.59	1.99
Amortization in 40 Years		.89	2.22
CHIBOUGAMAU ROUTE (European Sales)			
Amortization in 10 Years		$-0.97	$ 0.65
Amortization in 20 Years		1.01	2.03
Amortization in 30 Years		1.61	2.44
Amortization in 40 Years		1.86	2.62
CHIBOUGAMAU ROUTE (U. S. Sales)			
Amortization in 10 Years		$-1.70	$ 0.09
Amortization in 20 Years		.28	1.47
Amortization in 30 Years		.88	1.88
Amortization in 40 Years		1.13	2.06

CONCLUSIONS

The present investigation shows that an attractive profit can be obtained from the mining of ore from the Duncan Range iron-ore deposits, provided it is carried out on a scale of sufficient magnitude, provided that a suitable market for the finished product is obtainable, and provided that the necessary ships for transporting the product to the market area are available.

Throughout this investigation, the Engineer has endeavoured to be realistic in treating each step of the calculation and conservative in his estimations so that the results obtained are reasonably safe. If, in practice, the profits differ from those calculated herein, it is more likely that they will be better than shown in this report.

Because of access to ocean transportation through Hudson Strait, transportation costs are lower by the Hudson Route than for either of the other two alternative routes. Because of this, ore can be landed in Europe cheaper than in the United States.

The investigation shows that the selling price of both concentrates and pellets is likely to be higher in Europe than in the United States. Because of higher selling prices and lower shipping costs, the profits to be made from sales in Europe on material shipped by the Hudson Route are substantially higher than for any of the other possible alternatives. For this reason, the Hudson Route is the preferred shipping route and Europe is the preferred market. The Chibougamau Route is the second choice for shipping purposes. When selling ore in the United States, there is little to choose between shipping through Moosonee or Chibougamau; the result is about the same.

The study shows that Plan A is uneconomic under any circumstances. The lowest production rate that appears to be safe is 2,500,000 tons per year. In any event, the ore deposits of the Duncan Range are so large that it warrants a much larger production rate provided suitable markets can be found. Therefore, the production rate should be stepped up to 5,000,000 tons annually or even higher, as quickly as possible.

At the highest rate of production and with European sales, Plan C can be amortized in ten years. Both Plans B and C are profitable when the investment is amortized in twenty years. Greater profits are shown for longer write-off periods, but there appears to be no great advantage in extending this period for more than twenty years.

Higher profits can be made from the sale of pellets but there may be times when it would be preferable to sell concentrates. The operation should be arranged for the shipping of either product. The big advantage in concentrates is that a big saving in capital investment is possible and the mine can be got into operation easier and earlier.

There is no reason why the mine should not be put into operation on a small scale at the beginning and be built up gradually to the most economical size. In so doing, however, the plant design should be such that it can be added to for greater production when desired.

As already explained, accurate estimates are not possible at this time due to the lack of engineering drawings and detailed information on the property. Nevertheless this study serves a useful purpose in showing the magnitude of the operation that should be economic, the probable investment needed to bring the mine into production, the preferred route for shipping and the most desirable market area. With more detailed information, a closer estimate can be made and, although substantial saving could likely be made in some areas, higher costs are likely to prevail in others so that, on the average, the profits to be made from this enterprise are likely to be within close limits to those calculated herein.

Respectfully submitted,

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20th December 1960.

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