

GM 16871

REPORT ON PRELIMINARY ESTIMATE DEVELOPMENT OF LAKE ALBANEL PROJECT

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Énergie et Ressources
naturelles

Québec 

*Comité de***SIDÉRURGIE**

QUEBEC, le 1er décembre 1964

Dr. Paul-Emile Auger,
Sous-ministre des Richesses Naturelles,
Hôtel du Gouvernement,
Québec, Qué.

Docteur Auger,

M. Cyrille Dufresne m'a demandé de vous retourner le rapport ci-joint sur Albanel Minerals, Ltd. qui vous avait été remis par M. O'Brien au début de l'année 1964.

Veillez me croire,

Votre bien dévouée,

secrétaire

GM-16871

BECHTEL CORPORATION

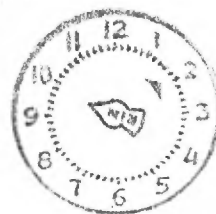


ENGINEERS-CONSTRUCTORS

TWO TWENTY BUSH STREET · · · SAN FRANCISCO 4, CALIFORNIA

January 18, 1961

MAR 3 1967



MINING PROPERTIES DEPARTMENT

Mr. Stanley W. Sundeen, Manager
Research and Ore Development
Cleveland-Cliffs Iron Company
Ishpeming, Michigan

Dear Mr. Sundeen:

We take pleasure in forwarding 36 copies of our report and preliminary estimate for the Lake Albanel Project of Albanel Minerals, Limited. These copies have been revised as discussed with you during the review held in your offices at Ishpeming on January 4 and 5. They replace the 5 work copies sent to you previously.

This report contains a preliminary design and cost estimate for a complete iron ore beneficiation plant capable of producing 3,000,000 long dry tons annually of high-grade iron pellets from the low-grade iron ore mined from your Sandspit ore deposit. Also included is a preliminary design and cost estimate of a combined winter stockpiling and vessel loading facility at Ha Ha Bay.

As you will recall, it was agreed in our early meetings that the study would be based on a single beneficiation plant utilizing wet autogenous milling equipment. We believe that the overall design and cost estimates set forth in the report for the concentrating facilities are in keeping with the present stage of research and development concerning the ores and methods of their beneficiation. A complete pilot plant testing program is needed to verify the flowsheet used in the study.

The study of long distance pumping of concentrates in a pipeline indicates costs comparing quite well with rail transportation for a throughput of 3,000,000 tons per year, and such a pipeline seems technically feasible. However, our basic assumptions need to be verified by a test program before proceeding and we have included an allowance of \$750,000 in the estimate for this purpose. We would expect that verification of our major assumptions would occur or be disproven quite early during a test program and an expenditure in the order of \$200,000 would be required to reach the point of determining feasibility.

Ministère des Richesses Naturelles, Québec

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SERVICE DES GITES MINÉRAUX

No GM- 16871

Mr. Stanley W. Sundeen

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January 18, 1961

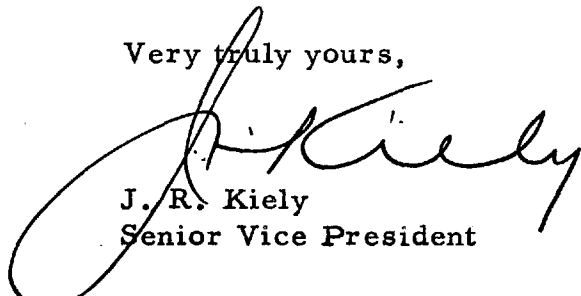
In developing the townsite and associated facilities, we have been guided by the desire to build a permanent "non-company", family-type community having reasonable comforts, conveniences and cultural facilities commensurate with the remote location and arctic climate. The cost of providing such a town is, of course, higher than for a more austere town. However, the sale of property is more likely and the recovery on investment is expected to be better. If a more austere town than we have proposed is desired, we can readily develop the probable costs for you.

The operating cost estimate of the direct operating costs, including general expenses of the entire operation from the mine through and including vessel loading indicates costs of \$8.93 per ton of pellets, including \$2.55 per ton for rail haulage. We believe this is in line with similar iron ore operations.

The cost estimate for the concentrating plant includes \$2,250,000 for constructing 90 miles of temporary access road for use during the construction phase of the project. Payment of part of this amount to the Province might result in accelerating construction of the Federal-Provincial access road to the point where overall savings would result.

This has been an interesting assignment and we look forward to being of further service to you in the development of this project. We wish to express our appreciation for the splendid cooperation given us by all who participated in the study, both of the Cleveland-Cliffs Iron Company and the Albanel Minerals, Limited. Should you have any questions concerning this report or further analyses you may wish us to undertake, please do not hesitate to call upon us.

Very truly yours,



J. R. Kiely
Senior Vice President

Enclosures: 36

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INTRODUCTION

The Albnel Iron Range extends approximately 36 miles along the south shore of Lake Albnel in the Mistassini Region, Province of Quebec. It is a wilderness area, the nearest town being Chibougamau, Quebec located some 95 air miles to the southwest. Albnel Minerals, Ltd. has done extensive exploratory work outlining iron ore deposits on the Albnel Iron Range, but to date there have been no actual mining operations or other commercial developments.

The objective of the Lake Albnel Project is to develop an iron ore beneficiation plant to treat the lean magnetic iron ore from Albnel Minerals, Ltd. mining claims covering the Sandspit ore deposits.

Contained in this report are preliminary designs and order of magnitude estimates for a complete iron ore beneficiation plant with a supporting town on the Albnel Iron Range, a winter stockpile for pellets and vessel loading facilities at Ha Ha Bay, a feasibility study of the long distance pumping of concentrates from the concentration plant to the harbor, and an operating cost estimate for the entire operation.

Included are General Criteria for the Process and Facilities, Flow Charts, General Drawings, Lists of Major Equipment, and order of magnitude estimates of capital Costs.

A joint inspection of Albnel Minerals, Ltd. mining claims was made in company of personnel of the Albnel Minerals, Ltds. and Cleveland-Cliffs Iron Company's Research and Ore Development Department who also provided geological sections of the mine, pilot plant results, guidance and consultation.

SUMMARY

GENERAL

This report presents a preliminary design and capital and operating cost estimates of the Lake Alanel Project. This project is a proposed iron ore development consisting of a mine, a complete iron ore beneficiation plant producing a pelletized product, a materials handling facility for loading the pellets for rail transportation, a stockpiling and shiploading facility, and a townsite and housing for the employees. A limited investigation of the feasibility and probable costs of pumping concentrates from Lake Alanel to the shiploading facilities is included.

Lake Alanel is in central Quebec approximately 400 miles north of Montreal. The nearest railhead is presently at Chibougamau approximately 95 airline miles southwest. No roads serve the plant area. Access is presently limited to an airstrip near the proposed townsite.

This report is preliminary in nature. The metallurgical process is based only on geological sections of the pits, Davis tube tests of diamond drill cores, and limited information obtained from the testing at the Michigan Institute of Minerals Research using exogenous equipment for size reduction on three bulk samples weighing 180 tons. The proposed locations of facilities have been based on available maps and a four-day field reconnaissance of the site during July 1960. Routes selected for access roads and pipeline have been based on a single aerial inspection.

The concentration plant has been laid out on the assumption that the ore would be ground autogenously in two stages. The first stage of grinding is done in a large diameter, Cascade type mill and is followed by a pebble mill using pebbles produced from the ore in the preceding Cascade mill. While the amenability of the Alanel ore to autogenous grinding has not been tested, the anticipated behavior of the ore and the power required for grinding has been estimated by the Cleveland-Cliffs Research and Development personnel based on the pilot plant testing of other ores.

The pelletizing plant has been laid out and estimated as a grate-kiln installation. Although the balling and pelletizing characteristics of the Alanel concentrates have not yet been tested, it can be reasonably expected that they will not present unusual difficulties in this respect.

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PLANT SIZE

The desired annual capacity of the beneficiation plant has been established at 3,000,000 long tons and it was concluded at a joint meeting between Albanel Minerals Ltd. and Bechtel personnel that the study should be directed towards developing a single plant of 3,000,000 tons annual capacity to treat ores from the Sandspit Deposit.

Investigations have indicated that the mining and beneficiation plant operations in this remote area on a seven day week around the clock basis will not be affected by the Lord's Day Act (Chapter 17) of the Canada Revised Statutes 1952).

CONCENTRATION PLANT LOCATION

The influence of the following factors was considered in making the site selection for the beneficiation plant:

- (a) Proximity of plant to mine
- (b) Process water supply
- (c) Tailings disposal
- (d) General area topography
- (e) Rail and highway access to plant

Two potential sites for the beneficiation plant were considered in detail. Both sites are as close as possible to the center of gravity of the Sandspit ore deposit but still off of the iron formation. The preferred site, shown on Area Map Drawing C1-2, is located west of the deposit permitting the unthickened tailings to flow by gravity and be deposited under water in Lake Albanel. This site is favored from the aspect of both lower capital investment and operating costs.

The second site considered for the beneficiation plant is located east of the ore body, as shown on Area Map C1-5. A plant located here requires tailings thickening tanks for the recovery of process water and an extensive dam system to impound the tailings in a basin covering Einar Lake and a portion of Kallio Lake.

CONCENTRATION PROCESS

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Run-of-mine ore is coarse crushed to approximately 8" nominal size (open side setting) by the means of a 54" gyratory crusher. A 26-hour live capacity ore bin provides segregated coarse and fine ore storage and surge capacity between grinding and concentration. Grinding is done by all autogenous equipment in 24' diameter Cascade mills followed by pebble mills in closed circuit with sizing cyclones. Concentration by magnetic separation follows each stage of grinding and a hydroseparator for desliming precedes the finisher magnetic separators.

PELLETIZING PLANT LOCATION

Comparative cost studies of transportation costs of concentrates and pellets and differences in capital and operating costs indicated little, if any, difference in total costs between locating the pelletizing plant at Lake Albanel versus locating it at the shiploading facility if rail transportation is used. Factors other than cost appear to favor the selection of the site for the pelletizing operation at Lake Albanel unless transport of concentrates by pipeline is adopted.

PELLETIZING PROCESS

Finished concentrates, after being filtered to approximately 10% moisture, are balled in ten balling drums, arranged five drums to a pelletizing line. The resulting green balls are fired in two Allis-Chalmers grate-kilns operating in parallel and these are followed by their respective annular and rotary coolers.

The pelletized product is stored in four silos for single shift loading into special pellet cars supplied by the Canadian National Railway for haulage to the Pellet Stockpile and Vessel Loading facilities located at Ha Ha Bay.

VESSEL LOADING FACILITIES

Two sites for a winter stockpile of pellets and facilities for loading vessels were under previous consideration by Albanel Minerals Ltd. One site was on the bank of the Saguenay River. The other was more protected, being located in a cove, Anse a Benjamin, at Ha Ha Bay. Both of these sites are east of Chicoutimi and have access to the St. Lawrence River via the Saguenay seven months of the year, there being a five months non-shipping season because of ice.

Several schemes were considered for stockpiling and reclaiming pellets produced during the five months non-shipping season. Each site and scheme was considered from both capital investment and operating cost standpoints. As a result of these investigations, the Ha Ha Bay site is preferred and a low-cost scheme for stockpiling, reclaiming, and loading vessels has been developed.

Operations are scheduled on a single shift basis and with no work scheduled on the Sabbath in compliance with the Lord's Day Act which is enforced in the Bagotville area.

PUMPING OF CONCENTRATES

The limited investigation of the feasibility and cost of pumping the concentrates approximately 250 miles from the concentrating plant located at Lake Albnel to a combined pelletizing, stockpiling and ship-loading operation at Ha Ha Bay indicates that the pipeline is competitive with the rates quoted by the Canadian National Railroad for hauling the pelletized product, provided that the plant is operated at 3,000,000 tons per year, and provided that a pipeline test program will prove the technical feasibility of the pipeline.

ESTIMATE

Order of magnitude estimates of the capital costs of the installation in Canadian dollars as described in the text of this report are summarized as follows:

	<u>Railroad Transport</u>	<u>Pipeline Transport</u>
Beneficiation Plant ?	\$ 73,000,000	\$ 71,100,000
Winter Stockpile & Shiploading	6,000,000	5,600,000
Townsite	22,000,000	18,400,000
Transporting Concentrates	<u>By CNRR</u>	<u>43,500,000</u>
Sub-Total	\$101,000,000	\$138,600,000
Recommended Escalation	<u>6,000,000</u>	<u>8,000,000</u>
Total Capital Cost	\$107,000,000	\$146,600,000
Estimated Recovery by Sale of of Houses to Employees	<u>(7,000,000)</u>	<u>(5,200,000)</u>
Capital Cost Less Recovery	\$100,000,000	\$141,800,000

In preparing the estimates, the labor, material and equipment costs have been based on present rates without allowances for future increases in costs. Based on past experience, it is estimated that cost increases will amount to about 3% per year, and if a contract was awarded now, for completion in four years, escalation would amount to about \$6,000,000 for the railroad transport scheme and \$8,000,000 for the pipeline transport scheme.

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PART I

SCOPE AND CRITERIA

1.0 SCOPE OF STUDY

The Lake Albanel Project consists principally of a mine, ore concentrating plant, pelletizing plant, means of transporting the product, stockpiling and vessel loading facilities, and a townsite with housing for employees. Included in the body of this report are descriptions of the project, drawings, flowcharts, and lists of major equipment. All of these have been carried out in sufficient detail to clearly define the project and for the preparation of order of magnitude cost estimates of the installations.

Specifically, the following components are included:

- (a) Concentration Plant: including coarse crushing, screen house, emergency stockpile for crude ore, crushed ore storage concentration plant, filter plant and concentrate storage, water supply and tailings disposal.
- (b) Pelletizing Plant: including balling, indurating, cooling, car-loading, and additive handling system.
- (c) Administrative and Maintenance: including plant administrative office, change facilities, warehouse, truck repair and storage, and maintenance shops.
- (d) Stockpiling and Vessel Loading: including car unloading, pellet stockpiling, reclaiming pellets from stockpile, vessel loading, and administrative office and maintenance facility.
- (e) Townsite: a study to determine the unit cost for providing housing for employees.
- (f) Operating Estimate: a study of all direct mining, concentrating, pelletizing and materials handlings costs of the pelletized product loaded into vessels.

PART I

2.0 METALLURGICAL TESTS:

2.1 Davis Tube Tests on Individual Core Composites:

The metallurgical tests made on the Sandspit iron ores consist mainly of Davis tube tests carried out on drill core sample composites (usually 50 feet long).

These tests were systematically conducted on most of the drill cores recovered and indicate a reasonable consistency of the Albanel ores in their amenability to magnetic beneficiation, in that part of the ore bodies that has sufficiently high magnetic iron content. In addition, there are appreciable quantities of non-magnetic and low-magnetic ores for which appropriate non-magnetic beneficiation processes may be developed in due time. They are not included in the calculated probable reserves of Albanel magnetic ores. (These only include ores yielding a Davis tube weight recovery of 27% or more).

The Davis tube tests were conducted on composite drill core samples crushed to 10 mesh and then ground for 20-24 minutes. The fines obtained in the ground ore ranged, according to individual samples from 70-90% minus 325. The concentrate recovered in the Davis tube was usually high in grade and the iron recovery satisfactory.

Results of the Davis tube tests conducted on cores recovered from holes drilled in 1959 in the Sandspit deposit were summarized in Memorandum 854 of April 14, 1960 of the Cleveland-Cliffs Research Laboratory. Averages calculated from the figures given in this memorandum for the magnetic iron horizons are as follows:

	Average Total of about 50 - 50 Ft. Composites
Heads: % Fe (Total)	29.8
% - 325 mesh after 20 min. grind	77
Davis tube concentrate:	
weight recovery	% 32.1
iron content	%Fe 66.9
iron recovery	% 72.0

The individual Davis tube tests indicate a wide variation in the beneficiation characteristics of the Sandspit ores. However, these

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may represent, to some extent, very localized conditions. Possible overall variations in the ore actually mined should be determined by establishing a tentative mining plan and evaluating, on the basis of the corresponding drill cores, the expected average variation of the large blocks of ore constituting successive mining benches.

2.2 Davis Tube Tests on Grand Composites of Several Drill Cores

Grand composites of drill cores were built up for batch Davis tube testing from holes drilled in the Sandspit and "B" Group ores prior to 1959. The results of the tests made on these samples were analyzed in Metallurgical Report No. 237, September 24, 1958.

Following is a summary of these results:

		<u>Sandspit</u>
Grinding time:	Minutes	.24
Davis tube feed:	% Fe	29.6
	% minus 325	88.0
Davis tube concentrate:		
	% weight	32.8
	% Fe	67.1
	% SiO ₂	6.4
	% Fe recovery	74.4
Davis tube tails:		
	% Fe	11.3

Tests on composites from a high grade and a low grade area indicate the following possible variations in concentrate weight and iron recoveries:

		<u>Sandspit</u>
Magnetic concentrate:		
weight recovery	%	27-36
iron recovery	%	67-74

Cobbing the crude ore at 10 mesh resulted in rejecting tails at that size which amounted respectively to 26.5% of the crude feed. This resulted also in a coarser finished size for the concentrate and a saving in grinding power.

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The power requirements were calculated on the basis of Bond's work index method for cobbing at 10 mesh with a final grind of 80% minus 325 mesh. The calculated values of the work index were equal to 9.1 and the figures obtained for the grinding power was respectively 16.1 HP per long ton of crude ore feed.

No grand composite tests were conducted on the 1959 Sandspit drill cores. The individual Davis tube tests indicate, however, that it can be reasonably expected that their beneficiation characteristics in general will not vary too much from the average results recorded on the earlier Sandspit drill cores.

2.3 Pilot Plant Tests:

Three bulk samples of approximately 50 tons each were collected from the Sandspit orebody and were expected to represent average ore (Lot AB) high ore (Lot CD) and poor ore (Lot EF). They were shipped to the Institute of Mineral Research (Michigan College of Mining and Technology). Test work started on them early in January 1960.

The test results are described and analyzed in a Report by the Institute of Mineral Research (May 31, 1960) and they are further reviewed in Albabel Minerals Report of Operations of June 1, 1960.

A preliminary series of batch Davis tube tests was made to establish the general beneficiation characteristics of these samples and it yielded the following results.

Lot		AB	CD	EF
Grinding time:	Minutes	15	30	30
Davis tube feed:	% Fe	36.4	42.2	28.4
	%-325M	82.6	93.2	98.8
Davis tube concentrate:				
	% weight	26.6	45.4	8.4
	% Fe	68.9	67.0	67.4
	% SiO ₂	3.5	6.4	4.4
	% iron rec	50.7	73.3	20.4
Davis tube tailing:				
	% Fe	24.3	20.4	24.4

An examination of the chemical analysis made on samples of these lots resulted in the following values for their total and magnetic iron content:

	Total Fe %	Magnetic Fe %	Ratio %
Lot AB	37.2	18.3	49.2
Lot CD	42.3	30.2	71.3
Lot EF	29.2	5.6	19.2

The batch Davis tube tests indicate that all three samples would yield, after proper grinding, a satisfactory high grade concentrate, corresponding to a high magnetic recovery. However, the overall iron recoveries for Lots AB and EF are abnormally low, because of the correspondingly low ratio of magnetic to total iron in the crude feed. This indicates definitely that neither of these samples can be held to be representative of the Sandspit magnetic iron ores.

From a practical beneficiation point of view, Lot EF is a low magnetic ore not amenable to direct magnetic concentration methods. It is typical of some of the iron formations which may be encountered on Albabel Iron Range.

Far from being representative of the Sandspit average magnetic formations, Lot AB could at best be considered a borderline low weight recovery ore, while Lot CD would only represent a localized high grade and high weight recovery ore. In this respect, therefore, the Houghton pilot test results can only represent extreme ore types and cannot be considered to be typical of the average Sandspit ore.

Work index values were established for both samples, and the values obtained were respectively equal to 9.5 (Lot AB) and 10.3 (Lot CD) they are very close to the work index figures established for the grand core composites and referred to in the preceding pages. (9.1 for Sandspit).

The results on Lot AB were, in general, satisfactory insofar that it was possible to obtain a high grade concentrate with two stages of grinding. The results of two typical runs are as follows:

Date of Test		March 30	April '27
Number of stages of grinding:		2	2
Circuit of 2nd grinding stage:		open	closed
Crude feed:	%Fe	37.5	36.2
Concentrate:	%weight	26.6	26.5
	%Fe	68.2	68.9
	%-325	88	95
	%Iron		
	Recov.	43.4	50.4
Tails	%Fe	23.1	23.8
Net grinding power per ton of crude	hp/lt	22.8	22.6

The preceding figures do not indicate any advantage for open circuit operation of the second grinding stage. The relatively high grinding powers per ton of crude can be partly attributed to the very fine grinding resulting in a relatively high concentrate grade. By reducing the grind fineness to correspond to a grade of 67% Fe, savings can be expected in the grinding power required.

Lot CD proved more difficult to beneficiate because it proved much harder to grind than AB. It seems that in none of the numerous tests made was a sufficiently fine grind obtained and, consequently, the test results are not as conclusive as though the grind had been pushed far enough to yield concentrates of satisfactory grade.

The results of the two test runs with the highest concentrate grade are summarized hereafter:

Date of Test		Feb. 17-18	April 18
Number of stages of grinding		3	3
Circuit of 2nd grinding stage		open	closed
Circuit of 3rd grinding stage		open	open
Crude feed	% Fe	41.2	41.5
Concentrate	% weight	44.2	45.1
	% Fe	67.3	66.3
	%-325	85.3	93.5
	% Iron Recov.	72.3	72.1
Tails	% Fe	20.5	21.1
Net grinding power per ton of crude	hp/lt	33.8	30.2

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Again, the above figures do not indicate an overall advantage of open against semi-open circuit, 3-stage grinding. As pointed out before, the 2-stage grinding tests on Lot CD cannot be considered as conclusive because of the insufficient fineness to which the final product was ground.

The grinding power figures are much higher than would have been expected from the work index established for samples of that lot.

For reasons discussed, the tests on Lots AB and CD can only be used as an indication of the beneficiation characteristics of extreme types of ore. It is still necessary, for the Albanel project, to determine on a pilot plant scale the behavior of the average Sandspit magnetic ore, and additional bulk samples have been collected for that purpose and will be tested in the near future.

2.4 Adopted Flowsheet Criteria:

Although no pilot test results on an average ore sample are yet available, the extensive drill core Davis tube tests constitute a reasonably reliable basis for the determination of the most probable beneficiation characteristics to be expected for these ores.

It is reasonable to assume that the following facts have so far been established:

- a. That the Albanel ores are amenable to magnetic beneficiation.
- b. That with the proper flowsheet they would consistently yield concentrates assaying 66% Fe or higher.
- c. That the weight and iron recoveries would on the average be of the order of 30% and 70% respectively.

H

There is no fully reliable test basis for the establishment of the required grinding power, and it was decided to use reasonable assumptions for this study with the understanding that they would be confirmed by proper pilot testing in the near future.

At the early stages of preparation of this report, it became apparent that very promising results were obtained by applying auto-genous Cascade-pebble mill flowsheets to the magnetic beneficiation of the Empire ore of the Cleveland-Cliffs Iron Company. The same flowsheet applied to several other magnetic ores gave very satisfactory

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results. Comparative studies made by Bechtel at that time, of various milling methods in connection with a projected magnetic beneficiation plant, indicated substantial savings in investment and operating costs in favor of the autogenous grinding flowsheet.

Taking all of these factors into consideration, Albanel Minerals decided that the present study and estimate be based on the assumption that the Sandspit ores would be amenable to autogenous grinding. It was agreed to assume that a two-stage grinding flowsheet would be adequate. Based on the available work index determination, Albanel Minerals indicated that the assumed grinding powers would be:

Cascade mill (1st stage)	14 net hp/lt
Pebble mill (2nd stage)	6 net hp/lt
Total	20 net hp/lt

In order to use standard electric motor sizes it was agreed that the following grinding powers would be installed per mill line:

Mill line feed	95 ltp
Cascade mill power	1500 hp (15.8 hp/lt)
Pebble mill power	700 hp (7.4 hp/lt)
Total	2200 hp (23.2 hp/lt)

It was also decided that for establishing the plant crude ore requirements a weight recovery of 30% (dry) be assumed for the concentrates obtained.

2.5 Recommended Future Tests:

H In order to justify the assumptions about the Albanel ores metallurgy, that have been used as a basis for this study and estimate, it is essential to confirm them by means of comprehensive pilot plant tests using the flowsheet adopted in this report.

Although there is little doubt that these tests will confirm that the Albanel ores are readily amenable to magnetic beneficiation, they are necessary in order to establish beyond doubt that these ores can be ground autogenously in two stages, and to determine the grinding power needed and its distribution between the Cascade and the pebble mill grinding stages.

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3.0 SANDSPIT ORE BODY

The Sandspit ore body is a shallow dipping outcrop of the Scarp structure located along the south shore of Lake Albanel. It consists of two magnetic iron ore bodies separated by a non-magnetic iron deposit. Approximately 80% of the total magnetic iron ore reserves lie in the north body.

The iron minerals in the ore are present as magnetite, hematite, siderite, and iron silicates. The main gangue minerals are chert, carbonates, silicates and quartz. The major portion of the economic iron mineral is in the form of a magnetic cherty siderite. Fine grinding to 90% passing 325 mesh is required to obtain the necessary liberation required to produce the desired grade of concentrates.

Albanel Minerals Limited's report of July 1, 1960 shows a total of 254,737,500 long dry tons crude ore reserves having an average weight recovery of 30%. Only ore having a weight recovery in excess of 27% and capable of being concentrated to an acceptable grade is included in these total reserves.

The mass center of gravity for the two magnetic iron ore bodies indicate an average truck haul to the primary crusher at the Lake Albanel site of 6,200 feet on a downgrade of 1.3% for the large northern ore body and 8,600 feet on a downgrade of 0.25% for the southern deposit. The haulage distance and grade to the primary crusher, if located at the alternate Kallio Lake site, would be 2,300 feet at 2.5% upgrade for the larger body and 12,500 feet at 1% upgrade for the smaller.

It is contemplated that the mining operations will be carried out in the same manner as on the Michigan and Minnesota iron ranges. Jet piercing drills will be used for iron ore and rotary drills for rock stripping. Six yard electric shovels equipped with five yard buckets will load into 40-ton diesel trucks. Other standard open pit equipment will be required for road maintenance and general open pit operations.

4.0 BENEFICIATION PLANT SITE SELECTION

The beneficiation of the magnetic iron ore mined from the Sandspit ore deposit consists of grinding the ore for concentrating the values by magnetic separation, and the recombining of the finely ground magnetic concentrates as a pelletized product. It is generally desirable to locate both of these operations together and close to the mine to avoid duplication of the common services such as administration, warehouse and shops. However, specific criteria, peculiar to each operation, influences the final site selection.

Criteria established for the site selection of the concentration plant are as follows:

- a) Proximity of the plant to mine.
- b) Possible future expansion of the mining operations.
- c) Tailings disposal.
- d) Water supply.
- e) Access to the plant.
- f) General area topography.

Criteria for the site selection of the pelletizing plant are as follows:

- a) Economics of rail haulage of concentrates.
- b) Economics and technical feasibility of pumping concentrates.
- c) Economics of rail haulage of the pelletized product, process fuel oil, and pelletizing additives.

4.1 Concentration Plant Site:

Two alternate sites for the concentration plant were developed. The preferred site, located west and north of the center of gravity of the Sandspit ore body and on the shore of Lake Albanel, is shown on Area Map, drawing C1-2. The alternate site is east of the ore body and is shown on Area Map (Kallio Lake Site) drawing C1-5.

Preferred Site: (Area Map, Drawing C1-2)

The disposal of tailings was the major influence in selecting this site. The unthickened tailings flow by gravity to Lake Albanel to be deposited under water along its shoreline. Slimes washed out of the tailings are trapped in a trough 150 to 200 feet deep, a short distance off the shore. There is adequate capacity for all of the tailings produced from the ores mined from the Sandspit ore deposit and from other

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ores hauled to the Sandspit concentrator for treatment.

Permission to deposit tailings in Lake Albanel must be obtained from the Department of Hydraulic Resources. It is natural that objections will be raised by the Department of Fish and Game, however, we believe that permission may be obtained to deposit tailings in Lake Albanel by Albanel Minerals, Limited, because of the economics involved, and in view of the precedent established by the successful disposal of taconite tailings in Lake Superior.

The preferred, Lake Albanel, site eliminates the need of costly hydroseparators, tailings thickeners, and the initial dams to construct a tailings basin. At present day prices these are estimated at approximately \$2,000,000 installed. Likewise, it is estimated that, at present day prices, \$0.08 per ton of concentrates may be saved in the operating costs by the elimination of flocculants, thickening, pumping and the forming of dams for impounding the tailings.

It is anticipated that the metallurgy of the concentrator may be slightly better at this location because of the abundant supply of clear lake water.

Alternate Kallio Lake Site (Area Map Drawing C1-5)

Throughout the life of mine, tailings produced from the mill at the Kallio Lake site would be impounded in a basin covering Einar Lake and a portion of Kallio Lake. Initially, large earth dams are needed to block off both ends of the natural trough in which these bodies of water are located. Later, more extensive berms constructed by tailings will be required. These will extend around a major portion of the basin's periphery to create a 90,000 acre foot volume needed to impound tailings produced from the presently known Sandspit ore reserves alone. The berms must be substantial as some are located on the very edge of the pit.

In addition to the high capital investment and operating costs for thickening and pumping tailings, a nuisance problem is added, because of "dusting" during high winds. This site is not favored.

4.2 Pelletizing Plant Site:

The pelletizing operations would be located at the Ha Ha Bay docksite if long distance pumping of concentrates proves feasible. This subject is covered in Part IV, Pumping of Concentrates, of this report.

It was considered essential that a study be made of the economics of hauling moist concentrates to the pelletizing operation at the docksite versus the hauling of dry pellets. This study takes into consideration rail transportation costs of concentrates or pellets, sources, loss of product in transit, operational requirements and equipment required for rail shipments of either pellets or concentrates, capital cost of equipment, manpower requirements and townsite facilities.

The results of this analysis show a lower operating cost but higher capital cost for pelletizing at Lake Albanel. The higher capital cost results from the increased size of the townsite needed for housing approximately 200 additional employees. However, the difference in total annual cost between the two locations considered was less than the accuracy of the estimate. Therefore the choice of location was considered as a standoff and the Lake Albanel site was selected as the logical for the following reasons:

- a) All process operations and maintenance are under a single coordinated administration.
- b) Pelletizing at Albanel affords better moisture control of the concentrates prior to the balling operations. Pelletizing at the docksite requires thawing and possibly some drying and moisture conditioning.
- c) Rail haulage costs per unit of iron is less for pellets than for concentrates due to the moisture content of the latter.
- d) There are comparatively fewer problems associated with pellets freezing in cars than with moist concentrates.
- e) Losses in handling and shipping pellets are less than with concentrates.
- f) The unloading of pellets requires less equipment and operators than for concentrates. A thawing shed, rotary dumper, covered storage pile with reclaiming system, and filters are required for handling concentrates at the docksite.

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5.0 BENEFICIATION PLANT CRITERIA

The beneficiation plant is designed to produce a grade of concentrates on a commercial scale closely approximating that which is obtainable from bench and pilot plant testing.

Surge capacities are provided at critical points to insure continuous production and normal delays for routine maintenance do not effect following steps of the process. First quality equipment is used and capacities or ratings are conservative.

5.1 Plant Capacity and Operating Schedule:

While the Lord's Day Act (Chapter 171 of the Canada Revised Statutes 1952) generally prohibits work on the Sabbath, the Act does not apply to industrial workers whose regular day's labor is not more than eight hours duration nor one who is allowed 24 consecutive hours off during the next six days period.

It is believed that in this remote area the church will permit the operations to continue on a 7-day week around the clock basis.

The following operating schedules and availability are assumed for sizing the equipment. The availabilities assumed are typical of similar plants.

Plant Capacity and Operating Schedule

Lake Albanel Beneficiation Plant is designed to treat 10,000,000 long tons of crude ore per year to produce 3,000,000 dry long tons of pelletized product.

Beneficiation Plant Operating Schedule

Holidays per year:	7
Operating weeks per year:	51
Scheduled maintenance shifts per week:	1
Scheduled operating shifts per week:	20
Scheduled operating shifts per year:	1020

Crushing Plant - (15 Scheduled shifts per week)

Effective operating shifts per year (at 75% efficiency):	765
Effective operating hours per year (8 hours per shift):	
Hourly production of crushed ore, LTPH:	6120

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Concentrator - (20 scheduled shifts per week)

Effective operating shifts per year (at 95% efficiency):	969
Effective operating hours per year (8 hours per shift):	7752
Hourly plant crude feed, LTPH:	1290
Hourly crude feed per line, for 14 mill-line plant, LTPH:	92.1

Pelletizing Plant - (20 scheduled shifts per week)

Effective operating shifts per year (at 90% efficiency):	918
Effective operating hours per year (8 hours per shift):	7344
Hourly production of pellets LTPH:	410

5.2 Primary Crushing Plant including Ore Storage:

The primary crushing plant receives run-of-mine ore and crushes it to a nominal 8" product for feed to the Cascade type, wet autogenous mills. The crusher and the mine operate on the same schedule.

Primary Crusher Design Criteria

There must be close coordination in the design of the crushing plant and the selection of the mining equipment, both as to size and capacity to obtain the optimum balance for low operating costs.

After weighing the factors known at this time, a 54-inch gyratory crusher is selected for this application. The selection is based on the following:

- a. A 54-inch crusher has adequate capacity to crush the 10,000,000 tons of crude ore annually. This can be done when operating 15 shifts per week.
- b. While it is anticipated that excellent fragmentation will be obtained when blasting, occasional large chunks will be delivered to the coarse crusher. The large gape of the 54-inch crusher will handle most of these chunks with a minimum of delay caused by bridging of the cavity.
- c. A large crusher is required to obtain the large rock required in the feed to the Cascade mills, otherwise

costly feeding and screening equipment is needed to screen a portion of coarse feed from the run-of-mine ore.

Ore Storage

To avoid shortages of feed in the remainder of the beneficiation plant during the periodic relinings of the primary crusher and mine stoppages, a 125,000 ton total capacity outside storage pile is provided for the storage of primary crusher product.

In addition to the outside storage, a 24-hour storage of segregated coarse and fine ore is provided in two separate piles under the same cover ahead of each mill line. This latter storage insures continued operation of the Concentrator during minor delays in the primary crusher and pit operation.

Segregation of Ore

When filling an ore pile there is a natural segregation of coarse material to the outer edges. Without adequate preventative measures there can be periods when withdrawing ore from storage no coarse ore is delivered with the mill feed. Consequently, with the absence of coarse ore delivered to the wet autogenous mills, the grinding rate falls off as there are no heavy pieces to do the breaking.

A vibrating grizzly is provided to separate the primary crusher discharge product into approximately equal amount of coarse and fine ore. These products are stored separately in the covered ore storage shed ahead of each mill line.

5.3 Concentrator:

The design of the concentrator is based on two stages of wet autogenous grinding with magnetic separation following each stage. The rougher concentrates are deslimed in a hydroseparator ahead of the final stage of magnetic separation.

Cascade Type Wet Autogenous Mills

Although the Sanspit ore has not been tested using all-autogenous milling equipment, it was agreed that primary grinding would be done in large diameter Cascade-type, wet autogenous mills operating

in closed circuit with 10 mesh opening vibrating screens. Reasonable assumptions of mill capacities and power drafts were made based on previous pilot testing of similar ores.

Pebble Mills

A single pebble mill follows each Cascade type mill. The pebble mill operates in closed circuit with wet sizing cyclones operated to produce a 90% -325 overflow product. The discharge of the pebble mill is cobbled in magnetic cleaners to reject liberated gangue.

Pebbles used as grinding media in the pebble mills are produced from the ore in the preceding Cascade type mills.

Grinding Mill Speeds

Both the Cascade type mills and pebble mills are sized to operate at comparatively slow speeds for efficient operation. The mill speeds may be increased in the future by increasing the drive pinion diameter. The speeds selected are as follows:

Autogenous mill speed 75% of critical speed
Pebble mill speed 75% of critical speed

Magnetic Separators

The design and performance of the magnetic separators are in accordance with current ratings in existing taconite plants.

- a. Cobbers: Double-drum separators of the concurrent flow-type equipped with electro-magnets.
- b. Cleaners: Single-drum separators of the counterflow-type equipped with permanent-magnets.
- c. Finishers: Triple-drum separators of the counterflow-type equipped with permanent-magnets.
- d. Loading: The magnetic separators have been sized on the following basis:

Cobbers: 10.0 LTPH per foot of magnet length
Cleaners: 11.0 LTPH per foot of magnet length
Finishers: 1.0 LTPH per foot of magnet length

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These loadings are conservative and provide a safe margin in case of variation of the iron contents or beneficiation characteristics of the plant crude ore feed.

Hydro Separators and Thickeners

The desliming hydroseparators and concentrate thickeners are sized based on the following criteria:

Desliming Hydroseparator:	18 sq. ft. /LTPH maximum
Concentrate Thickener:	13 sq. ft. /LTPH maximum

Filters

The thickened concentrate is filtered in disc filters with agitated pools. A nominal loading of 220 lbs/hr/sq. ft. of filtration area is assumed. Vacuum is produced with two-stage vacuum pumps operating at 20" - 22" Hg vacuum.

5.4 Pelletizing Plant:

Although pilot plant pelletizing test results are not available for the Albabel concentrates, it was agreed that reasonable assumptions could be made on the basis of previous tests on similar ore. These assumptions are subject to verification by future test work.

Balling

Balling drums operating in closed circuit with seed screens were chosen on the basis of proven performance in many installations. While various other types of balling machines have some advantages of lower cost and conservation of building space, the positive control of ball quality due to the product screening was one of the important factors in the choice of the balling drum. The balling drum has a higher capacity per machine. A sufficient number of balling drums are provided to insure reasonable flexibility in operation.

- a) Balling Drums: 9' ϕ x 30' drums with traveling cutter-bar mechanism and variable speed d-c drives rated at 42 LTPH, (new feed).
- b) Mixer: Reel-type mixers operating on flat belts with enclosed skirting.
- d) Seed Screens: 5' x 14' curved seed screen with 3/8" openings, rated at 105 LTPH.

All ratings are conservative and provide ample margin for variation in concentrate balling characteristics.

Traveling Grate

A traveling grate is included in the treatment scheme to take advantage of the possibilities it offers in the efficient utilization of heat and the principle of drying and partial hardening of the balls in a fixed bed.

- a) **Traveling Grate Proper:** Two 12'-3" x 126'-5" Allis-Chalmers traveling grates with gas fans and dust collect-cyclones. Rated at 205 LTPH or 3.2 LTPD/ft².
- b) **Distributing Screen:** Two 12'-3" x 9'-7" Allis-Chalmers curved, rod-decked distributing screens.
- c) **Grate Fines Re grind:** A single 3' x 3' ball mill operating in closed circuit with a 24" x 13' spiral classifier. A bucket elevator and surge bin provides continuous and controlled operation. The regrind circuit is rated at 20 LTPH.

Rotary Kiln

A rotary kiln provides the final hardening of the pellets. The rolling action of the kiln exposes each pellet to the firing gas and insures the uniform quality of the finished product.

- a) **Rotary Kiln:** Two 17' diameter by 140' Allis-Chalmers rotary kilns with 9" refractory lining and auxiliary drive are selected complete. The kilns have a rating of 205 LTPH or 0.155 LTPD/ft³ each.
- b) **Kiln Burner:** Refractory lined firing hood with oil burner rated at 1060 Imp. gallons per hour of fuel oil.

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Annular Cooler

Annular coolers are provided to both cool the pellets and to recover the useful heat which they contain. The hot air from the cooler is introduced to the kiln as a secondary heat source. Each cooler is 40 feet in diameter by 7 feet wide and is rated for cooling 205 TPH from 2450°F to approximately 700°F.

Rotary Cooler

Rotary coolers are provided for final cooling of the pellets to a temperature suitable for conventional belt conveying. The rotary cooler has provision for the use of cooling spray water, if needed, and is equipped with exhaust fan and scrubber. Each rotary cooler is 8 feet in diameter by 22 feet and is rated at 205 LTPH.

Pellet Loading and Emergency Stockpiling

Steel silos having a capacity equivalent to one day's production are provided at the car loading tracks. Loading of railroad cars may be done in a single shift. An emergency by-pass conveyor is provided in the event of full silos. Pellets will be reclaimed from the stockpile with power shovels, loading directly onto railroad cars.

5.5 Administrative and Maintenance Facilities

Administrative offices are provided together with change facilities for 710 bargaining unit employees and 90 foremen.

Maintenance shops, mobile equipment storage, and warehousing are combined in a single structure.

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6.0 STOCKPILING AND VESSEL LOADING FACILITY

Pellets produced during the non-shipping season for water transportation will be hauled to a stockpile located adjacent to the vessel loading facility. The stockpile is sized for 5-months production of pellets. The vessel loading facility is sized to load out the entire annual production of 3,000,000 long tons of pellets during the 7 months shipping season.

The vessel loading facility is capable of loading pellets into any of the present day lake or ocean-going ore carriers in the minimum time. It is also sized to load into the larger vessels of the future.

7.0 TOWNSITE

The number of employees for which Albanel Minerals Limited will be required to provide housing is dependant upon the location of the pelletizing operations. Cost estimates of Mining Company capital investments for the support and housing of personnel permanently employed on the project were made to determine the unit cost of housing each employee for both 800 and 1000 employees.

The townsite is capable of expansion and is considered as permanent.

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PART II - BENEFICIATION PLANT

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PART II BENEFICIATION PLANT

1.0 GENERAL

This part of the study contains the criteria, descriptions, cost estimates and drawings of the beneficiation plant located at the preferred site as shown on the Area Map, Drawing C1-2. The arrangement of the buildings, structures, and facilities is shown on the Plot Plan, Drawing No. C1-3, attached.

2.0 GENERAL DESIGN CRITERIA

2.1 General:

General design criteria for the proposed ore beneficiation plant and related facilities were established in conferences held in Ishpeming and San Francisco, attended by representatives of the Albabel Minerals Limited and the Bechtel Corporation. Plant size, location, and operational requirements were outlined at these conferences and by correspondence.

Where specific data related to the process and the plant design could not be obtained, assumptions were made based on the best practices followed in similar concentrating plants. Where these assumptions have a major effect on locations, operation, or cost of facilities, they are discussed in the appropriate section of this design study.

Due to the large tonnage of known ore reserves, all equipment and building installations are designed as permanent facilities, for the expected long life of the plant. First quality machinery and building materials are specified.

2.2 Site Location:

The Sandspit ore deposit and the proposed plant site of the Lake Albabel Project are located in the Mistassini District of Quebec at latitude 51° N longitude 73° W. The Sandspit ore deposit parallels the southeast shore of Lake Albabel and follows a ridge approximately one mile from the lake shore line.

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The site selected for the plant, shown on the Area Map, drawing C1-2, lies on the northwesterly slope of this ridge, off the iron formation, with the primary crusher located approximately opposite the center of gravity of the proven ore at an elevation to afford a downhill haul from the mine. The site has sufficient slope to provide gravity flow of tailings into Lake Albanel.

2.3 Beneficiation Plant Requirements

The beneficiation plant is sized to process 10,000,000 long dry tons of crude ore to produce 3,000,000 tons of pelletized product annually. A single 54" gyratory crusher operating 15 shifts per week will handle this tonnage when crushing with an 8" closed side settling.

The concentrator contains 14 identical milling lines with space for adding 2 additional milling lines if required to balance the tonnage output with that of the pelletizing plant.

The pelletizing section contains two Allis-Chalmers grate-kiln process pelletizing machines with accessory equipment.

Both the concentrator and the pelletizing plants are scheduled to operate 20 shifts per week with 1 shift down for scheduled maintenance.

2.4 Administration and Maintenance Facilities

Two separate structures are provided for the administration and maintenance of the plant and equipment.

The administrative offices and change rooms for all personnel are located in a single structure adjoining the Concentration Plant at the elevation of the operating floor. Change facilities for approximately 800 persons are provided. The Service Building also adjoining the concentrator contains machine, plate, welding and electric shops, truck repair and tire storage and repair, warehouse, and miscellaneous tractor and equipment storage. This building is located adjacent to the repair bay of the Concentration Plant at the ground floor level.

2.5 Mechanical

2.51 General

To insure adequate clearances in the mechanical layout of equipment when the plant is actually designed, space is

provided for the largest unit recommended by any of the recognized manufacturers, thus avoiding the possibility of having to eliminate a supplier because of the physical dimensions of the equipment proposed. Special attention is given to the reliability of the process equipment, accessibility and ease of maintenance. Whenever the failure of a section of the plant interferes with continuous production either surge capacity on standby equipment is provided.

In view of the many years of anticipated operation of this plant, conservative ratings and operating speeds are used in sizing the equipment. First quality, recognized equipment, is selected throughout the plant.

Criteria for specific items are as follows:

2.52 Conveyors

Rubber belt conveyors are used extensively throughout the proposed plant. Each belt is specifically designed to suit its location, conditions of operation, and nature of materials transported. Special attention is given to the cover thickness of the belts operating in the crushing plant, and the heat resisting qualities of belts transporting the pelletized product. Slopes of conveyors are limited to a maximum of 16° inclination. All conveyors handling crude ore and concentrates are equipped with 20° troughing idlers. Belt conveyors used for transporting fired pellets are equipped with 45° troughing idlers.

2.53 Belt Scales

Belt scales are provided at the specific locations as indicated on the flow-schemes to weigh, integrate, record and to control the flow rates of the various material in process.

2.54 Pumps

Pulp pumps: Because of the highly abrasive nature of the ore, rubber-lined pumps are selected for the pumping of pulps and slurries. All pipes and fittings handling slurries are as short and straight as possible and are readily replaceable. Standby pulp pumps are provided only at locations where the failure of one pump could shut down a major portion of the plant. All pulp pumps are equipped with V-belt drives and stationary control vari-pitch sheaves or sheaves with "taper-lock" hubs to facilitate speed changes.

Water pumps: Fresh water and process water pumps are of standard design and fitting, and are either vertical turbine or horizontal centrifugal as required.

2.55 Piping, Fittings and Valves.

Domestic water: Galvanized, carbon steel, standard weight pipe with cast iron or brass valves is used.

Process water supply and return headers: Standard weight pipe, carbon steel, welded, and/or with grooved or Dresser-type couplings is used as the service requires. Valves three inches and larger are 125# flanged, cast iron; two inches and smaller are 150# brass screwed.

Process water piping within the mill and pump house: Standard weight, carbon steel pipe with 125# cast iron and 150# steel valves are used.

Pulp piping: Standard weight carbon steel pipe with 125# flanges, pinch valves or plug valves are used as required. Bends in pulp piping are heavy-duty rubber pipe.

2.56 Dust Control

Recognizing the importance of good control of the dust to safeguard the health of employees and to promote good house-keeping, careful thought is given to the selection of the dust collectors, ducts and building design. The following criteria covers specific locations:

Dry type dust control equipment is provided at the truck dumping pocket in the crushing plant. Special provisions are also made in the building design to isolate this pocket from the remainder of the building and to provide a filtered air pressurized room for the crusher operator from which he controls the operation.

Dry type collectors are also provided for the crushed ore storage and screen house to control dust. Dry type collectors are selected to avoid the freezing of spray water used in wet collectors if used in these unheated buildings.

Dust from the collectors is wetted and pumped as a slurry to the magnetic separators for the recovery of the iron values.

The more efficient wet-type collectors are provided in the concentrator as these buildings are heated. Slurry from these collectors also flows by gravity to the magnetic separators for the recovery of the iron values.

2.57 Plumbing

Toilet rooms and showers in the plant and service buildings are based on male occupancy only and are furnished with industrial-type fixtures. Water closets are wall hung and are equipped with flush valves. Lavatories are enamel cast iron and wash fountains are of terrazzo. The employees change rooms are provided with gang showers. Drinking fountains are provided adjacent to each toilet area. Washdown water is provided generally from the mill water system, but in areas where mill water is not available, hose connections are provided on the domestic water system.

2.58 Compressed Air

Compressed air is provided where required and individual compressors are located in each building rather than from a central type system.

2.59 Heating and Ventilating

All space heating equipment is designed for the use of low pressure (15 psi) steam distributed from a central system serving the entire plant. General areas are heated with individual unit heaters. Each unit heater has a supply pipe and steam condensate return pipe and is thermostatically controlled. Radiant heated floors shall supplement the unit heaters in the change rooms and shops. An ice melting radiant heating system is provided in the ground slab at the pellet loading station.

Plant heating has been based on the following design temperatures in the various facilities:

Coarse Crushing	45° F
Coarse Ore Transfer and Screen House	45° F
Concentration Plant	50° F
Pelletizing Plant (Lower Floor)	45° F
Pellet Load-Out	45° F
Pit Service Building:	
Warehouse	60° F
Shops	60° F

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Offices
Change Rooms

70° F
75° F

Ventilation systems are provided for the truck repair, welding shop, change rooms and inside the toilet rooms.

2.6 Electric Power:

2.61 General:

The following assumptions are made in the preparation of the electrical portion of this study:

- a. The Quebec Hydro-Electric will provide the main terminal line, erect and operate their own substation at the plant site, and deliver power to the switchgear at 13.8 kv. This voltage is selected because of the economic savings to be found in the distribution equipment at 13.8 kv as compared with the 25 kv suggested by the Commission in their correspondence.
- b. The plant electrical scheme consists of a simple radial system emanating from the main switchgear located adjacent to the Hydro Electric Commission's substation.
- c. Cable trays are used extensively throughout the plant wherever they are protected from physical damage.
- d. The townsite contains a population of approximately 4,750.

2.62 Voltage Levels:

A basic distribution voltage of 13.8 kv is established with secondary systems at 4160 volts and 480 volts for motor utilization voltage levels. All feeders are designed with the intent of maintaining each line or section of the plant as electrically independent as possible.

2.63 Equipment Enclosures:

All exposed electrical equipment located in operating areas is designed with NEMA V enclosures. Equipment located in

electrical rooms is designed with NEMA I enclosures. All motors, except mill type synchronous motors and remote pumping installations, are totally enclosed, self or forced ventilated.

2.64 Lighting Levels:

- Operating areas - 30-foot candles
- Conveyor ways - 10-foot candles
- Yard and Roadways - 2-foot candles
- Shops - 40-foot candles
- Offices - 50-foot candles

2.65 Codes and Standards:

All design, equipment and work conforms to the latest applicable portions of the Canadian Electric Code as well as the applicable sections of any local codes.

2.7 Architectural:

The several major plant structures, namely, the Service Building, General Office and Change House, and Pelletizing Plant are contiguous with the Concentrator permitting convenient access from one structure to another without exposure to the elements.

All buildings are of structural steel frames with foundations, substructures and ground floors of reinforced concrete.

The exterior building walls are insulated with corrugated, sandwich type siding of galvanized metal except for the primary crusher which is uninsulated, galvanized, corrugated metal sheets.

The building roof enclosures are metal deck with insulation and built-up roofing except in the crushed ore storage building where the roof enclosure is uninsulated, galvanized, corrugated metal sheets.

Exterior swing doors for personnel access are metal with frames of matching construction. Flush, wood panel, doors are used in offices. Vehicle access doors are of the overhead type, of metal construction, manually operated except those which are frequently raised and lowered which are equipped with motor operators.

Windows are not provided in the general plant areas. Steel sash are provided in toilet rooms, change house, laboratories and

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plant offices when they adjoin exterior walls. Windows in the administrative offices are of wood construction in order to control condensation. Two sections of all overhead doors are glazed.

Interior partitions consist of non load-bearing masonry units or metal panels as dictated by individual requirements.

Floors are finished with vinyl asbestos tile in the administrative offices and laboratories.

Field painting consists of a touch-up coat of "Rust-Oleum" for all structural steel and one finish coat of aluminum paint. Interior walls and ceilings of administrative offices and laboratories are covered with two coats of paint.

2.8 Civil

2.81 Clearing

The site is cleared of all brush and trees within 100 feet of any building and for 50 feet beyond the top of cut or top of fill for roads or graded yard areas. Most of the growth can be felled and stacked for burning by means of heavy mechanical equipment.

2.82 Earthwork and Site Grading

For the purpose of this study it is assumed that the site consists of hard dense rock covered with glacial till and decomposed organic matter to an average depth of five feet. In order to avoid excessive excavation, no balance in cut and fill for the plant area is attempted; the additional fill material required being available from mine strippings.

2.83 Roads and Parking Areas

All plant roads including the access road from the townsite have an aggregate surfacing on a well drained stabilized aggregate base course. The access road from the townsite has an overall width of 30 feet including shoulders. Plant roadways have an overall width of 40 feet except the service road between the Primary Crusher and the Shop Building which is 60 feet, and 20 feet for roadway to the screen house and water storage tank. Grades are limited to 6 percent maximum. The parking area serving the plant has a capacity for 190 private automobiles.

2.84 Yard Railroads

The railroad enters the plant from the west with the ladder tracks for empty cars east of the pellet loading bins. Empty car tracks are sloped 1.5 percent down to end for 200 feet following the loading pocket and followed by a 0.5 percent grade tapering out to zero grade in 500 feet. All turnouts are No. 8. Yard trackage serving other plant facilities have maximum grades of 2 percent and maximum curvature of 16 degrees. Rails are 100-lb relayer rail. Clearances and construction details are in accordance with the requirements and standards of the Canadian National Railroad.

2.85 Drainage

All areas are sloped to a collection system of ditches and culverts for conveyance of runoff to natural drainage channels. The design of drainage facilities is based on runoff from the most severe rainfall expected once in 10 years.

2.86 Sanitary System

The sanitary sewer system is designed and constructed in conformance with the Quebec Water Resources Commission requirements and the "National Building Code of Canada."

Sewage treatment consists of two parallel septic tanks with effluent disposal into Lake Albanel. Design conditions for the system are as follows:

- a. Tributary population 800 (three shifts)
- b. Average per capita daily flow 30 gal.
- c. Septic tank capacity (2 tanks) 20,000 gal.

Outside sewer lines are protected from freezing by burying to a minimum depth of 6 feet. Where sewer lines are laid in a common trench with domestic water lines, the invert of the sewer line is 12 inches below the invert of the domestic water line.

2.87 Water Systems

Service water for plant make-up, fire protection and domestic use is obtained from Lake Albanel.

The fire protection system consists of a looped pressure main serving outside hydrants and interior hose systems with two 1500 gpm fire pumps taking suction from a 300,000 gallon service water storage tank in which 150,000 gallons is reserved for fire use. The fire protection system conforms to the requirements of the Canadian Underwriters Association and the insurance carrier for the plant.

Raw domestic water is obtained from the plant service water system. The raw water is chlorinated and filtered before discharging to a 10,000 gallon compartment in the service water storage tank from which the distribution system is fed by gravity.

2.9 Structural

2.91 Codes

The design and construction of all buildings and structures is in compliance with the National Building Code of Canada.

2.92 Live Loads

- a. Wind: In accordance with the National Building Code for a maximum gust speed of 80 MPH.
- b. Snow: 70 lbs. per sq. ft.
- c. Seismic: Zone 0, National Building Code.

2.93 Foundations

- a. Pending detailed foundation investigation, the following bearing values are assumed as the basis for this design study and estimate:

Glacial Till overburden	2 tons per sq. ft.
Rock	10 tons per sq. ft.

All foundations in overburden extend 8 feet below the surface for frost protection.

2.94 Concrete

Concrete design and construction is in accordance with section 4.6 of the National Building Code and the American Concrete Institute.

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Quality of concrete is 2500 psi ultimate compressive strength for foundations and slabs on the ground. All other concrete is 3000 psi.

2.95 Steel

Structural steel design and construction is in conformance with section 4.7 of the National Building Code and the American Institute of Steel Construction.

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3.0 PLANT DESCRIPTION

The following paragraphs describe the 3,000,000 long tons annual capacity beneficiation plant. The descriptions cover the quality and type of machinery equipment and structures on the basis of which the cost estimate was prepared.

3.1 General

The plant is located on a moderately sloping hillside close to the southeast shore line of Lake Albanel. The various floor levels of the Crushed Ore Storage, Concentrating and Pelletizing structures follow the natural surface slope with a minimum of cuts and fills. The proximity of the plant to Lake Albanel permits the gravity discharge of tailings directly into the lake without thickening.

The Mill Building is considered as the core of the several major plant structures with the Filter and Pelletizing Plants, Change Rooms and Office Buildings physically attached to it. This arrangement permits the free movement of personnel and equipment from one structure to another without exposure to the weather.

The Primary Crusher is positioned to minimize the length of conveyor transporting coarse crushed ore to the Screen House which is considered more critical than the length of haul road from the mine.

3.2 Yard Improvements

3.22 Roads and Parking

The main access road from the townsite enters the plant area from the east terminating at the parking lot adjacent to the General Office building. Parking area requirements are estimated on the basis of a total of 800 employees with 350 on day shift and 225 on

each of the remaining two shifts. An average of 3 employees per car is assumed with the parking requirements of the oncoming shift overlapping those of the offgoing shift. The parking lot is furnished with electrical receptacles for "head bolt heaters" which are used to keep automobile engines warm during severe winter conditions. These receptacles are mounted on standards in such a manner as to serve 4 cars from each.

Service roads are arranged to provide access to each structure with a minimum of cuts and fills where necessary for proper grades.

3.23 Railroad

Plant railroads include all the trackage from the first switch point on the main line. Three ladder tracks above the pellet loading bins have a capacity for 150 cars with similar trackage provided below the loading bins for loaded cars. Coupled length of cars is assumed as 38 feet. Cars are moved through the loading point by gravity with air charging connections and trailing air hoses used to control the cars. A passing track parallels the pellet car ladder tracks to provide access to spur tracks to the Concentrator, Service Building, Additive and Oil unloading stations. An engine turn-around wye is also provided with turnouts on the passing track.

Grades and curves are in accordance with those listed in the General Design Criteria.

3.3 Crushing, Conveying and Storing

3.31 Coarse Crushing Plant

- a. The coarse crushing plant building houses all of the machinery and equipment needed to crush run-of-mine ore.

The building is a four-level structure approximately 40 feet wide, 96 feet long. Approximately 63 feet of the structure, constructed entirely of reinforced concrete, is below the dumping floor. The superstructure, 53 feet high located at the haulage road level, contains the ore dumping hopper and the control room.

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The crusher is installed at an elevation of 1,462 feet. The crusher repair bay, 40 feet wide by 48 feet long, can be reached by a service road.

The pressurized electrical room and the crusher forced feed lubrication system are located on the intermediate floor at an elevation of 1,456 feet. Access to the crusher eccentric is from the next floor below.

A 75-ton overhead bridge crane equipped with a 15-ton auxiliary hook serves both the crusher and the repair bay. By attaching rock hook this crane may be used for clearing the crusher. A 3-ton jib crane mounted on a building column will serve the crusher pocket during crusher repair.

The repair bay is isolated from the crushing section by a 20-foot wide horizontal accordion-type door and a movable section of wall attached to the crane. During crusher repairs the overhead curtain and accordion-type door remain closed thereby protecting the maintenance personnel and replacement parts from the elements.

The lowest floors contain the apron feeder and the crushed ore conveyor. Hatchways with removable covers in each floor provide a means for the bridge crane to deliver heavy equipment to each level. In addition to stairways in the building, a 5-ton capacity freight elevator provides access to each level for light loads and personnel.

A

b. Coarse Ore Crusher

The coarse ore crusher is a 54-inch bottom discharge heavy duty gyratory type with a mantle diameter of about 90 inches. The crusher has a rated capacity of 2,000 long tons per hour when crushing crude ore at an open side setting of 7 to 8 inches. It is driven by a 600 hp direct-connected motor. An

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independent forced feed lubrication system , continuously delivers filtered and cooled lubricant to the crusher mechanism at an operating pressure of 30 psi. An auxiliary oil head tank insures forced lubrication of the crusher at 15 psi in case of emergency. The crusher bearings are protected by an alarm system in the event of oil pump stoppage or excessive temperature of the oil.

c. Apron Feeder

A 60-inch heavy duty manganese apron feeder receives the discharge of the primary crusher , and controls the rate of feed onto the 48-inch wide belt conveyor. The feeder has a design capacity in excess of 2,200 long tons per hour and is driven by a 25 hp motor through suitable gear reducers.

d. Primary Coarse Crushed Ore Belt Conveyor

A 48-inch belt conveyor receives the ore from the apron feeder and conveys it to a splitter bin in the screen house. A continuous integrating ore assay computing system is installed on this conveyor. A belt scale is provided to automatically weigh and totalize the tonnage of the crude ore received from the mine.

e. Ore Assay and Computing System

The continuous, integrating ore assayer and computing system is provided to monitor and record automatically the magnetic iron content of the ore passing over the primary crushed ore belt conveyor. The average ore assay is automatically computed and recorded over a selected period of time. The ore tonnage is automatically totalized for this same period of time by the belt scale. These devices will assist the pit graders in developing a mining plan to maintain a uniform delivery of a proper blend of ore to the plant.

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3. 32 Screen House

The screen house is a 30 ft. wide by 52 ft. long steel structure with corrugated sheet metal siding. It houses a splitter bin, vibrating grizzly, and auxiliary equipment required for sizing and conveying "fine" and "coarse" ores to their respective storage piles.

a. Coarse Crushed Ore Splitter Bin

A steel bin 20 feet by 20 feet by 17 feet lined with cast manganese liner, located in the screen house receives the crushed ore from the primary crushed ore belt conveyor. Two apron feeders below this bin transfer the ore as required, either to the 125,000-ton capacity open storage pile or to the vibrating grizzly.

b. Vibrating Grizzly and Apron Feeders

To insure a continuous and adequate supply of coarse ore, which acts as an autogenous reducing media, in the Cascade mill, a vibrating grizzly separates the crusher products into approximately equal amount of "coarse" and "fines".

The vibrating grizzly is 8 feet wide by 14 feet long. It is fed by a 72-inch apron feeder which withdraws the ore from splitter bin.

c. Crushed Ore Storage Shed Belt Conveyors

Two 48-inch belt conveyors equipped with tripper cars traveling side by side deposit the coarse and fine fractions of the primary crushed ore in their respective piles in the covered crushed ore storage shed.

3. 33 125,000 Ton Storage Pile

a. Transfer Belt Conveyor

Surplus crushed coarse ore is conveyed from the splitter bin by a 48-inch belt conveyor to the 125,000 ton open storage pile located to

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the north of the primary crushing plant. The live capacity of the pile is approximately 30% of the total. Dozers are used for reclaiming dead storage.

b. Reclaim Apron Feeders and Conveyor

In the event of crusher breakdown or stoppage of the pit operation, three 48-inch heavy duty manganese apron feeders located in a tunnel below the 125,000 open storage pile reclaim the ore and deposit it on the primary crusher belt conveyor which passes through the tunnel under the pile.

3. 34 Crushed Ore Storage Shed

The fine and coarse ore is stored under a common shed roof in two piles adjacent to each other. Fine and coarse ore piles, each with an approximately live storage capacity of 14 hours of mill feed, receive the undersize and the oversize products of the vibrating grizzly. Two 48-inch tripper cars traveling together distribute the coarse and fines to their respective piles. By placing the coarse and fine ore storage piles together, the interface between the coarse and fine materials, adjusts itself automatically. This will permit a maximum storage regardless of the irregularities of the amounts of fines delivered from the pit.

The tripper car gallery in the peak of the shed roof is isolated from the ore piles by enclosures and flexible rubber curtains. The crushed ore storage shed is under slightly negative air pressure produced by dust collectors which causes the air to flow from the tripper gallery into the storage shed, thus maintaining a clean and dust-free tripper gallery.

3. 4 Concentrator

The concentrator building houses the machinery and equipment necessary for grinding and the magnetic concentration of the iron ore. The building is a rectangular, stepped-down type steel structure 264 feet wide by 700 feet long, including a 100-foot combined repair and storage bay extending the full width of the concentrator. Dust control equipment and the pressurized electrical rooms are located in the area between the ore storage and the grinding bay.

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The autogenous grinding mills are placed in line and in one bay served by a single 30-ton capacity overhead crane which also serves a corresponding portion of the repair bay. The pebble mills are also located in a single bay. These mills are served by a 25-ton capacity overhead crane.

All magnetic separation equipment is arranged on a single floor served by a 5-ton capacity overhead crane. The hydroseparators are located directly below the magnetic separator floor.

All of the concentration equipment is placed on a single operating floor for maximum efficiency in operation and accessibility for maintenance. Hydroseparators and pumps are located on the basement floor which is adequately sloped towards two concrete drainage trenches. These trenches also collect the mill tailings and discharge them into a concrete sump, located approximately at the center of the mill near the north wall. The tailings are then discharged into an excavated flume which carries them by gravity to the Lake Albanel.

3.41 Mill Feed System

Below the coarse and fine storage piles are 14 reinforced concrete conveyor tunnels, one for each mill line. Each tunnel contains five 48-inch apron feeders feeding a 42-inch mill feed conveyor. These 48-inch apron feeders are equally spaced and are all controlled remotely by a feed weighing and totalizing belt scales to deliver a constant tonnage to the mill. Selector switches controlling the feeder operation are provided to permit the mill operators to change the blend of coarse and fine ore fed to the primary wet autogenous mills.

Each 42-inch mill feed belt conveyor is designed to convey 95 LTPH of new feed plus the recirculating load estimated at 150%. It is extra wide to convey with minimum spillage the 8" nominally sized ore.

3.42 Wet Autogenous Grinding Circuit

- a. One wet autogenous grinding mill is provided for each mill line. These mills are 24 feet in diameter and 7 feet in length and are equipped with grate-type discharges. Each mill is driven by a 1500 hp synchronous motor. Integral trommels are provided with the mills. Each trommel is equipped with two sizes of

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opening for sizing the product. The trommel, section nearest to the mill has nominal 1/2-inch clear openings and delivers a minus 1/2-inch feed to the vibrating screens. The trommel section farthest from the mill is equipped with nominal 1-inch clear openings and the material passing through is returned to the mill by recirculating belt conveyors for further grinding. The trommel oversize consisting of -2 inches +1 inch pebbles are conveyed as required to the pebble mill to serve as grinding media. Excess pebbles are returned to the autogenous mill for further reduction.

b. Vibrating Screens

Two 6 ft by 16 ft single deck vibrating screens, operating in closed circuit with each cascade mill, screen the 1/2-inch material passing through the cascade mill trommel at 10 mesh. The plus 10 mesh material is returned to the autogenous mills for further grinding by the recirculating belt conveyors and the minus 10 mesh product is pumped to the cobber magnetic separators.

3.43 Magnetic Cobbers

The 10 mesh screen undersize from vibrating screen is pumped to a double-drum cobber. Each drum is 36 inches in diameter and 60 inches long. The intensity of the magnetic field of each drum is adjustable by manual regulation of the current to the electromagnets in the drum. The tailings from the cobbers are discharged by gravity to the tailings collecting launders. The cobber concentrates are further reduced in size in the pebble mills.

3.44 Pebble Mill Circuit

Each mill line is provided with a pebble mill operating in closed circuit with cleaner magnetic separators, and primary and secondary classifying cyclones.

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a. Pebble Mills

Each pebble mill is 11'-6" in diameter inside of the shell and 17'-6" in length. The pebble mills are of the grate type and equipped with an integral trommel for removing tramp over-size material from the mill discharge. Each mill is driven by a 700 hp synchronous motor.

Pebbles produced in the cascade mill serve as grinding media in the pebble mills. The minus 2", plus 1" pebbles reporting as trommel over-size of the cascade type mills fall into charging boxes on a belt conveyor used to transport the pebbles to the pebble mills. Each pebble conveyor is equipped with a belt scale which weighs and delivers pebbles to the pebble mills at a constant, predetermined rate by changing the pebble belt speed. The belt scale is adjusted either manually or automatically to deliver pebbles at a fixed rate. When set for automatic operation, the tonnage setting of the belt scale is adjusted by the power demand of the pebble mills. Adjustable timing devices are provided in the electrical circuits to prevent "hunting" of the scale and controls. Recorders indicate the power demand and tonnages of pebbles fed, and provide the operators with visual records of the pebble mill operation.

b. Cleaner Magnetic Separators

The discharge of the pebble mill flows by gravity to an 8-inch cleaner feed pump sump. This pump delivers the pebble mill discharge to a four way distributor which divides the pulp equally to four cleaner magnetic separators per mill line. These cleaner magnetic separators are equipped with a single-drum 36-inch in diameter and 60 inches in length. They contain permanent magnets. The concentrates from the cleaner magnetic separators flow by gravity to a primary classifying feed pump sump where they are combined with the concentrates from the cobber magnetic separators.

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A 10" rubber lined centrifugal pump delivers these concentrates to the primary cyclone.

c. Primary Classifying Cyclones

Four 15-inch cyclones are provided for classifying the combined concentrates of the cobbing and cleaning stages of magnetic separation. The overflow of the primary classifying cyclones flow by gravity to the secondary classifying cyclone feed pump sump.

d. Instrumentation

The desired fineness of the product of the grinding circuit is maintained within a narrow limit by a radioactive isotope density meter-controller which senses the amounts of solids in the feed to the primary cyclone and regulates the rate of crude feed. The density meter-controller automatically adjusts the tonnage setting of the belt scale controlling the rate of the feed to the cascade mill.

e. Secondary Classifying Cyclones

Eight 10-inch cyclones are provided per line to classify the overflow of the primary classifying cyclones to a final product approximates 90% minus 325 mesh in fineness. The overflow from the secondary classifying cyclones flow by gravity to the desliming hydroseparator ahead of the final stage of magnetic separation.

3.45 Desliming Hydroseparator

The desliming hydroseparator is 30 ft in diameter with an 8 ft high side wall. The slime overflow of the hydroseparators is carried by launders to the tailings trench.

3.46 Magnetic Finishers

The underflow of the hydroseparators is pumped by a rubber lined centrifugal pump drive with a variable speed drive to a pulp distributor which distributes the pulp to 6 triple-drum

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magnetic finishers. The finisher separators are equipped with 30-inch diameter by 72-inch long drum and permanent magnets. The concentrates of these magnetic finishers is pumped by a 4-inch pump to the filtering section.

3.5 Filter Plant

The filter plant contains all of the machinery and equipment for thickening, storing, and filtering the final concentrate plus the reground fines from the pelletizing plant. It also contains equipment to repulp concentrate from an externally located concentrate emergency stockpile.

The building is steel frame with insulated sheet metal sandwich type roofing and siding. It is arranged on two floors, the overall size is 200 feet long by 116 feet wide and averages 80 feet high. It has one common wall with the concentrator and the lower floors are inter-connected.

The thickeners are located on the second floor to provide gravity flow to the filters while the slurrifiers are on the ground floor. All equipment is arranged in modules of like machinery in bays. Lay-down and repair areas are provided for each bay at the end of the building.

All floors are sloped and provided with floor drains for easy cleanup.

Main electrical equipment is housed in pressurized electrical rooms to prevent dust damage.

3.51 Concentrate Thickener

Three 50 foot diameter by 12 foot high thickener tanks are provided for thickening all of the finisher concentrate and/or repulped concentrate combined with reground fines from the pelletizing plant. The concentrates are magnetized prior to thickening to increase the effectiveness of the operation. Thickener rating is 10 ft²/LTPH. Eight-inch duplex diaphragm pumps discharge the thickener underflow at controlled density through demagnetizing coils to pulp distributors. From the pulp distributors, the concentrate flows by gravity to the filters. Amounts in excess of filter requirements are diverted to slurrifier tanks for storage.

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3.52 Concentrate Filters

Ten 6 ft diameter 8-disc agidisc filters equally fed from two pulp distributors are provided to filter the total plant concentrates to approximately 10% moisture. Filter loading is 382 pounds per ft² per hour. Vacuum for the filters is provided by two-stage wet type rotary pumps furnishing 27 inches of Hg vacuum through a common manifold and barometric leg. Five vacuum pumps drawing 300 hp each are required. The filter cake discharges onto a common collecting belt conveyor which elevates it to the concentrate bins located in the pelletizing plant. Filtrate is returned to the thickeners by pumps.

3.53 Slurrifier Tanks

A total of sixteen hours of plant concentrate production is stored in the four 37 foot diameter by 37 foot high slurrifier tanks. Each slurrifier has a capacity, at 70% solids, of 1650 LT of concentrate, the equivalent of four hours production. Anyone or all of the slurrifiers may be used as required. Slowly revolving rake arms equipped with air outlets provide agitation to keep the concentrate pulp in suspension. The concentrate from the slurrifiers is returned, as needed, to the concentrate filter distributors by means of 4-inch sand pumps driven by 40 hp motors.

3.54 Scrubber Section

An externally located concentrate emergency stockpile is provided to store filtered concentrate in the event of pelletizing plant delay. This stockpile will be reclaimed as needed by a bucket loader feeding a hopper and belt feeder. The concentrates are received in the scrubber section on a belt conveyor equipped with a recording scale. A 5' x 12' scrubber of 200 LTPH capacity is provided to break up agglomerated or frozen chunks and repulp the concentrate. The repulped concentrate is introduced to the filter plant circuit at the thickeners.

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3.6 Pelletizing Plant

The pelletizing plant contains all of the machinery and equipment for agglomerating the filtered concentrate. This includes receiving the concentrate, adding and mixing bentonite, balling the concentrate, indurating of balls to produce pellets, and the cooling of fired pellets. Because of size limitation on equipment and the required overall capacity, the plant is divided into two identical lines, each consisting of five balling drums, one traveling grate, one rotary kiln, and a combination of one annular and one rotary cooler, together with accessory equipment for the process. This gives a measure of flexibility to the plant since the two lines can be operated independently of each other.

The plant is housed in a simple steel frame building with uninsulated corrugated sheet metal siding and insulated sheet metal sandwich-type roofing. The general arrangements is step-down to fit the requirements of the process equipment to the natural contour of the plant site. A ventilation monitor extends the full length of the grate-kiln cooler section, and adjustable louvers are provided in the monitor and near the floor levels. Unit heaters are included for spot heating portions of the building away from the firing sections. These heaters have sufficient capacity to maintain the building above freezing in case of plant stoppage during cold weather.

The balling section is serviced by a 25-ton traveling bridge crane. A single 12-ton crane is provided for both grates and a 5-ton jib crane for each cooler.

3.61 Concentrate Handling

Filtered concentrate containing 10% to 11% moisture is collected from the filters at the nominal rate of 420 long tons of solids per hour. This includes 20 tons per hour of reground grate fines, representing 5% of the product. The concentrate is conveyed to the pelletizing plant on an inclined conveyor belt which in turn delivers it to a shuttle belt for distribution to ten concentrate day bins. Each day bin has a capacity of 85 long tons, equivalent to two-hour storage ahead of each balling drum.

The shuttle belt is also used to bypass the concentrates to the emergency stockpile belt conveyor.

3.62 Concentrate Feeding and Mixing

From each of the ten day bins, a table feeder feeds the concentrate onto a mixer feed belt equipped with a belt scale. The scale regulates the table feeder to deliver a constant feed rate; it also controls a bentonite gravimetric feeder which deposits a constant, pre-selected proportion of bentonite on top of the concentrate. The proportion of bentonite is selected by the setting on the scale beam of the gravimetric feeder. Drives for both table feeder and the bentonite feeder are by variable speed d-c motor.

3.63 Mixer

Reel type mixers are provided to mix the bentonite with the concentrate. Each mixer is mounted above a separate inclined flat belt with enclosed skirting, thus isolating the mixing vibration from the controlling belt scale. The mixer belt discharges onto a drum feed conveyor which delivers the blended concentrate to a balling drum.

3.64 Balling Drum Circuit

Each of the ten 9-foot diameter by 30-foot long balling drums has a nominal capacity of 43 long tons per hour and is equipped with a reciprocating cutter bar to maintain the proper surface for balling. The balling drum discharge is received on a 5' x 14' seed screen with 3/8-inch slotted openings which separates the undersize or seed balls from the desired size balls. These seed balls are returned to the feed belt and recycled through the drum. Proper sized green balls, approximately 90% 3/8" to 1/2", are collected by short ball collector conveyor belts and deposited on a reciprocating belt conveyor. The reciprocating conveyor distributes them on the traveling grate feed belt.

The ball collector belt is equipped with a recording scale. The belt can be reversed to discharge onto the seed return belt to provide a totally closed balling drum circuit during start-up periods.

3.65 Traveling Grate

The 12'-3" wide grate feed belt delivers the green balls to a distributing screen for the removal of broken ball fragments and deposits the whole balls in an even layer on the traveling grate. The grate is formed by an endless chain 12'-3" wide by 126'-5" between centers. The chain itself is a series of linked cross bars with hinged pallet sections and vertical side plates. The hinged pallets are designed to form a rigid continuous overlapping bed during the forward or loaded travel,

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and to hang vertically and open during the return cycle. In this manner the pellets are carried forward with no movement relative to the pallet bed. At the same time, the movement of the pallets on the return cycle tends to clear the chain, allowing fines to fall free. A rotary brush finishes the cleaning of the grate pallets at the feed end just prior to loading. The speed of the grate is regulated by a variable speed d-c motor drive to maintain the bed depth for optimum operation.

The loaded grate chain passes through a refractory lined enclosure on the forward travel. This enclosure is divided into drying and preheating zones. Large fans draw the hot gases from the kiln down through a bed of balls in the two consecutive passes. The balls are thus dried in the drying zone by approximately 700° gases from the preheat zone, and then hardened in the preheat zone by 1800° to 1900° gases from the kiln. This arrangement provides essentially a counter current passage of balls and kiln gases, with green balls entering the grate at ambient temperature and being discharged into the kiln at approximately 1800°.

3.66 Rotary Kiln

The hardened balls from the grate enter the rotary kiln at approximately 1800° to 1900° and are heated by gases during the passage through the kiln. The fully fired pellets are discharged at approximately 2400°.

The kiln is 17' in diameter by 140' in length with a 9" refractory lining. There are two supports and drive is by a variable speed d-c motor. An auxiliary electric motor, driven from the emergency diesel-electric power supply, is provided to rotate the kiln to prevent warpage in case of a power failure.

Heat is supplied to the system by the combustion of preheated (250°) fuel oil in refractory lined firing hoods. The fuel oil is delivered from a recirculating fuel oil system.

3.67 Coolers

The fired pellets discharge from each kiln into a slowly rotating 40' diameter by 7' wide pallet annular cooler. Air is blown upward through the 3' deep pellet bed and then collected and drawn into the rotary kiln. The pellets are discharged at approximately 700°F by the tilting of the hinged pallets after a nearly complete revolution of the cooler. The annular cooler is driven by two variable speed d-c motors controlled by bed-depth sensors.

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Final cooling of pellets is done in an air swept 8' diameter by 22' long rotary cooler to which controlled amounts of water spray may be added as required. The rotary cooler is fed by a vibrating feeder placed below the hoppers under the annular cooler. The discharged pellets from both rotary coolers fall through a chute onto a common 30" pellet belt conveyor and are carried to the pellet load out bins. The pellets are cool and essentially dry when discharged.

3.68 Burner and Gas Fans

Fifty horsepower airfoil fans exhaust the air and moisture from the rotary coolers to the atmosphere.

Two 600 horsepower airfoil fans provide the draft for each annular cooler. Air enters the fans and is blown upward through the pellet bed. After passing through the pellets, the air is collected in hoods and drawn into the rotary kiln as a secondary heat supply.

Air at ambient temperature is supplied to each burner by a 50 hp primary air blower.

The hot gases, consisting of burner combustion products and secondary air, are drawn through the kiln and down through the pellet bed in the preheat zone in the grate by 700 horsepower first pass gas fans. There are two of these fans per grate, each handling the draft through one side of the grate. Gas enters the discharge end of the grate at approximately 1800° to 1900°F and is cooled by passing through the pellet bed. The discharge from the first pass fans is about 700° and is ducted to the refractory chamber above the drying zone. Two second pass fans consuming 300 hp each draw the gases through the green balls in the drying zone and exhaust 250° gas to the exhaust stack.

An adjustable ventilating stack over the preheat zone of the grate allows any excess hot gas to be vented to the atmosphere to avoid overheating of the grate bed. This is normally necessary only during start-up periods.

3.69 Grate Fines

Approximately 7% of the total grate product is collected as undersize. About 2% is collected as brokeng reen balls under the grate distributing screen and returned to the balling circuit by belt conveyors. The remaining 5% consists of grate fines, chain spillage and cyclone dust. Dust is collected in 16 dual cyclones connected in parallel in the circuit between the preheat zone wind box hoppers and each first pass gas fans. Coarse material is collected in the hoppers and delivered to the fines collection belt conveyor system. The same conveying belts receive the cyclone dust. Spillage from the return grate is collected in hoppers and delivered to the same system as is the product from the grate cleaning brush.

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The undersize from both grates exclusive of distributing screen fines are conveyed on dust-skirted belt conveyors to the regrind section. The regrind section consists of a 3' x 3' ball mill operating in closed circuit with a spiral classifier. The fines are delivered to the classifier and the classifier overflow is collected in a sump and pumped to the concentrate thickener in the filter plant.

In case of breakdown of the grinding circuit or the temporary production of excessive amounts of fines, a movable gate will divert the material from the classifier to a bucket elevator feeding a 480 long ton capacity surge bin.

A vibrating feeder returns the fines to the classifier as required. A feature of the system is that with the vibrating feeder, the feeding to the ball mill classifier circuit is maintained at a controlled rate independent of fines production.

3.7 Pellet Loading and Emergency Stocking

3.71 Pellet Loading

Pellets are collected at the drum coolers and transported by a 30" belt conveyor in an enclosed insulated conveyor gallery to the pellet car loading station. The pellet conveyor is equipped with a recording belt scale. A shuttle belt distributes the pellets to four 37' diameter by 38 foot high conical bottom steel load out bins which provide storage for 10,000 long tons equivalent to 1 days' production. The bins are located on 38' centers to provide simultaneous loading for four railroad cars.

Each bin is provided with a single loading chute fitted with air operated gate. The chutes are located at a height above the cars calculated to assure adequate loading but to prevent overflowing or spillage. Distribution over the length of the car is controlled by allowing the car to move slowly down the declined track during the loading cycle. The movement of the cars is controlled by the loading operator through the use of the car air brakes connected to an air compressor.

3.72 Pellet Emergency Storage

Provision is made for storage of pellets in case of delay of rail service. The pellet emergency conveyor will receive the pellets from the main conveyor by means of a chute equipped with a diverting gate. The pellets are conveyed to an externally located

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emergency stockpile having a capacity of 12,000 long tons. The stockpile is reclaimed by a power shovel loading directly onto railroad cars.

3.8 Additive Handling and Storage

Bentonite for the balling section of the pelletizing plant will be received in 50 ton hopper-bottom railroad cars. Plant requirements will be approximately 10 cars per week. A pneumatic handling system of 50 tons per hour capacity is located in the Additive Building. The Additive Building is 30' x 60' x 25' high of steel frame and sheet metal construction. An air slide conveyor in a trench conveys the bentonite to an air pump which in turn delivers the bentonite to either of two externally located 35' diameter 750 tons main storage silos. The silos are provided with bag type dust collectors and remote controlled air operated diverting valves. Separate air slides return the bentonite from the bins to the pump for distribution to the 10 additives day bins in the balling section of the pelletizing plant. Air valves and day bin level indicators allow the operator to control the filling operation from the additive control panel in the unloading shed. Each day bin holds the equivalent of 30 hours supply for one balling drum. Bins will be filled once each day. Final proportioning to the balling drum feed is provided by gravimetric feeders controlled by individual belt scales on the mixer feed belts.

3.9 Tailings Disposal and Water Systems

3.91 General

An investigation of the proposed plant site pointed out that the following tailing disposal and water system is most economical. The plant tailings will be collected in a concrete sump inside the plant. A flume excavated in rock will discharge these tailings into the Lake Albanel. Because of the size of Lake Albanel there is very little possibility of polluting the lake water with plant slimes yet there is an abundant supply of fresh water for plant use. By adopting this scheme the necessity of initial investment in tailings hydroseparators and thickeners and further expenditure for flocculating reagents has been eliminated.

3.92 Tailings Disposal

A 60" diameter by 200' long pipeline from the plant dumps all the plant tailings into a 5' wide by 750' long open trench excavated in the rock discharging into the lake. A composite length of 245' steel-lined, rectangular 5' wide tailings box culvert has been

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provided under railway and roadway crossings. The tailings trench follows the natural slope of the ground to Lake Albanel. At no place is the slope less than 4%.

3.93 Water Pumphouse:

In order to avoid heavy thrust of the ice against the pumphouse and stay above high water mark, which was assumed at 1300', the pumping station is located some 200' from the edge of the Lake and at an elevation of 1305'.

A 30' x 40' steel building houses the large water pumps, their main valving and auxiliary equipment.

Three 28,000 gpm vertical turbine type pumps each driven by a 2000 hp, 600 rpm vertical synchronous motor, pump the lake water to the mill water header.

Two 60" intake pipes located 15' below water level conduct lake water to common pump sump. Three 8' wide double stationary water screens prevent fish and trash from entering into the pump bowls.

A motorized lift, manually-operated 10-ton bridge crane is provided to serve the vertical pumps, valving, and electrical control system in the pumphouse.

3.94 Water Pipelines:

Two 42" welded and coated water pipelines, buried 7' deep in a trench, each 1900' long, supply process water, at a pressure of 20 psi (at the magnetic finisher nozzles), either directly into a 42" diameter loop-like mill water header or to the mill water tank. The cost estimates include funds for the adequate valving and control at the pumphouse, mill water header and the tank necessary to maintain a reasonable constant pressure in the mill water header.

3.95 Mill Water Tank:

A 32' diameter by 55' high two-compartment storage tank located on a knoll near the screen house acts as a constant head tank.

The lower 50' high compartment of this tank has a capacity of 300,000 gallons of which bottom 25' is reserved for fire

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protection and the balance is available for mill use. The upper 5' high compartment contains treated domestic water. Both compartments are equipped with steam heating coils to control ice formation.

Two 42" short pipelines will connect the mill water tank with the mill water header loop inside the concentrator.

3.10 ELECTRIC POWER SUPPLY & DISTRIBUTION

The connected electrical load for the plant is estimated to be approximately 64,000 Kva, including mining and townsite electrical requirements. The average running load is estimated to be approximately 45,000 Kva.

3.10.1 Power Supply and Primary Substation:

Electric power to the plant will be supplied from a 161 Kv, 3-phase, 60-cycle transmission line to be built by the Quebec Hydro Electric Commission. This line will be a new installation and its regulation and reliability is expected to be adequate.

The primary substation is located adjacent to the mill building and as centrally located as practicable with respect to load. A fenced substation area encloses the high voltage structure, the power transformers, and the switchgear building. Except for the mine and townsite distribution feeders, all distribution circuits leave the substation area by means of underground conduit. The mine and the townsite will be fed over head.

a. Power Company Equipment:

Provision is made for space in the High Voltage Switchgear building for mounting the metering equipment and apparatus of the Quebec Hydro-Electric Commission.

b. High Voltage Structure:

The steel structure in the substation yard will be supplied and erected by the Quebec Hydro Electric Commission.

c. Power Transformers:

The power transformers will be supplied and installed by the Quebec Hydro-Electric Commission. All primary connections will be made by the Quebec Hydro-Electric Commission.

d. Substation Grounding:

A ground grid of bare No. 4/0 copper cable connected by welding to the main water supply piping is installed at the substation. This grid is tied to the main transformer, to the switchgear ground bus, to the station lightning arrestors, and to protective metal grating under the high voltage switch manual operators.

e. Switchgear Building:

A 45' x 50' x 10' high, pre-fabricated metal building on a concrete slab provides housing at the substation for the primary distribution switchgear and metering equipment.

f. Primary Distribution Switchgear:

The switchgear consists of two lines of 10 cubicles each of 13.8 Kv drawout switchgear rated at 1200 amperes and three rated at 2000 amperes. Metering consists of a voltmeter, ammeter, watt-hour meter, and a recording demand meter. Each circuit breaker is equipped with three induction-type overcurrent relays, one ammeter, A-C closing D-C tripping, and control switch. The two main 13.8 Kv breakers are, in addition, equipped with under-voltage trip devices. A current balance relay operating from current transformers in the 161 Kv circuit trips both main circuit breakers in the power transformer secondary circuits upon loss of one primary fuse or single phasing at the transformer primary for any other reason.

3.10.2 Primary Distribution System:

All feeders originate at circuit breakers in the metal-clad switchgear via underground conduit, and either continue to their first termination underground or ascend a pole for transition to overhead circuits.

a. Underground Primary Feeders:

Primary feeder circuits running underground consist of three single conductor shielded cables having heat resistant and moisture resistant rubber or rubber-like insulation, with a neoprene jacket overall. The

cable is pulled in transite or fiber duct buried in a concrete envelope and below the frostline. Man-holes are provided where necessary to facilitate cable pulling.

b. Overhead Primary Feeders:

Primary feeder circuits running overhead at 13.8 Kv consist of three conductors. The conductors are bare, hard-drawn copper. Insulators have a minimum flash-over rating of 65 Kv dry, 35 Kv wet and 100 Kv impulse flash-over. Design of pole and conductor strengths are based on the standard "heavy loading" classification as follows:

- 0.5 inch radial ice
- 8 lbs. per sq. ft. horizontal wind loading
- 0°F
- 9.29 lbs. per ft. additional loading constant

In general, poles are 40 feet high, spaced about 150 feet apart. The poles are of Western Cedar, or equal, butt-treated with pentachlorophenol to a 0.5 inch penetration.

All ground-level transformer installation are protected by wire fencing. Pellet-type lightning arrestors, pole-mounted and rated for grounded-neutral service, are provided at each point of transition between overhead and underground circuits, and at each distribution transformer.

3.10.3 Secondary Distribution System:

The secondary distribution system consists of a number of 4160 volt, 3-phase, 3-wire systems. All feeders form simple radial arrangements.

a. Secondary Distribution System Grounding:

The neutrals of 4160 volt windings of all stepdown transformers are brought out and resistance grounded to the nearest ground grid. This classifies the secondary distribution system as grounded and permits rapid clearing of phase to ground faults on the system.

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b. Selective Tripping:

In case of a fault on the secondary distribution system, a portion of the system is de-energized automatically by the circuit protective elements, causing outage to equipment until service can be restored by switching and/or repair of the faulted device. To restrict outage to a minimum of equipment, and at the same time to take advantage of full-rated interrupting capacity circuit breakers, selective tripping schemes are used in the more important portions of the plant.

c. 480 Volt Facilities:

Power at 480 volts is available at the various facilities from askarel-insulated transformers when they are installed in the electrical rooms and from oil-filled ones when located outdoors. The transformers and 480 volt drawout switchgear equipment with which they are associated are of the load center type. Motor control equipment is grouped into motor control centers.

d. Emergency Power Generation:

A diesel-engine-driven alternator is provided. The alternator is rated 300 Kva, 0.8 power factor, 480 volts, 3-phase, 60 cycles and is driven by a suitable diesel engine with battery starting. No automatic starting facilities are provided.

The primary function of the emergency generator is to maintain continuous operation of critical auxiliaries. It is connected by means of circuit breakers to the Mill Line Auxiliary Buses. Sufficient capacity is also available to provide minimum lighting in the entire plant. The generator is equipped with a voltmeter, an ammeter, and a tachometer or frequency indicator.

Keyed interlocks, electrical interlocks or a combination of the two are provided to prevent connecting the generator to an energized bus and likewise to prevent re-closing of the main 13.8 Kv circuit breaker

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when the plant system is energized from the emergency generator.

3.10.4 Direct Current System:

Individual motor generator sets are provided to supply d-c power to each synchronous motor. One motor generator set is provided to supply the d-c power to all of the magnetic cobber separators in each mill line.

3.10.5 Low-Voltage Distribution System:

The low voltage distribution system in general supplies power for lighting, fractional horsepower motors and miscellaneous small loads through 3-phase, 4-wire 120/208 volt switchboards, with starters mounted at the individual motors. The low voltage system is supplied from 480 volt motor control centers or power panels.

Transformers stepping down from 480 volts are generally within the buildings and of the dry, self-ventilated type.

3.10.6 Motor Controls:

Motor controls in general are installed in groups of factory-wired metal-clad enclosures, each situated near the center of density of the load group served. Each motor starter includes short circuit and overload protection for the motor and circuit served. All starters are of the full-voltage starting type.

a. 4000 Volt Motor Controls:

Motors of 200 horsepower and larger are rated 4000 volts, 3-phase and controlled by 4000 volt combination starters each consisting of current-limiting fuses and an air-break magnetic contactor in a metal-clad enclosure. Where the motor is synchronous, the enclosure includes field contactors and relays. Where two or more high-voltage starters are installed in a continuous line-up supplied from one 4160 volt feeder, they include a 4160 volt interconnection bus, unless specific conditions warrant otherwise.

b. 440 Volt Motor Controls:

Integral horsepower motors less than 200 horsepower are rated 440 volts, 3-phase and controlled by drawout

type 600 volt circuit breakers or combination starters each consisting of fused disconnect and a magnetic air-break contactor.

Occasionally, a group comprising a very few motor starters is required at some distance from other load, and the motor control center method is not economical. In this case, a feeder circuit is run from the nearest related motor control center or switchgear, and terminates on a 600 volt type NAB molded-case breaker switchboard. This switchboard, protected physically as required, has a main disconnect and a breaker for each motor to be fed. The control for each motor is a combination starter comprised of a non-fusible disconnect switch and a magnetic air-break contactor mounted at or close to the motor.

c. Control Scheme:

A standard industrial control scheme for A-C motor drives using magnetic contactors is employed. Control voltage is 480 volts. Three-wire control connection is standard, thus permitting momentary operation of push buttons as well as control from more than one location. Wound-rotor induction motors are started by push button and automatically accelerated to full speed by standard high voltage magnetic contactors designed for wound rotor motor control.

d. Control Stations:

In general, all motor control is from centrally located operators boards. Each drive has a start-stop button and red running light mounted on the board. In addition, local control at the motors is provided to facilitate maintenance.

e. Interlocking:

Where it is necessary to interrupt operation of a sequence of machines on stoppage of one in the sequence, electrical interlocking is used. Each machine is made dependent upon the succeeding machine in the sequence by electrical inter-connecting between the magnetic contactors. Switches contained within the starter

enclosures are used to provide isolation between interlocked starters for code compliance.

f. Automatic Controls:

Automatic controls specifically designed for the application are furnished where required.

3.10.7 Motors:

Electric motors, with the exceptions noted below, of integral horsepower ratings are, in general, of the squirrel cage induction type, full-voltage starting. All motors have enclosures in accordance with Paragraph 2.63 of Part II. Motor torque and starting characteristics are selected on the basis of load requirements. Motor drives with special requirements are as follows:

a. Synchronous Motors:

Synchronous motors are used to drive the mills. These motors are rated 4000 volts, 0.80 pf., full-voltage starting, and equipped with automatic field application relays which connect the D-C field supply when the motor approaches synchronous speed.

b. Wound Rotor Induction Motors:

The primary crusher is driven by a 4000 volt wound rotor motor providing high starting torque. A local jog push button is provided to permit reverse operation of the motor to facilitate the clearing of jams. This motor is enclosed, separately ventilated, and interlocked with a separate motor-driven blower. Wound rotor motors are also used on high-inertial loads such as the large conveyors.

c. Direct Current Motors:

Separate A-C power sources are supplied for the variable speed feeder belts.

d. Fractional Horsepower Motors:

Fractional horsepower motors, in general, 1/2 HP and above are rated 220 or 440 volts, 3-phase and those

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below 1/2 HP are rated 120 volts single phase.

3.10.8 Illumination Levels and Fixtures:

The average interior illumination level in the operating areas of the plant is 30-foot candles. This is supplemented in specific localities to raise the level for more exacting requirements. No allowance is made for daylighting.

High bay fixtures are self-ventilating, color corrected mercury vapor throughout. In operating areas, other than high bays, the standard fixture is the RLM dome porcelain enamel reflector, spaced at a height to facilitate maintenance with a short stepladder. Both high bay and dome reflector fixtures use conduit as the mounting means. Interior illumination in office and laboratory is maintained at about 50-foot candles using fluorescent fixtures.

Conveyor galleries are lighted by overhead lamps spaced as required.

Road lighting in the immediate vicinity of the plant is by mercury vapor street lighting fixtures supported from buildings or wood poles. Other roads are not illuminated. A minimum of two-foot candles of illumination is maintained around areas such as the primary crusher truck approach, the primary substation yard, parking lots and railroad yards, and the area around the office, shop and change house.

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3.11 Service Systems:

Plant service systems include service water, domestic water, fire protection and sanitary sewage as described below.

a. Service Water System

The pumphouse supplying water for plant make-up, domestic use and fire protection is located near the shore line of Lake Albanel with an intake line extending into the lake to a depth of 15 feet below normal lake level at the inlet. Three vertical turbine pumps feed the various plant services through two discharge lines. These lines connect with a two compartment storage tank located on the knoll at the east end of the crushed ore storage building. The lower compartment of this tank has a storage capacity of 300,000 gallons of which 150,000 gallons is reserved for fire protection and 150,000 gallons available for mill use. The upper compartment contains treated domestic water. Both compartments are equipped with steam heating coils to control ice formation.

b. Domestic Water System

This system includes the treatment, storage and distribution of water for domestic use. Water from the service water system is chlorinated, filtered and pumped to a 15,000 gallon treated domestic water storage compartment in the top of the service water tank. The distribution system is fed by gravity from storage. A small pump and pneumatic pressure tank boosts the pressure at the Primary Crusher Building. The system is arranged for a minimum of underground piping; the majority of the distribution system being inside buildings or conveyor galleries.

c. Fire Protection System

The fire protection system consists of a looped 8" fire main serving yard hydrants and interior hose systems pressurized by one electric and one gasoline engine driven fire pump, both rated at 1500 gpm at 100 psi. The fire pumps take suction from the 300,000 gallon service water storage tank of which

150,000 gallons is available at all times for fire protection. The yard loop system of fire mains of spiral welded steel pipe is arranged for a shallow burial of two to three feet with provision for draining in winter. In summer the lines are full and the electric pump arranged to start automatically with the gasoline pump manually started in the event of power failure. This system is selected, subject to the approval of the owner's insurance carrier. It is assumed that a more elaborate system consisting of heated elevated tank with fire mains under pressure all year and buried 8 feet deep would not be economically justified by savings in insurance premiums.

d. Sanitary System

The plant is served by a central sanitary system collecting wastes from the General Office, Service Building, Concentration Plant, Pelletizing Plant and Pellet Loading Station discharging to two septic tanks east of the Pellet Loading Station. The collecting system is so arranged that a minimum of sewer lines are located outdoors in trenches; the longest run being that from the Pelletizing Plant to the septic tank and thence to the lake. The remaining sewer lines are run under floor slabs or through buildings. Because of its remote location, the Coarse Ore Crusher Building is served by a separate small septic tank and leaching field. The septic tanks are equipped with heating systems consisting of a small hot water heater, a circulator, and a heating coil using a solution of anti-freeze as a heat transfer medium. A minimum temperature of 50° F is maintained in the tanks. Effluent from the septic tanks is conveyed to an underwater discharge in Lake Albanel.

3.12 Heating and Ventilation

A central boiler house with three 21 million Btu oil-fired (No. 6 fuel oil) low pressure (15 psi) steam boilers supply steam for unit heaters in the various facilities.

Besides the forced draft warm air unit heaters for the change rooms, an air-to-air heat exchanger to temper the fresh cold incoming air with the warm air exhausted is provided. Balancing

louvers permit any desired amount of inter-mixing of new and exhausted air.

Office heaters are of wall and baseboard convection type. To prevent ice and snow build-up on service shop entrance ramps and on the ground floor slab at the pellet load-out station, steam coils are encased in the concrete.

To maintain bacterial action in the plant septic tanks an immersed steam coil is furnished and thermostatically operated. A domestic type hot water heater with a circulating pump furnishes the heat supply. Electric unit-type heaters supply the heat to the make-up water pumphouse.

Heaters are thermostatically controlled with auxiliary door and manual over-ride switches as required.

Ventilation for fresh air make-up and fume removal is controlled by roof and wall exhausters and building louvers. Ventilation requirements are supplemented by filters and control dampers where conditions require them.

Carbon monoxide control in the truck maintenance shops is handled by floor and overhead exhaust connections with flexible hose to connect to gas and diesel engine exhaust pipes.

3.13 Administration and Maintenance

The administration and maintenance facilities are separated into two structures. Offices and change rooms are in one building designated General Office with warehouse, shops and truck storage in a separate structure designated Service Building. Both structures are connected to the east wall of the Mill Building.

The two story administration area of the General Office Building is 52 feet wide and 96 feet long. The ground floor contains administration, industrial relations, accounting and superintendents offices with assembly room, plant engineering, mining engineering and mine superintendent offices on the second floor. The structure housing change rooms is on one level 78 feet wide, 245 feet long and 14 feet high providing accommodations for 795 men. Separate areas are provided for "clean" and "dirty" clothes, each man having a basket in each area. Change facilities for foremen are provided in separate rooms.

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The Service Building, 147 feet wide, 580 feet long and 26 feet high contains the machine shop, electric shop, plate and welding shops, truck repair and storage and 16,300 square feet of warehouse space. The warehouse is served by a covered railroad unloading dock and a dock for truck loading. A 5 ton tramrail traverses the full length of the warehouse. The truck repair area electric shop and machine shops are serviced by a 15 ton bridge crane, with a 5 ton tramrail covering the plate and welding shops. A passage running the full length of the structure connects with the repair bay of the Mill Building.

4.0 SERVICES AND SUPPLIES

Thorough investigations were undertaken in this study as to the availability of the large quantities of water and power required on a continuous basis for the proposed beneficiation plant. In addition, a survey was conducted to appraise the relative costs and availability of fuels and other supplies required for pelletizing in order to recommend and include in the estimate the cost of the handling and storage facilities for these items.

4.1 Water:

Lake Albanel, which is approximately 3 miles in width and 50 miles long is the source of plant water. It is anticipated that severe ice conditions will prevail during the winter months with the possibility of a considerable depth of ice accumulating along the shore line during the spring break-up. For this reason, the pumping station intake pipelines are laid on the lake bottom and extend to a depth where the inlets are 15 feet below normal water surface. The pipe intakes are fitted with bonnets to provide low inlet velocities.

4.2 Power:

Inquiries made to the Quebec Hydro-Electric Commission have indicated that they would be able to deliver power to Lake Albanel 2-1/2 years after the signing of a contract. The transmission line would be of woodpole construction following an access road provided by others.

Quebec Hydro has quoted tentative rates of \$54.00 per kilowatt year at 75% load factor and \$62.00/Kw/Yr at an 87% load factor for a load of 40,000 Kw. This rate is calculated to be slightly over 8 mills per kilowatt hour.

4.3 Fuel Oil:

There are two primary users of fuel oil in the beneficiation plant. The largest consumer is the pelletizing operation, which based on an estimated heat requirement of 900,000 Btu's per ton of product, uses approximately 50,000 imperial gallons daily. During the winter months an estimated additional 8,000 imperial gallons will be required for total plant heating.

The Imperial Oil Limited have indicated a price of \$0.07 per imperial gallon of Bunker C fuel oil, f. o. b. Bagotville. The Canadian

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National Railways has indicated a freight rate of \$0.67 per cwt. (without subsidy) for hauling fuel oil to the plant site at Lake Albanel.

4.4 Pelletizing Additives:

(a) Bentonite:

Swelling type bentonite clay is used as a binder to increase the strength of both the green ball and the fired pellet. The quantities used are dependent upon the nature of the material to be pelletized and the pelletizing equipment. The price of 200 mesh swelling type bentonite is quoted at \$11.50 per ton f.o.b. Rosalind, Alberta.

The Canadian National Railways has indicated a freight rate of \$1.31 per 100 lbs. (\$26.20 per ton) from Rosalind to Lake Albanel.

(b) Limestone:

If a demand develops for self-fluxing pellets and it proves feasible to make them with the grate-kiln pelletizing, powdered limestone is available in the Dolbeau area. Preliminary inquiries indicate a price of \$200 per ton f.o.b. cars at Roberval. Tentative freight rates to Lake Albanel have been quoted at \$0.31/Cwt. (\$6.20 per ton).

4.5 Highways:

Late in October 1960 the Federal Government of Canada and the Provincial Government of Quebec signed an agreement allowing Quebec to participate in the Roads to Resources program, including the roadway connecting to Lake Albanel.

This agreement includes 95 miles of new road from the southern tip of Lake Waconichi in the vicinity of Chibangamau to the east shore of Lake Albanel. This new road will be built to high level gravel standards with a 28-foot travel surface and 4.5-foot shoulders. Bridges and roadway will be constructed to withstand wear and tear of large lumber rigs and ore hauling trucks and in accordance with the specification set out in the Federal-Provincial agreement.

Part II

II

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4.6 Railroad:

The Canadian National Railways has expressed an interest in entering an agreement with Albanel Minerals, Limited to haul the pelletized product from Lake Albanel to the vessel loading facility at Ha Ha Bay. They propose to construct the necessary trackage and to haul pellets on a "hook and haul" basis, i.e., no switching, at a freight rate of \$2.55 per long ton with a guaranteed minimum of 1,000,000 long tons per year. This rate appears to be an "incentive rate" and entirely in line with similar iron ore mining operations in Labrador.

The location of the pelletizing plant has considerable bearing upon the amount and type of railroad equipment required for hauling the product. If the pelletizing operation is located at Lake Albanel, the CNR will design and build cars to suit the requirements of the Mining Company and the CNR. The car will probably be similar to that use by Erie Mining Company with bottom hoppers and a nominal capacity of 90 S.T. Roller bearings will be supplied, if necessary, but will be subject to negotiation with the CNR.

In the event that the pelletizing operation is located at Ha Ha Bay, 3,330,000 wet tons of filtered concentrates containing approximately 10% moisture would be transported annually. For this service the CNR will design and build cars to suit the requirements of the Mining Company and CNR. The car will probably be similar to the present gondola type car used by the Quebec North Shore and Labrador Railway for Iron Ore Company of Canada, with swivel couplings for rotary dumper. Nominal capacity of car to be 90 S.T. Roller bearings will be supplied.

4.61 Criteria:

Considerable discussion with representatives of the Canadian National Railways has established the following criteria:

A. The route presently preferred by the CNR along the Nestakenow River will require the following trackage:

1. Approximately 16 miles of new trackage from the docksite to Ha Ha Junction.
2. Considerable rehabilitation of approximately 175 miles of existing trackage between Ha Ha Junction and Lake Chigoubiche.

3. Approximately 123 miles of new trackage from Lake Chigoubiche to Lake Albanel.

B. The existing ruling grade in both directions is 1-1/4%. Detailed survey information is not available for the new lengths of trackage required but it is assumed that the ruling grades will not exceed 1-1/4%.

C. Local climatic conditions will decrease efficiency of the railroad by an estimated 10% over a period of four months each year.

D. The local topography forces the CNR to lay some trackage through areas of muskeg. The experience to date indicates that the existing track bed is still "shifting" but it is believed that it will stabilize at which time it may be possible to increase the number of cars per train and also increase the operating speeds. The CNR therefore estimate a considerable restriction on both load and speed, which is reflected in the figures quoted below for train operations.

E. The following schedules and rolling stock requirements are estimated for this service by the Canadian National Railway.

Pelletizing plant located at Lake Albanel with rail haulage of pellets to Docksite by CNR on a "hook and haul" basis. Mining Company loads and unloads extra strings of cars between trains.

Number of trains per year	770
Allowance included in above for winter operation	25
Number of cars per train	50
Number of diesel locomotives per train	4
Hours of travel time - Albanel to Docksite	18
Hours of travel time - Docksite to Albanel	16
Cycle time for cars - in days	4-1/2
Single train cycle time - in days	2

Pelletizing plant located at Docksite with rail haulage of concentrate from Albanel by CNR on a "hook and haul" basis. Mining Company loads and unloads extra strings of cars between trains.

Number of trains per year	850
Allowance included in above for winter operation	30
Number of cars per train	51
Number of diesel locomotives per train	4
Hours of travel time - Albanel to Docksite	18

Hours of travel time - Docksite to Albanel	16
Cycle time for cars - in days	4-1/2
Single train cycle time - in days	2
Number of operating days per year	365

4.62 Construction Period:

During the informal conferences held with The Canadian National Railways officials in September 1960, it was indicated that if normal construction schedule is followed, it seems likely that the railroad could be completed during summer of 1964 (46 months).

However, if the initial reimbursable cost of the survey for the new length of track between Chiboubiche and the proposed plant site is advanced by the Albanel Mineral Limited, the completion of the railroad may be expedited to the fall of 1963 (36 months).

In the event that the Albanel Mineral Limited would be willing to pay the difference in increased construction costs, an accelerated construction program could be arranged with the Canadian National Railways. The completion of the project may then be advanced to the fall of 1962 (26 months).

4.63 Sources of Information:

The following were contacted in connection with railroad operations:

Canadian National Railway, Montreal, P. Q.

Mr. Keith Ralston	-	Commissioner of Development
Mr. Louis Marchand	-	Industrial Engineer
Mr. A. Sutherland	-	Freight Agent
Mr. W. Moffat	-	Operations Department

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5.0 EQUIPMENT LISTS

The following lists contain the major equipment required for the beneficiation plant.

5.1 Ore Dressing Section:

Major equipment for the crushing, grinding, concentrating and filtering sections of the plant.

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MAJOR EQUIPMENT LIST FOR
CRUSHING, GRINDING, CONCENTRATING, FILTERING
AND AUXILIARIES FOR A PLANT PRODUCTION OF
3,000,000 DRY LONG TONS PER YEAR OF
CONCENTRATES

MECHANICAL EQUIPMENT

<u>Description</u>	<u>No. Units</u>	<u>Size</u>	<u>Nominal Rating</u>	<u>HP Ea. Unit</u>
<u>Crushers:</u>				
Primary Gyrotory	1	54"x84"	2000 LTPH	600
<u>Grinding Mills:</u>				
Wet Autogenous Mill	14	24'dia.x7'	95 LTPH (net)	1500
Pebble Mill	14	11'-6"dia.x17'-6"	40 LTPH (net)	700
<u>Magnetic Separators:</u>				
Wet Cobber (2 Drum)	28	3'dia.x60"	LTPH	6
Wet Cleaner (1 Drum)	56	3'dia.x60"	LTPH	2
Wet Finisher (3 Drum)	84	30"dia.x72"	LTPH	6
<u>Feeders:</u>				
Primary Coarse Ore Apron	1	60"x17'	2000 LTPH	25
125,000 LT Reclaim Apron	3	48"x10'	700 LTPH	15
Grizzly Feed	1	72"x12'	2000 LTPH	25
Splitter Bin Overflow	1	54"x12'	2000 LTPH	20
Mill Feed	70	48"x10'	20 LTPH	5

MECHANICAL EQUIPMENT - Continued

<u>Description</u>	<u>No. Units</u>	<u>Size</u>	<u>Nominal Rating</u>	<u>HP Ea. Unit</u>
<u>Conveyors:</u>				
Crushed Ore	1	48"x737'	1675 LTPH	300
125,000 LT Stockpile	1	48"x400'	1675 LTPH	300
Coarse Ore Tripper	1	48"x960'	2000 LTPH	250
Fine Ore Tripper	1	48"x885'	2000 LTPH	250
Autogenous Mill Feed	14	42"x219'	270 LTPH	20
Mill Recirc. -Collecting	14	24"x 16'	10 LTPH	2
Mill Recirc. -Collecting	14	24"x 39'	170 LTPH	2
Mill Recirc. -Return	14	24"x120'	180 LTPH	15
Mill Recirc.-Transfer	14	24"x 27'	180 LTPH	5
Pebble Feed	14	24"x 32'	10 LTPH	3
Concentrate Collecting	1	36"x447'	410 LTPH	50
Concentrate Shuttle Feed	1	30"x125'	410 LTPH	5
Concentrate Stockpile	1	30"x. 50'	410 LTPH	2
Concentrate Reclaim	1	24"x230'	200 LTPH	200
<u>Screens:</u>				
Vibrating Grizzly	1	8'x14' DD	2000 LTPH	20
Vibrating Screens	28	6'x16' SD	115 LTPH	10
<u>Cyclones:</u>				
Primary Classifying	56	15" Dia.	500 GPM	-
Secondary Classifying	112	10" Dia.	235 GPM	-

MECHANICAL EQUIPMENT - Continued

<u>Description</u>	<u>No. Units</u>	<u>Size</u>	<u>Nominal Rating</u>	<u>HP Ea. Unit</u>
<u>Thickeners:</u>				
Hydroseparator	14	30'Dia. x8'SS	18 ft ² /LT	3
Concentrate	3	50'Dia. x12SS	13 ft ² /LT	7-1/2
<u>Filters:</u>				
Disc Type	10	6'Dia. x 8'	220 lbs/ft ² /hr	10-1/2
<u>Sand Pumps:</u>				
Cobber Feed	28	6"	750 GPM@55'TDH	25
Primary Cyclone	14	10"	2200 GPM@90'TDH	150
Cleaner Feed	14	8"	1350 GPM@40'TDH	50
Secondary Cyclone	28	10"	2100 GPM@60'TDH	75
Finisher Feed	14	4"	210 GPM@30'TDH	10
Concentrate Thickener Feed	14	4"	200 GPM@90'TDH	20
Slurrifier	6	4"	330 GPM@50'TDH	40
Concentrate Repulping	1	6"	650 GPM@50'TDH	40
<u>Diaphragm Pumps:</u>				
Hydroseparator Underflow	1	6" Duplex	180 GPM	5
Concentrate Thickener Underflow	3	8" Duplex	420 GPM	7-1/2
<u>Water Pumps:</u>				
Make-up Water	3		28,000 GPM@230TDH	2000
Fire Water	2	6"	1,500 GPM@100PSI	125(1 Gas Driv.)

MECHANICAL EQUIPMENT - Continued

<u>Description</u>	<u>No. Units</u>	<u>Size</u>	<u>Nominal Rating</u>	<u>HP Ea. Unit</u>
<u>Vacuum Pumps:</u>				
Drum Filter	5	2 Stage 16x35 & 14x24	5,600 CFM @ 20" Hg	300
Filtrate	10	3"	150 GPM @ 50' TDH	5
<u>Belt Conveyor Scales:</u>				
Coarse Ore	1	48" Belt		Fract.
Mill Feed	14	42" Belt		Fract.
Pebble Feed	14	24" Belt		Fract.
Concentrate Collecting	1	36" Belt		Fract.
<u>Dust Collectors:</u>				
Coarse Crusher	1	-	12,000 CFM	30
Screen House	1	-	25,000 CFM	50
Crushed Ore Storage	1	-	30,000 CFM	75
Mill Feed Conveyors	14	-	5,000 CFM	10
<u>Bridge Cranes:</u>				
Coarse Crusher	1	36' Span	75T/15T	125
Autogenous Mill	1	68' Span	30T	55
Pebble Mill Bay	1	54' Span	25T	55
Magnetic Separator Bay	1	81' Span	5T	10

MECHANICAL EQUIPMENT - Continued

<u>Description</u>	<u>No. Units</u>	<u>Size</u>	<u>Nominal Rating</u>	<u>HP Ea. Unit</u>
<u>Samplers and Density Meter:</u>				
Continuous Assayer	1	48" Belt	1675 LT	-
Copper Feed	28	-	550 GPM	Fract.
Concentrate Thickener Feed	14	-	200 GPM	Fract.
Tailings	2	-	3260 GPM	Fract.
Primary Cyclone Feed Density Meter	14	10"	2000 GPM	-
<u>Concentrate Tank:</u>				
Slurrifier	3	37'Dia. x37'		25

5.2 Pelletizing Sections:

Major equipment for the balling, indurating, cooling, additive handling, and car-loading facilities.

LAKE ALBANEL PROJECT
 MAJOR EQUIPMENT LIST
FOR 3,000,000 LTPY PELLETTIZING PLANT

<u>Name</u>	<u>No. Units</u>	<u>Size</u>	<u>Rating</u>	<u>HP Each</u>
MECHANICAL EQUIPMENT				
<u>Bins</u>				
Concentrate Day Bin	10	22'Ø	100 LT	-
Bentonite Day Bin	10	8'Ø	10 LT	-
Fines Surge Bin	1	22'Ø	480 LT	-
Pellet Load-out Bin	4	37'Ø	2500 LT	-
Bentonite Storage Bin	2	32'Ø	750 LT	-
<u>Feeders</u>				
Concentrate Table Feeder	10	11'Ø	100 LTPH	7-1/2
Bentonite Feeder	10	9"x3'	800 lb/hr	Frac.
Fines Vibrating Feeder	1	18"x60"	30 LTPH	-
Pellet Vibrating Feeder	4	36"x72"	200 LTPH	-
<u>Conveyors</u>				
Mixer Feed Belt Conveyor	10	30"x25'	42 LTPH	2
Mixer Belt Conveyor	10	30"x23'	42 LTPH	2
Drum Feed Belt Conveyor	10	30"x32'	105 LTPH	3
Seed Collecting Belt Conveyor	10	84"x22'	63 LTPH	1
Seed Return Belt Conveyor	10	30"x60'	63 LTPH	3
Seed Transfer Belt Conveyor	10	30"x15'	63 LTPH	1
Ball Collector Belt Conveyor	10	30"x25'	42 LTPH	2
Reciprocating Belt Conveyor	2	30"x205'	210 LTPH	4
Grate Feed Belt Conveyor	2	12'3"x20'	210 LTPH	3
Grate Undersize Belt Conveyor	2	54"x27'	4 LTPH	1
Grate Fines Flight Conveyor	2	3"x65'	3 LTPH	3
Grate Fines Belt Conveyor	4	18"x142'	5 LTPH	2

<u>Name</u>	<u>No. Units</u>	<u>Size</u>	<u>Rating</u>	<u>HP Each</u>
<u>MECHANICAL EQUIPMENT</u>				
<u>Conveyors (continued)</u>				
Regrind Feed Belt Conveyor	1	18"x105'	20 LTPH	3
Pellet Belt Conveyor	1	30"x565'	390 LTPH	50
Pellet Shuttle Belt Conveyor	1	30"x60'	390 LTPH	3
Pellet Stockpile Belt Conveyor	1	30"x110'	390 LTPH	3
Fines Bucket Elevator	1	60' Lift	20 LTPH	7-1/2
<u>Belt Scales</u>				
Mixer Feed Belt	10	30"	42 LTPH	Frac.
Ball Collector Belt	10	30"	42 LTPH	Frac.
Regrind Feed Belt	1	18"	20 LTPH	Frac.
Pellet Belt Conveyor	1	30"	390 LTPH	Frac.
<u>Pumps</u>				
Regrind Fines Return Pump	1	3"	200 GPM	15
<u>Bentonite Handling</u>				
Blower	1	300 cfm at 15" S.P.		1-1/2
Air Slide Conveyor	1	8"x70'	50 LTPH	-
Pump	1	9"		60
Compressor	1	-	775 cfm at 70 psi	75
<u>Screens</u>				
Ball Seed Screens	10	5'-14'	105 LTPH	20
Grate Feed Screens	2	12'3"x9'7"	210 LTPH	20
<u>Mixers</u>				
Concentrate Mixer	10	30"x13'	42 LTPH	2 at 10
<u>Balling Drums</u>				
	10	9'Øx30'	42 LTPH	63

<u>Name</u>	<u>No. Units</u>	<u>Size</u>	<u>Rating</u>	<u>HP Each</u>
<u>MECHANICAL EQUIPMENT</u>				
<u>Traveling Grates</u>	2	12'3"x126'5"	210 LTPH	88
<u>Rotary Kilns</u>	2	17'Øx140'	200 LTPH	525
<u>Burner</u>	2	-	2000 GPH	25
<u>Coolers</u>				
Annular Cooler	2	40'Øx7'	200 LTPH	18
Rotary Cooler	2	8'Øx22'	200 LTPH	100
<u>Ball Mill</u>	1	3'x3'	20 LTPH	15
<u>Spiral Classifier</u>	1	24"x13'	20 LTPH	3
<u>Fans</u>				
Second Pass Gas Fans	4	342,000 cfm at 450° F, 7" S.P.		300
First Pass Gas Fans	4	223,000 cfm at 800° F, 10" S.P.		700
Burner Primary Air Fan	2	14,000 cfm at 70° F, 14" S.P.		50
Annular Cooler Fans	2	140,000 cfm at 70° F, 20" S.P.		600
Rotary Cooler Exhaust Fan	2	50,000 cfm at 150° F, 6" S.P.		50
<u>Air Compressor</u>	1	-	100 cfm at 100 psi	25
<u>Dust Collectors</u>				
Grate Dust Cyclones	64	40"	12,000 cfm	
Pellet Load-out Gallery Dust Collector	1	-	15,000 cfm	25
Grate Fines Dust Collector	1	-	5,000 cfm	10
<u>Cranes</u>				
Balling Section Bridge Crane	1	63' Span	25 Ton	42
Grate Bridge Crane	1	102' Span	12 Ton	22
Cooler Jib Cranes	2	15' Beam	5 Ton	10

<u>Name</u>	<u>No. Units</u>	<u>Size</u>	<u>Rating</u>	<u>HP Each</u>
MECHANICAL EQUIPMENT				
<u>Unit Heaters</u>	20	-	100,000 Btu/hr	1/2
ELECTRICAL EQUIPMENT				
<u>Control Panels</u>				
Master Kiln Control Panel	2	-	-	3
Balling Control Panel	2	-	-	-

6.0 COST ESTIMATE

6.1 General:

The following are the estimated order of magnitude capital costs of the integrated beneficiation plant located between the Sandspit ore deposit and Lake Albanel as shown on Area Map, drawing C1-2:

<u>Description</u>	<u>Canadian Dollars</u>
1. Site Improvements and Yard Utilities (roads, parking areas, railroad, domestic water, fire, sewage and heating systems with distribution to the buildings).	\$ 3,200,000
2. Service Buildings (shop, warehouse, change house and office).	3,300,000
3. Yard Water System (pump house, pumps and pipelines).	1,200,000
4. Yard Tailings System (gravity ditch and culverts).	100,000
5. Yard Electrical System (transformer and gear, yard lighting and plant communications, pole lines, including pole line to townsite).	600,000
6. Primary Crushing Plant	1,500,000
7. Screen House and 125,000-ton Coarse Ore Stockpile (including covered coarse ore yard conveyors, and mill feed conveyors).	2,000,000
8. Fine and Coarse Ore Covered Storage (including reclaim tunnels).	4,500,000
9. Concentrating Plant	34,200,000
10. Filter Plant	2,700,000
11. Pelletizing Plant and Bentonite Storage	18,000,000
12. Pellet Loadout (including conveyors and emergency storage).	800,000
13. Sales Tax	<u>900,000</u>
Total Concentrating and Pelletizing Plant	\$73,000,000

6.2 Qualifications:

The following are the major qualifications for the above estimate:

1. The estimate is in Canadian funds.
2. The estimated Canadian Sales Tax is based on the Contractor buying for the Owner's account.
3. The above estimate includes \$2,250,000 for building approximately 90 miles of temporary access road from the termination of the existing road at the southern end of Lake Waconichi to Lake Albanel.
4. The estimate includes a temporary construction camp to house 500 men. It is assumed that the cafeteria and permanent housing facilities of the townsite will be available for the Contractor's use when built.
5. No allowance has been made for escalation.
6. Labor costs are based on present wage rates and on a 54-hour work week.
7. The price of the land, depreciation and amortization are not included.

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7.0 DRAWINGS

<u>Drawing Number</u>	<u>Title</u>
C1-1	Location Map
C1-2	Area Map
C1-5	Area Map (Kallio Lake Site)
C1-3	Plot Plan
F1	Basic Flow Diagram
F2	Pelletizing Plant - Flow Diagram
F3	Ore & Water Balance
M2-1	Primary Crusher - Plans & Sections
M3-1	Screen House - Plan & Sections
M3-2	Coarse Ore Storage - Plan & Sections
M3-3	Conveyor Schedule
M3-4	125,000 Ton Ore Pile - Plan & Sections
M5-1	Concentration Plant - Plans
M5-2	Concentration Plant - Sections
M7-1	Concentrate Filters - Plans
M7-2	Concentrate Filters - Sections
M9-1	Service Water Pump House
M8-1	3,000,000 Long Ton per Year Pelletizing Plant - Plans & Sections
M8-2	Pellet Load Out Bins - Plan & Sections
M6-1	Additive Handling Layout & Flow Diagram
E-0-1	Single Line Diagram
E-0-2	Pelletizing Plant - Single Line Diagram
C2-1	Combined Administration & Change House Facility
C2-2	Sandspit Plant Service Building

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PART III - STOCKPILING & LOADING FACILITIES

1.0 GENERAL

2.0 REQUIREMENTS

- 2.1 General
- 2.2 Capacity
- 2.3 Site
- 2.4 Handling of Pellets

3.0 DESCRIPTION OF FACILITIES

- 3.1 Railroad Yard and Car Unloading Hopper
- 3.2 Stockpile
- 3.3 Dock and Shiploading
- 3.4 Service Building
- 3.5 Utilities
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4.0 LIST OF MAJOR EQUIPMENT

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PART III - STOCKPILING & LOADING FACILITIES

1.0 GENERAL

This part of the report concerns Bechtel's study of the combined winter stockpiling and vessel loading facilities. Included is the selection of the site, the preliminary design and order of magnitude costs.

Although the facilities are designed specifically for receiving pellets shipped by rail from Albnel, the stockpiling and vessel loading facility will operate in the same manner and as efficiently if the pelletizing operations are located in the immediate vicinity.

Previously Albnel Minerals, Limited have concluded that the logical location of the shipping port for its pelletized product should be located on the Saguenay River. A shipping dock located here could load ocean-going vessels and serve as an outlet to world trade via the St. Lawrence River.

During the course of their studies, Albnel Minerals, Limited determined that none of the existing facilities on the Saguenay were capable of storing the tonnage of pellets produced during the 5 winter months while water transportation is impossible.

Several potential sites on Saguenay River below Chicoutimi and in Ha Ha Bay were suggested in reports previously submitted. After having studied the reports, and inspected the several sites considered, Bechtel has determined that the Ha Ha Bay site is best suited for the purpose intended. Preliminary designs of the various facilities at this site were then developed and cost estimates prepared.

While gathering data in regards to the Ha Ha Bay docksite, Bechtel was approached by Saguenay Terminals, Limited who operate the dock facilities for the Aluminum Company of Canada, Limited. They indicated that their Company owned land adjoining to their operations at Bagotville and would be interested in constructing and operating a new wharf for Albnel Minerals, Limited on a wharfage rental basis with a wharfage charge per ton handled. Bechtel concluded that the development of a stockpile and vessel loading facility on the land owned by the Aluminum Company would require a considerable amount of fill to provide a wharf surface at an elevation to suit the tidal conditions. Also, further dredging would be required to obtain sufficient draft for the large ore carriers which will be used for ocean trade.

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2.0 REQUIREMENTS

The following requirements were established as a basis for the design of the stockpiling and vessel loading facilities:

2.1 General:

The nature of all possible materials to be handled over the dock facility was considered as well as the type of carrier and form in which they would be delivered. It was concluded that the dock should be designed for the single purpose of handling pellets and the bulk supplies would be handled as follows:

- a) Bentonite: Bentonite will be loaded into cars in western Canada and delivered to the pelletizing operation by all rail transportation.
- b) Limestone: Limestone is available in the Lake St. John area.
- c) Fuel Oil: There are existing commercial facilities at nearby Chicoutimi for receiving vessel shipments of fuel oil. The oil companies who are interested in supplying Albabel Minerals, Limited with fuel oil can be induced to provide the storage necessary to support the operation during the winter non-shipping season.
- d) Grinding Media: The decision to use all autogenous methods of grinding has eliminated the need for rods and balls.
- e) Other Supplies: All other supplies are handled in car-load lots from inland Suppliers.

2.2 Capacity:

The following criteria are assumed for sizing the equipment.

- a) Generally in the Bagotville vicinity no work is done on Sundays in compliance with the Lord's Day Act (Chapter 171 of the Canada Revised Statutes 1952). The unloading of cars and the stockpiling of pellets is restricted to six days per week on a single shift basis.

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- b) The pellet stockpile is sized for 5 months production during the winter non-shipping season when the Ha Ha Bay is frozen. The stockpile has capacity for 1,250,000 long tons of pellets.
 - c) Facilities are provided to load pellets into any type of present day lake or ocean-going carrier. Consideration was given to future carriers of 50,000 tons capacity having a beam width up to 120 feet.
 - d) Loading rates are variable up to 4500 long tons per hour depending upon the type of vessel and location of ships hatches. Under normal conditions the entire cargo can be loaded with the vessel in one position.

2.3 Site:

The following criteria applies to the site selection:

- a) No dredging is required for vessels having up to 39 ft. draft.
- b) A minimum cost for excavation in preparing the site.

In general, the stockpile base follows the natural slope of the ground.

- c) There is adequate turning room in the bay for the largest vessels.
- d) The vessels are protected from severe northerly winds by the steeply rising headland while at the loading dock.
- e) Facilities are provided for the vessels to take on potable water and fuel oil during the pellet loading operation.

2.4 Handling of Pellets:

The following criteria are used for handling pellets:

- a) A minimum of transfer points are used to stockpile, reclaim and load pellets into vessels.
- b) The height of fall of a pellet into storage is kept a minimum

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by using pellet ladders.

- c) Special pellet shipments are made by transferring the pellets through an enclosed pellet ladder onto one of the reclaiming belt conveyors without becoming mixed with other pellets in the pile.
- d) The stockpile can receive pellets at any time. No special preparations need be made.

3.0 DESCRIPTION OF FACILITIES

3.1 Railroad Yard and Car Unloading Hopper:

The railroad yard consists of three empty car and three loaded car tracks with a car unloading hopper separating them. The tracks are sloped for gravity movement of cars to the unloading hopper and to the empty car tracks. A string of approximately forty cars is lowered by gravity on each of the two tracks over the unloading hopper. The strings are controlled by the car brakes activated by compressed air supplied by hose from a stationary air supply. The system is capable of unloading 120 cars per 8 hour shift.

The unloading hopper has a capacity of 600 long tons and is excavated from rock. The hopper is unlined and has a gate and chute to control the rate of feeding the tripper conveyor.

3.2 Stockpile:

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The base of the stockpile covers an area 600' by 900' between the unloading hopper and the dock. A 36" tripper conveyor with a traveling tripper car having a design rate of 1500 LTPH is carried on a steel truss over the pile and supported by five steel bents. This conveyor is fed from the car unloading hopper. The tripper discharges onto an open pellet ladder used for lowering the pellets without degradation. After the pile is brought to full height, it is extended by inching the tripper car forward to discharge on the face of the pile.

The approximate capacity of the storage pile is 1,250,000 LT and is equal to five months' pellet production. The design takes advantage of the sloping site and, except for final clean up before the end of the navigation season, reclaiming is from live storage.

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Below the pile there are three 36" reclaim conveyors, each installed in a tunnel driven through the rock base and unlined. Each conveyor has a design capacity of 1,500 LTPH and feeds the shiploading conveyor at each of three vessel loading towers of the dock. Pellets from the stockpile reach each reclaim conveyor by way of twenty 16" diameter vertical holes drilled in the rock over the tunnel. Feed from these holes is controlled by gates and chutes. The reclaim tunnels are interconnected by cross tunnels for access.

3.3 Dock and Shiploading:

The dock consists of three loading towers spaced at 200' centers. Each tower has a boom conveyor that can be retracted to clear the ship during docking or extended up to 120'. The boom conveyor can also be rotated through a 180 degrees and these two motions allow each shiploading conveyor to cover an area 120' by 200'. Each of the three 36" boom conveyors has a capacity of 1500 LTPH. With this arrangement, any ship, from an 8,000-ton lake carrier to a 50,000-ton ocean-going ship of the future, can be loaded in a minimum of time without warping along the dock. The boom conveyor is fifty feet above high tide to allow loading even the largest ship without ballast.

3.4 Service Building:

The service building contains administrative offices, laboratory, change house, machine shop, garage, power distribution center and heating plant. The building is 40 x 180 x 13 feet high with a steel frame, insulated metal siding, and insulated built-up roof. Change facilities are provided for 32 men. Foremen change area is separate. The machine shop is designed for light repair work and general maintenance. Garage facilities are provided for light trucks and snow removal equipment.

3.5. Utilities:

a. Domestic Water:

A 75-gpm well pump near the bank of the Benjamin River supplies fresh water for the service building, and arriving vessels. Well water is pumped through a 4-inch pipeline to a 100,000 gallon storage tank located on the hill for gravity distribution to the dock. A small chlorinator automatically injects chlorine solution into the pump discharge line while the pump is operating. A 6-inch pipeline from the storage tank terminates at a hydrant connection at the dock for filling of the fresh water tanks of the ships.

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b. Fire Protection:

A 50,000 gallon reserve storage in the water tank is provided for fire protection. A buried fire line from the tank feeds fire hydrants at the service building and dock area. Provisions is made to drain the above ground portions of the line during freezing weather.

c. Electrical System:

The loading dock power system will consist of a 480-volt radial system utilizing conduit and cable tray as required. A simple substation will be established at the dock to transform the power from the Saguenay Power Company line. The class of equipment and distribution system will be similar to that described for the Beneficiation Part II of this study. The dock area will be lighted for night operation.

3.6 Vessel Refueling:

A 30,000 barrel tankfarm, located at the southside of the dock area, consists of two 55-foot diameter by 40 feet high insulated steel tanks and two 500 gpm rotary pumps. The pumps and a metering unit are housed in a shed near the tanks. A steam-traced oil pipeline is extended to the dock. Steam heating for the tanks and the fuel oil unloading station at the trackage is provided by the boiler in the Service Building.

LIST OF MAJOR EQUIPMENT

<u>Mechanical Equipment</u>	<u>No. of Units</u>	<u>Size</u>	<u>Nominal Rating</u>	<u>Total Hp each Unit</u>
Belt Conveyor w/Tripper	1	36" x 900'	1500 LTPH	125
Reclaiming Belt Conveyor w/Electric Brake	3	36" x 1120'	1500 LTPH	25
Apron Feeder	3	36" x 10	750 LTPH	7-1/2
Tunnel Gate	7	24"	300 LTPH	-
Shiploading Tower w/Belt Conveyor Boom	3	Boom radius: 120' Conveyor: 36" x 125'	1500 LTPH	100
Air Compressor w/Receiver	1		150 CFM	15
Tank for Fuel Oil No. 2	1	8' dia. x 8' High	2800 GAL.	-
Tank for Bunker Oil	2	55' dia. x 40' High	630,000 GAL.	-
Pump For Bunker Oil Supply	2		100 GPM	5
Boiler w/Accessories	1		500,000 BTU/HR.	2
Load Center (indoors)	1 Lot		480 V (Dist. Voltage)	
Incoming Section	1			
Transformer	1		480 V, 3Ø 500 KVA	
Circuit Breaker	1		480 V, 800 A	
Circuit Breaker	1		480 V, 600 A	
Circuit Breaker	1		480 V, 225 A	

4.0

LIST OF MAJOR EQUIPMENT - Continued

<u>Mechanical Equipment</u>	<u>No. of Units</u>	<u>Size</u>	<u>Nominal Rating</u>	<u>Total HP each Unit</u>
Motor Control Center	1 Lot		480 V	
Combination Starters	12		480 V, Size 1	
Combination Starters	7		480 V, Size 2	
Combination Starters	3		480 V, Size 3	
Combination Starters	2		480 V, Size 4	
Lighting Transformers	1		480-208/120 V, 3 ϕ , 25 KVA	

5.0 COST ESTIMATE

The estimated order of magnitude cost of the combined stockpiling and vessel loading facilities complete with service building tracks, roads, water supply and vessel oil fueling facilities are as follows:

<u>Description</u>	<u>Canadian Dollars</u>
Site Improvements (including access roads, empty and loaded yard trackage).	\$ 460,000
Water Supply (including wells, pumps, pipe, and storage tank.	70,000
Service Building (complete with equipment)	300,000
Stockpiling Equipment (including unloading hopper, tripper car conveyor, supporting bents and trusses.	1,100,000
Reclaiming and Vessel Loading Equipment (uncluding tunnels, conveyors, and caissons	3,900,000
Sales Tax	<u>170,000</u>
Total Cost	\$ 6,000,000

Qualifications:

The estimate is qualified by the following major considerations.

1. The rock at the Ha Ha Bay site is solid and capable of withstanding the loads imposed over the unlined tunnels.
2. No dredging is required.
3. Approved potable water, in adequate quantities, is available from wells drilled on the property.
4. Construction work is done in a 54-hour week.
5. Costs are current, November 1960 prices.
6. No escalation is applied.
7. No construction camp is required.

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PART IV

PART IV - PUMPING OF CONCENTRATES

1.0 GENERAL

The purpose of this part of the study is to determine whether the economies of a pipeline for the transportation of concentrates for this project justify further research into the technical phases of the problem. With this in mind, we have developed a system for pumping the concentrate which we believe to be the most likely solution to the problem. Whether it is the best solution can only be determined from test data. However, we believe that our cost estimate is representative of any reasonable solution. It should be noted that the estimate is order-of-magnitude only, and was made without benefit of a field survey.

The most significant feature of this project is that no iron ore pipeline of this size and length has ever been built. None of the existing ore lines is more than a few miles long. There are two long pipelines, however, which do successfully transport solids. One is Consolidated Coal Company's 108-mile 10-inch coal line in Ohio, and the other is Standard Oil Company of California's 72-mile 6-inch gilsonite line in Utah. These lines, however, carry materials with densities less than half that for iron concentrates.

In view of this lack of experience, and because there is meager laboratory data, the technical feasibility of an ore pipeline is subject to question. Before such a line can be given serious consideration, a thorough test program using a pilot test loop is needed.

With a test loop the actual technical feasibility of the pipeline can be quickly determined with a minimum expenditure. A longer testing period is needed later to determine wear factors.

The following would be learned from the test program:

1. The angle of repose of concentrates in water is needed to determine maximum allowable pipe slopes.
2. The physical behavior of the actual concentrates.
3. The ability to start the pipeline again after a prolonged shutdown without flushing.
4. The ability of the positive displacement type

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pump to handle concentrates.

5. Actual wear data on pump parts, valving and pipeline.

In our order of magnitude cost estimate for the pumping system we have allowed for research and development. It is contemplated that a test loop be set up using prototype equipment for pumping the actual Albanel concentrates, of the same physical characteristics as those which will be produced in the commercial operation. We believe that with a minimum initial expenditure, the technical feasibility of pumping concentrates will quickly be learned. The pipeline would be operated in exactly the same manner as contemplated for long distance pumping. The ability to start again without flushing would be thoroughly tested. Later, the system would be operated for a sufficiently long period to obtain accurate wear data on the pipe, pump, and valves. This data is required for preparing more accurate operating cost estimates.

The transportation of concentrates by pipeline has considerable merit. The major advantages are as follows:

1. Approximately 200 fewer houses are required at Lake Albanel as it is assumed that the employees associated with the pelletizing operation could obtain their own housing in the nearby towns of Bagotville, Port Alfred, and even as far away as Chicoutami.
2. Freight from the Chicoutami area to the plant at Lake Albanel on approximately 75,000 ST of oil required for pelletizing is saved annually.
3. The Company would not be subjected to increasing railroad tariffs over the years.

Investigations made by Bechtel in this study are preliminary in nature, being made from existing general area maps and without the benefit of field surveys.

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2.0 DESIGN CRITERIA

Certain assumptions have been made in order to proceed with a preliminary investigation. These are as follows:

1. The pipeline must be arranged for fully automatic operation and with as few operating personnel as possible. Experience has shown that if a pipeline is to be competitive with other means of transportation, such as a vessel or rail, the pipeline must be made to operate continuously and as though it were handling gas or petroleum products.
2. It is assumed that the concentrates are finely ground to approximately 90% minus 325 mesh and the specific gravity of the dry solids is approximately 4.6.
3. The plant will produce 3,000,000 LT of concentrates in 323 operating days per year.

3.0 DESCRIPTION

A pumping system suitable for this service has been designed using available data. It provides a single, 12-inch nominal diameter, steel pipeline buried for protection, extending 250 miles from Lake Albanel to Ha Ha Bay. Eight pumping stations spaced approximately thirty miles apart are each equipped with one operating and one standby positive displacement pump. The operation of these pumps is completely automatic as is the valving necessary for switching to the standby units.

Adequate storage for concentrates in the form of a slurry is provided at both ends of the pipeline to insure continued feed to both the pipeline and to the pelletizing plant. In addition to these concentrates, which are in the form for immediate use, facilities are provided to stock and reclaim larger tonnages of semi-dewatered concentrates both at Lake Albanel and at the pellet plant at Ha Ha Bay.

The following description covers the various aspects of the pipeline and pumping stations:

3.1 Route:

From a brief study of the existing maps and a single

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reconnaissance flight, a route has been selected. The pipeline leaves the plant in a southeasterly direction crossing the height of land approximately twenty miles distant to the headwaters of the Mistassini River. It follows the Mistassini River to the Lake St. John area and then easterly to the pelletizing plant located at Ha Ha Bay.

3.2 Pipeline Installation:

The only practical way to keep the pipeline from freezing is to bury it below the frost line. This is less expensive than attempting to heat or to insulate the line. For central Quebec, an earth cover of six to seven feet over the pipe is recommended. Conventional underground construction is specified for the concentrate line, except that sharp sag bends are avoided and the slope of all sections is kept well under the natural angle of repose for iron ore in water.

In our opinion the only practical basis for operating a line 250 miles long is to be able to stop and start it more or less at will, without regard to flushing. At a flow rate of 4.5 fps, flushing would require over three days if done from the mine end of the pipeline. It is more practical to stop the flow and allow the suspended concentrate to settle to the bottom and then start the line at the full flow rate so that the concentrate will immediately return to suspension. For this reason it is necessary to install the pipeline on grades less than the angle of repose of concentrates in water to prevent their flowing to low places causing plugging when the flow is interrupted. The practicality of this procedure must, of course, be proven by tests.

3.3 Pipe Size and Flow Rate:

A 12-3/4-inch O. D. steel pipeline is selected for transporting 3,000,000 long tons of iron ore concentrates per year. This pipe size is needed to attain the flow velocity for carrying the specified tonnage in suspension at approximately 60% solids. In our opinion, a minimum flow velocity of 4.5 feet per second is required to assure that no concentrates will settle out of the slurry. A flow rate any higher than this results in an uneconomical increase in pumping horsepower. The 4.5 fps velocity is based on the theoretical formula developed by Spells and the experience of the International Nickel Company at Copper Cliff, Ontario.

When the values given for the Albabel minerals concentrate are used in Spells' formula, the critical velocity is 3.7 fps. A velocity of 4.5 fps should, therefore, provide a reasonable safety factor since it is some 20% above the rate at which plugging will theoretically occur.

A check on the Creighton mill operation of the International Nickel Company using Spells' analysis shows a critical velocity of 3.9 fps for the nickel concentrates. The actual velocity in the eight-inch diameter concentrate pipeline in operation is 5.1 fps.

3.4 Pipe Specifications:

A 1/2-inch wall thickness AP1 5L-X42 non-cold, expanded pipe is selected for this service of transporting the Lake Albanel concentrates. The extra thickness allows for abrasion of the pipe. The amount of abrasion is primarily a function of particle size, hardness, density and velocity. The allowance used for abrasion and corrosion is 0.01 inches per year. For twenty years, the assumed life of the pipeline, a total of 0.20 inches is allowed. The 0.01-inch allowance is probably on the safe side and represents the midpoint in actual operating experience. Some ore lines have reported an erosion rate of 0.02 inches per year where fairly large particles are transported. On the other hand, Standard Oil Company reports that gilsonite caused no erosion in their experimental loop, and no allowance was put into their pipeline. In actual operation they are finding that sand impurities are causing some wear. The reasonableness of this allowance must be confirmed by experimentation.

The 1/2-inch wall thickness AP1 5L-X42 specification pipe selected for this service, after deducting the allowance for erosion, has adequate strength when subjected to an operating pressure of approximately 1,020 psi and with a maximum allowable pressure 25% greater, or 1,280 psi, which may occur at times of partial plugging of the line.

3.5 Type of Pumps:

Although centrifugal pumps are more commonly used for pumping concentrates and have been used for shorter pipelines, they are not satisfactory for a long line. Those manufacturers of centrifugal pumps contacted were reluctant to recommend them for this service. On the other hand, three manufacturers of positive displacement pumps had no hesitancy in saying this type would be suitable. Positive displacement pumps were, therefore, selected for this service.

Positive displacement pumps have the following advantages:

1. Only one pump is required at each pump station to produce the desired discharge pressure. If centrifugal pumps were used, four or five pumps would be operated in series at each station to produce the necessary head. Multiple-stage centrifugal pumps

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are not suitable for this severe service.

2. A constant flow rate is assured. With centrifugal pumps, any obstruction in the line reduces the flow rate unless the pumps are equipped with speed control. A reduction in flow rate must be avoided to prevent ore from dropping out of the slurry.
3. Changes in specific gravity do not affect the output pressure of the pump. When a slug of water passes through centrifugal pumps the pressure differential is cut in half since its specific gravity is nearly half that of the slurry. Yet, if most of the pipeline is filled with the slurry, the full discharge pressure is needed to produce the required flow rate.

Positive displacement pumps, of course, have two distant disadvantages.

1. They cause pressure pulsations and, therefore, usually require chambers to keep the pulsations within tolerable levels.
2. They are considerably more expensive than centrifugal pumps.

Both types of pumps require considerably more maintenance than pumps operating on clean fluids. Experience with these pumps on various types of pipelines carrying solids does not indicate that one is clearly superior to the other. The fact that high maintenance is to be expected leads us to prefer a small number of large pumps to many small pumps.

3.6 Number of Pumping Stations:

Eight pump stations, at approximately thirty-mile intervals, are required to limit the normal pipeline pressure to the 1,020 psi discussed above. This is based on a pressure drop of 45 feet per mile (35 psi per mile). Most of the investigators in the field of pumping solids state that slurry of fine particles pumps about as easily as clear water. Generally, tests indicate that fine slurry acts about the same as a fluid having a viscosity of water.

Using this viscosity and allowing 25% for the possibility of an unexpected increase in friction gives a head loss of 45 feet per mile.

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The 25% allowance is included because investigators in the field have found that the pressure drops cannot be accurately predicted. The effects of particle size and shape and concentration have not been adequately determined.

3.7 Automation of Pumping Stations:

Complete automation of the pump stations is provided. Since most of the pump stations are remotely controlled and are located in an uninhabited region, unattended stations are considered essential to economical operation. However, elaborate instrumentation is not necessary for positive displacement pumps. Either all pumps are on or all pumps are off. Small variation in the capacities of the pumps, due to faulty valves, etc., are compensated for by correspondingly small changes in the speed of the high-slip motor drives.

Because of the high cost of housing for employees if located near the pump stations, the maintenance crew will be based in one of the towns to the north of Lake St. John approximately midpoint of the pipeline. A helicopter will be used for speedy transport of maintenance men to a station requiring work. In this way one crew is able to service all the pumps quickly and at minimum cost. Although storms may interfere with helicopter flights, it is felt that surface transportation would also be impeded by storms, and the helicopter's speed advantage makes it the better choice.

3.8 Access Road:

An access road is required to service the pumping stations and pipeline. From Ha Ha Bay to the Dolbeau region the pumping stations may be reached from existing roads. North from the Dolbeau area along the Mistassini River there is approximately 160 miles of wilderness area through which a road will be constructed for servicing the pipeline.

3.9 Transmission Line:

Present plans are to rebuild the existing high-tension line from Lake St. John area to Chibougamau and to extend the line from Chibougamau to Lake Albanel. However, if the pipeline is built, the transmission line must follow the pipeline and access road to provide power for the pumping stations. We estimate an additional cost of \$500,000 to Quebec Hydro for the pipeline route.

3.10 Operating Schedule:

The pipeline will operate continuously throughout the year. With 100% spare pumping capacity available at the pump station, very little time will be lost due to pump failures. Since the pipeline has adequate cathodic protection, not more than ten days a year is expected to be lost due to leaks or breaks in the pipe. External corrosion of pipelines has been virtually eliminated by cathodic protection plus a good protective coating such as coal tar enamel with fiber glass inner wrap and felt outer wrap. Inner corrosion is more difficult to control but an adequate allowance has been made.

The major cause of lost time will be power outages. However, they are not expected to be of consequence as the power line serving the pumps is fed from either end.

3.11 Facilities for Preparation and Storage of Concentrates:

Final concentrates leaving the finisher magnetic separators contain 45% to 50% solids. These concentrates must be dewatered in three 50-foot diameter thickening tanks to approximately 60% solids for pumping.

A small surge capacity equivalent to approximately sixteen hours of production (6,200 tons) is provided in the concentration plant at Lake Albanel. There, concentrates are stored ready for pumping after dilution to maintain a uniform pumping rate. This surge is in the form of a 70% solid slurry stored in four 37-foot diameter by 37-foot high slurrifier tanks.

In addition to this, facilities are provided to store concentrates at Lake Albanel produced while the pipeline may be out of service several days for repair. This storage is in the form of an open trough into which concentrates are diverted and excess water decanted after the solids have settled out. A 53,000 C.Y. excavated trough provides storage equivalent to one week's production.

Concentrates will be reclaimed from the trough during the warmer months of the year by means of a crane mounted clamshell or drag line and trucks hauling to a feeder. The feeder will deliver concentrates to a revolving scrubber for repulping before reintroduction to the circuit ahead of the concentrate thickening tanks.

At the pelletizing plant located at Ha Ha Bay, the pipeline carrying concentrates from Lake Albanel will discharge into concentrate

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thickeners for dewatering ahead of filtering. In the event of a prolonged delay in the pelletizing section during which time it could not receive concentrates at the rate at which they are pumped from Lake Albanel, provisions are made to bypass the filtered concentrates to trucks for stockpiling until they are needed.

3.12 Research and Development:

We have allowed \$750,000 in the accompanying order of magnitude cost estimate for the research and the development of the pipeline to determine its feasibility. This includes the procurement and installation of prototype equipment in a test loop, and salaries and expenses for operating personnel. It allows sufficient time to establish wear factors for equipment after the basic flow characteristics of the Lake Albanel concentrate have been determined.

4.0 COST ESTIMATE

Order of magnitude capital costs of the pumping installation and appurtenances are estimated as follows: in Canadian dollars.

4.1 Capital Costs - Pipeline:

The following expenditures are estimated for the pipeline:

Pipeline	\$29,000,000
Pumping Stations	7,500,000
Proportionate share of access road	4,250,000
Increased cost of transmission line	500,000
Research and Development	750,000
Concentrate preparation equipment	<u>1,500,000</u>

Gross Capital Cost \$43,500,000

4.2 Saving in Plant Capital Costs:

The capital costs of the beneficiation plant and townsite have been predicated on the pelletizing operations being located at Lake Albanel and rail haulage of the pelletized product to Ha Ha Bay. If the pipeline is selected as the method of transporting the concentrates, some of the facilities included in these estimates may be reduced in size or eliminated entirely.

The magnitude of these savings is estimated as follows:

200 fewer houses for employees	\$ 3,600,000
Elimination of yard trackage at Lake Albanel and Ha Ha Bay	800,000
Elimination of pellet loading and unloading facilities	700,000
Estimated lower construction costs of the pelletizing facility if located at Ha Ha Bay	<u>800,000</u>
Total Estimated Savings	\$ 5,900,000

It should also be noted that the Canadian National Railroad has quoted a freight rate of \$0.67/Cwt. for fuel oil delivered to Lake Albanel and the CNR make a flat assumption that an imperial gallon weighs 8 lbs (approximately 10 lbs/Imp. gal. actual). Using this freight rate and an assumed 900,000 Btu/Ton of pelletized product, the annual cost of the freight to Albanel on the fuel oil for pelletizing alone is estimated to be \$800,000. This saving has not been credited to the pipeline, however, as it is expected that there may be an indeterminate increase in the freight cost of fuel oil used for heating and other plant and town supplies if these are moved by truck.

4.3 Annual Operating Expense:

The following are the estimated annual operating expenses of the pipeline and its auxiliaries:

Power (assumed at \$0.01/Kwh)	\$ 550,000
Operating labor: Pumping system	150,000
Maintenance: Pipeline, pumping stations, road	700,000
Helicopter Rental	<u>50,000</u>
Annual Operating Expense	\$1,450,000
Say	\$1,500,000

With the pelletizing plant located at Ha Ha Bay remote from the main operation at Lake Albanel, additional supervision and clerical help is required. Also maintenance labor is not as efficiently utilized as if all operations are together. For these items \$150,000 has been assigned as a debit to the pipeline, thus increasing the total operating cost to \$1,650,000.

4.4 Fixed Costs:

Annual fixed costs consisting of depreciation, amortization, interest on the debt, general taxes and insurance are not included.

5.0 CONCLUSIONS

From these preliminary examinations it appears that the long distance pumping of concentrates from Lake Albanel to Ha Ha Bay has considerable merit as a means of transportation. It should be emphasized that there is some question as to the technical feasibility. This, however, can be determined with a test loop using prototype equipment.

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PART V

TOWNSITE

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TOWNSITE

1.0 GENERAL

It will be necessary for Albanel Minerals, Limited to provide good housing in a well appointed but functional townsite to attract stable employees to its operations in this remote area.

The Provincial Government of Quebec takes an active interest in the establishment, management, and financial arrangements of all new mining communities through the regulatory powers of the Department of Mines and the Department of Municipal Affairs. Bechtel met with representatives of these governmental departments to ascertain their requirements, recent experience in developing similar mining communities, and their present views in light of this experience.

The various authorities have indicated that the Departments will offer full cooperation and assistance to Albanel Minerals, Limited in the development of the new town at Lake Albanel. They indicated that the Department of Mines will work with the Mining Company in the mutual development of an overall townsite plan following which they will then arrange to undertake the establishment of the community. They will undertake the physical installation of the survey, clearing of the site, building of roads, construction of sewers and water mains, completion of rough grading, and construction of a water intake pump-house and sewage treatment plant. These facilities will be designed to serve the fully developed townsite.

Land used for townsite purposes is provided by the Department of Mines and is sold as individual lots. The legal transfer is a Emphyteritic Lease of up to 99 years. Income received from the sale of the lots is retained in a municipal fund by the Department of Mines and used to reimburse it for the cost of the physical development of the townsite. The Mining Company sponsoring the town, in this case Albanel Minerals, Limited, purchases the requisite number of serviced lots it requires for constructing houses for its employees and company buildings. This number is estimated at 750 lots.

The Department of Mines also arranges the sale of the remaining developed lots for housing as well as sites allocated for industrial and commercial purposes to business concerns and private enterprises to

construct and operate the various establishments deemed necessary after due consultation with the mining company.

Under the terms of the Quebec Mining Act, the Mining Village is governed by a town "Manager", appointed by the Lieutenant-Governor in Council, for the initial period of up to five years during which time the Lieutenant-Governor may elect to appoint the first municipal council and convert the Village, by letters patent, into a town municipality, in accordance with the Act to Organize Mining Towns (Assented to, the 30th of January 1953).

2.0 SCOPE AND CRITERIA

The scope of Bechtel's study, in conjunction with the townsite, is to develop a unit cost for housing an employee of Albanel Minerals, Limited. As discussed in Part IV, Pumping of Concentrates, there is a possibility that the pelletizing operations may be located at Ha Ha Bay if pumping proves feasible. In this event the total number of housing units for Mining Company employees at Lake Albanel will be lessened. It is assumed that personnel employed in the operations at Ha Ha Bay will be absorbed in the nearby communities. This will relieve the Mining Company of the need of providing housing for this group.

For the purposes of developing a unit cost of housing per employee, Bechtel has estimated that housing for 1000 employees will be required if all operations are located at Lake Albanel and for 800 employees if the operations are divided between there and Ha Ha Bay. The actual head count of the estimated total number of employees on the Albanel Minerals, Limited's payroll may be obtained from the Operating Estimate, Part VI of this study.

The quality of housing, costs, and the composition of the population have been estimated based upon Bechtel's previous experience and research in the field. The housing criteria assumed will provide Albanel Minerals, Limited with a townsite adequately suited for its needs.

The following criteria has been developed for 1000 Mining Company employees:

2.1 Population Criteria:

The estimated population is classified into the following categories:

Employees of Albanel Minerals, Limited

Single	380
Married	<u>620</u>
	1000

Dependents of Employees

a. Wives	620
b. Children School Age & Above	1250
c. Children Below School Age	<u>620</u>
	3490

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Supporting Population

a. Married Workers	250
b. Wives	250
c. Children School Age & Above	500
d. Children Below School Age	250
	<u>1250</u>

TOTAL POPULATION 5740

2.2 Composition of Population:

These assumptions are made in order to develop the town plan and building requirements:

- a. 85% of the population are Roman Catholic.
- b. 80% of the population are French speaking.
- c. 60% of the children are school age (7 - 18 years).

2.3 Housing Criteria:

Housing requirements for company employees are established as follows:

<u>Houses</u>	<u>Bldgs.</u>	<u>Living Units</u>
Type A - 3 or 4 bedroom - 1 family	12	12
Type B - 3 or 4 bedroom - 1 family	36	36
Type C - 3 bedroom - 1 family	183	183
Type D - 3 bedroom - 1 family	300	300
<u>Apartments</u>		
1 and 2 bedroom units	3	90
<u>Staff Houses</u>		
20 bedroom units	5	100
<u>Bunk Houses</u>		
60 beds each	5	300

2.4 Company Financed Buildings:

In addition to housing facilities, it is assumed that the Mining Company will construct and operate the following buildings during the early life of the community in order to control and maintain a high standard of building and operating staff:

- a. Hospital
- b. Schools
- c. Community Center
- d. Fire Hall and Police Office
- e. Cafeteria
- f. Guest House

2.5 Privately Financed Buildings:

It is assumed that the new town will attract private enterprizes who will provide their own housing and places of business. Churches will be constructed privately; however, the Mining Company may find it expeditious to furnish the land, the cost of which is included in our cost estimate.

The privately financed structures are as follows:

- a. Churches
- b. Town Hall
- c. Sawmill
- d. Services including Shopping Center, Banks, Hotel, Laundry, etc.
- e. Professional and Business Offices
- f. Service Stations
- g. Theatre
- h. Housing for Non-Company Personnel

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3.0 TOWNSITE LOCATION AND DEVELOPMENT

The final location and layout of the town and site will be mutually developed with the Department of Mines. The preliminary plans contained in this study have been developed to the degree necessary to define the requirements for arriving at an estimated cost for housing each employee.

3.1 Preliminary Location:

The site selected for the townsite is shown on the Area Map Drawing No. C1-2 attached to Part II. This site, although close to the Sandspit operation, will also serve the future operations at Group "B" and other possible mining operations as it is located at the approximate center of the Alanel Iron Range. The townsite is protected to some degree from the prevailing winds by the rising ground to the west. It is situated on a sunny slope and drainage presents no problem. Soil conditions are believed to be such that will permit excavation for basements and utilities at low cost.

3.2 Preliminary Plan:

While the physical surveying, clearing of the site and the building of the roads, sewers, sewage treatment plant, water intake pumphouse, and water mains will be carried out by the Provincial Government a tentative plan has been developed as shown on the attached drawing C1-4.

3.21 Traffic Pattern:

The town is laid out with a loop road skirting the main townsite. Residential streets are not affected by through traffic and in the event of the second mine site being put into operation, this same loop feeds the town from both ends. Cul-de-sacs are avoided to facilitate winter maintenance. Areas are allocated for the townsite to expand.

3.22 Land Use:

The single employee housing and apartments are located close both to the commercial center and to the loop road to reduce, as far as possible, the walking distance for personnel.

School and community center are centrally located to provide the minimum travelling distance between these facilities and the houses.

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The shopping center is planned as an enclosed unit with a central covered courtyard where only foot traffic is allowed. Access to the stores is from this courtyard.

An industrial area is located away from the townsite and in an area that will allow rail sidings to be economically provided.

3.23 Electrical:

The Quebec Hydro-Electric Commission will supply electrical power to the mining operations and will also run a lower voltage line to distribute power and lighting throughout the town at no cost to Albanel Minerals, Limited. This cost will be recovered by way of charges to the consumer served. The details of any such arrangement will be worked out in cooperation with the Provincial Government and Quebec Hydro.

3.24 Highway:

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The construction of a highway from Chibougamu to Lake Albanel was assured when a Federal Provincial agreement was signed recently (article published in the October 20th, 1960 issue of the Northern Miner). It is assumed that this road will terminate at the townsite. A private road connects the townsite with the plant.

3.25 Railroad:

In the event it is decided to use rail haulage for pellets a railroad station and siding are provided as indicated on the plot plan. (Refer to discussion on the Pelletizing Plant location in Part II of this study.)

3.26 Air Strip:

The proposed townsite encroaches on the existing airstrip. A new airstrip is located approximately 1-1/2 miles from the center of town. The new runway is oriented in an east-west direction parallel to the prevailing winds. The airstrip is so situated that the runway may be extended and a second runway added at an angle of approximately 50 degrees with the primary runway.

The airstrip has a compacted mineral aggregate surfaced runway with a width of 100 feet and a length of 5000 feet suitable for Convair type aircraft of 39,000 pound gross weight. It is located

at an elevation of approximately 1500 feet and has a maximum longitudinal grade of 1.5 percent. Shoulders on either side of the runway are 50 feet in width, graded, and surfaced to support the weight of the aircraft. Total width of the airstrip clearing is 300 feet with a 1000 foot cleared area beyond each end of the runway.

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4.0 BUILDINGS AND STRUCTURES

Related experience has shown that it is necessary to furnish good housing and community services to attract desirable employees to a remote area and to encourage them to purchase their own housing. The following sections describe in general terms the quality of these buildings and services.

4.1 Mining Company Financed Housing:

4.11 Family Housing - is classified as follows in four general types for pricing:

Type A - Single family detached houses with 3 or 4 bedrooms, garage and basement to cover a ground area of approximately 1,300 square feet. This house will be designed to give 1,800 to 2,000 square feet of finished living area and made available to top management on a rental basis, as outlined elsewhere in this report.

Type B - Single family detached houses with 3 bedrooms and basement to cover a ground area of approximately 1,150 square feet. This house will be designed to give 1,500 to 1,700 square feet of finished living area and made available to supervisory personnel on a rental basis as outlined elsewhere in this report.

Type C - Single family detached houses with 3 bedrooms and basement to cover a ground area of approximately 1,050 square feet. This house will be designed to give 1,250 to 1,500 square feet of finished floor area and will be constructed for sale to employee, as outlined elsewhere in this report.

Type D - Single family detached houses with 3 bedrooms and basement to cover a ground area of approximately 950 square feet. This house will be designed to give 1,100 to 1,300 square feet of finished floor area and will be constructed for sale to employees as outlined elsewhere in this report.

4.12 Staff House:

Each staff house contains 20 bedrooms, 10 baths, a lounge and a small community kitchen. Each building has a gross

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area of 300 square feet per resident.

4.13 Bunk Houses:

Each bunk house contains thirty 2-man rooms, 2 main washrooms and a lounge. Each building has a gross area of 165 square feet per resident. Bunk houses are 2 floors high. In our cost estimates for the construction camp we have assumed that the bunkhouses will be available for construction personnel.

4.14 Apartments:

Each apartment block contains thirty apartments each with 1 or 2 bedrooms, for rental to employees, fully serviced with main and escape stairways, central laundry room, incinerators and are complete with kitchen equipment including refrigerators and stoves. Each block is 3 floors high with a basement for lockers and other communal rooms.

4.2 Other Mining Company Financed Housing:

It is assumed that Albabel Minerals, Limited will construct the community a hospital, schools, fire and police stations and a community center. Cost of the operation of these facilities is not included in the estimate.

Descriptions of these are as follows:

4.21 Hospital:

A 10-bed facility provides medical, dental, maternity care and limited surgery. Laboratory, X-ray and dispensary equipment are included. As noted for the cafeteria it is the intention to construct the hospital at the same time as camp construction for its use during the construction period.

4.22 Schools:

Schools are provided for children ages 7 to 18 according to the population and religious assumptions previously stated. Based on a gross area of 70 square feet per pupil, the total areas allowed are 70,000 square feet for Roman Catholic and 17,000 square feet for Protestant. Classrooms provided are as follows:

	<u>Pupils</u>	<u>Classrooms</u>
Roman Catholic	1,000	32
Protestant	250	9

Both schools have been located in the same area so common facilities may be shared.

4.23 Community Center:

The community center consists of an ice hockey rink 180' x 80', two curling rinks 160' x 25', eight bowling alleys 95' x 45', and a community room 200' x 90', offices, and washrooms.

The development of outdoor playing areas are not included as part of this study but areas are allocated for such activities.

4.24 Fire Station and Police Station:

Included in the Fire Station is space for a garage 50' x 30' for fire fighting equipment with a hose storage and drying area, a locker room with showers and an office with central alarm system.

The Police Station contains three cells, wardroom and offices.

4.25 Cafeteria:

The cafeteria covers a ground area of 14,000 square feet and has a full basement for refrigerated storage, meat shops, preparation rooms and vegetable storage. The ground floor section contains a kitchen including all equipment, the main dining room is adequately large for providing meals and box lunches for 400 persons and the staff dining room has space for serving meals to 100 persons.

It is the intention to construct the cafeteria as early as possible during the temporary camp construction period for use during the main construction period.

4.26 Guest House:

The guest house provides accommodation for 10 people and consists of 10 bedrooms, 5 baths, a small community kitchen and a lounge.

4.3 Privately Financed Buildings:

Although the buildings described under this section are assumed to be privately financed, the details, based on similar projects are submitted for general information.

4.31 Churches:

The area of church buildings is estimated as follows:

	<u>Square Feet</u>
Roman Catholic (Including Parish Hall in basement and rectory)	13,000
Protestant (Including full basement) It is assumed in the estimate that the Company will donate the land for both	1,650

4.32 Town Hall:

The Town Hall contains offices, conference rooms and a court room. It has a floor area of approximately 10,000 square feet.

4.33 Shopping Center and Services:

The shopping center is adequately large for the following:

	<u>Square Feet</u>
2 General Stores	80,000
Hotel - 20 bedrooms	12,000
2 Banks	5,000
1 Restaurant	3,000
12 Private Shops	12,000
1 Post Office	4,000
1 Laundromat	1,200
	<u>117,200</u>

Other services not in the shopping center provides for the following:

	<u>Square Feet</u>
3 Service stations with garage repair and parking	120,000
Business Services	20,000
Professional Services	10,000
Theatre to seat 300 (Including parking)	<u>15,000</u>
	<u>165,000</u>

As previously indicated the shopping center area is designed to provide for mainly foot traffic, and access to each facility is covered and heated. Parking space is provided on the perimeter of this complex with exits and entrances as required into the central walking zone.

Excluded from, but adjacent to, this complex is the hotel, theater, and service stations.

4.4 Housing for Non-Company Personnel:

Discussions with the Department of Mines of the Provincial Government have indicated that the arrangements for commercial and industrial enterprises to erect business establishments at Lake Albanel will be made through their offices. Zoning of the land required for such establishments will be carried out in conjunction with the Mining Company at the outset. Similar arrangements will be made with respect to the housing for these people. The attached townsite cost estimate does not include housing for non-company personnel.

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5.0 COST ESTIMATE

The estimated average costs per employee have been developed for both an 800 and 1000 employee nominally sized town.

5.1 Criteria and Assumptions:

Preceding paragraphs have described the quality of the housing and services provided by Albanel Minerals, Limited, the Provincial Government and private enterprizes.

Discussions with the Central Mortgage & Housing Corporation, who administer and insure loans from approved lenders through the National Housing Act of Canada, have shown that it is reasonable to expect that loans will be available to a builder and/or the Mining Company for the construction of those housing units intended for sale to employees.

In order for the Company to interest the employees in the purchase of their own homes, it will be necessary to construct well designed, well constructed and attractive houses at a price which will establish total monthly payments of less than 30% of the employees' gross income (mortgage payments plus taxes). There appear to be many different ways in which the construction and sale of these units may be handled and no attempt has been made to determine the final complex financial arrangements required to cover the various aspects of this matter. However, the following points deserve special mention:

- a. It may be necessary to incorporate some form of buy-back feature to provide the employee with an assured sale when it may be necessary to restrict the sale to other Mining Company employees.
- b. It may be necessary for Albanel Minerals, Limited to invest a certain amount of money in the lots and houses to bring them within the financial means of the employees. This has been considered in arriving at the average cost of housing.
- c. To obtain the minimum construction cost, it is suggested that the Mining Company may secure competitive bids on the construction of a large number of units from reputable builders and award the work by contract. In addition, it is suggested that the Mining Company establish the actual

selling price of these units to the employees. This would enable the Mining Company to obtain both the lowest possible construction cost and also control the selling price. If this plan is followed it would be necessary for the Mining Company to obtain the National Housing Authority loans directly, and later transfer them to the purchasers of the houses.

5.2 Estimated Average Cost per Employee:

The estimated average capital cost for housing each employee of Albnel Minerals, Limited consists of the cost of the land and services purchased from the Provincial Government, the house, and the proportionate share of the public buildings provided by the company for the public welfare. This total cost per employee is reduced by the amount of the mortgage assumed by the employee when he purchases the house. The average costs are estimated to be as follows for the two sizes of town considered in Canadian dollars:

1000 Nominal Size Town:

\$22,000	average investment per employee
\$22,000,000	total investment for 1000 employees
\$15,000	average capital expenditure per employee
\$15,000,000	total capital expenditure for 1000 employees

800 Nominal Size Town:

\$23,000	average investment per employee
\$18,400,000	total investment for 800 employees
\$16,000	average capital expenditure per employee
\$12,800,000	total capital expenditure for 800 employees

Not included in the above are management's expense in developing the town nor operating costs of the hospital and schools.

5.3 Basis for Construction Costs:

The following criteria was used as the basis for estimating the costs of housing construction:

- a. 54-hour work week during construction
- b. Pricing is current in Canadian dollars
- c. No allowance for escalation in construction costs

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6.0 REFERENCES:

The following were contacted in connection with the townsite study:

Quebec Provincial Government:

Department of Mines -

Mr. Bertrand Denis, Acting Deputy Minister

Mr. L. A. St. Pierre, Superintendent of Public Works

Mr. R. Tachereau, Superintendent of Mining Operations

Department of Municipal Affairs -

Mr. Jean-Louis Doucette, Deputy Minister

Department of Hydraulic Resources -

Mr. A. Dussault, Q. C. Deputy Minister

Central Mortgage & Housing Corporation:

Mr. R. E. Gohier - Director of Sales

Mr. G. Perron - Manager of Sales

Albanel Minerals, Limited, Ottawa

Mr. Walter Sutton - Project Engineer

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PART VI - OPERATING COST ESTIMATE

1.0 GENERAL

The following operating cost estimate includes all of the direct charges per long ton of product delivered aboard a vessel attributable to mining, concentrating, pelletizing, stockpiling and loading. Royalties, fees, taxes and capital amortization are not included.

2.0 PLANT OPERATING COSTS

The costs included in the following estimate contain the following: operational labor, supplies, services and power costs as reflected by the consumed kilowatts, maintenance labor, materials and services. A replacement cost for mobile mining equipment has been included with the mining costs.

2.1 Qualifications

- a. Labor costs are based on the C.I.O. United Steel Workers of America indicated wage rates effective in the area, and have been adjusted for vacations, holidays, overtime, payroll taxes, pensions and other employee benefits. No adjustment was included for shift differential as we understand there is none. Labor costs and manpower requirements are based upon a 40-hour work week per man.
- b. Operating and maintenance costs are based on average conditions and reflect present day material costs.
- c. Cascade grinding mill and Allis-Chalmers-Lellep pelletizing plant operational cost data at present is limited. The operation and maintenance costs reflected herein are those which we believe to be reasonable and compatible with the information we have at present.
- d. Electric power has been calculated at a rate of \$0.008 per KWH which applies for an annual plant rating of 40 MW.

2.2 Plant Data Used in Obtaining Operating Costs

2.21 General

Crude Ore - Long Tons Total		254,700,000
Concentrates - Long Tons		76,100,000
Tons Crude Ore per Year		10,000,000
Tons Concentrates per Year		3,000,000
Percent Recovery		30.00
Rock Stripping	Cubic Yards	29,700,000
	Tons	66,900,000
Surface Stripping	Cubic Yards	8,600,000
	Tons	10,700,000
Shifts per Day		3
Life of Mine - Years		25

2.22 Mining

a. <u>Drilling:</u>	Tons/Ft.		Equip.	
	<u>Hole</u>	<u>Ft./Hr.</u>	<u>Life</u>	<u>Avail.</u>
Jet Piercers (ore)	33.75	16.00	10 Yrs.	73.5%
Rotary Drill (rock)	25.50	11.50	10 Yrs.	50.5%

A Drill Replacement Cost of \$0.007/LT ore is included.

b. Electric Shovel:

6 yd. 150-B with 5 yd. Bucket with 55% operating availability. 120° swing and 0.8 Bucket Factor.

<u>Material</u>	<u>Long Tons/Shovel Shift</u>
Ore	3000
Rock	4400
Overburden	4600

c. Diesel Truck:

40-Ton - End Dump.

Truck Cycle on Ore:

Average length of haul 6840 ft. or 1.295 miles.

	<u>Miles</u>	<u>Hours</u>	<u>Min.</u>
Haul Time	$\frac{1.295}{20.8}$.0623	3.74
Return Time	$\frac{1.295}{22.3}$.0581	3.49
Turning and Dumping			1.75
Spotting			.50
Waiting and Miscellaneous			<u>2.00</u>
			11.48

Truck use factor of 80%.

Truck Cycle on Rock and Earth Stripping:

Average length of haul 7000 ft. or 1.326 miles.

	<u>Miles</u>	<u>Hours</u>	<u>Min.</u>
Haul Time	$\frac{1.326}{20.8}$.0638	3.83
Return Time	$\frac{1.326}{22.3}$.0595	3.57
Turning and Dumping			1.75
Spotting			.50
Waiting and Miscellaneous			<u>2.00</u>
			11.65

Truck use factor of 80%.

A Truck Replacement cost of \$0.021/LT ore is included.

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d. Explosives:

Pounds Explosives/LT

Ore	.52
Rock	.38

e. Roads and Dumps:

Tractor and Grader. Replacement cost of \$0.005/LT ore is included.

f. General Pit Expense:

A miscellaneous mobile equipment replacement cost of \$0.004/LT ore is included.

2.23 Concentrator

a. Power:

Total Concentration Plant power assumed to be 22.2 KWH/LT at motor terminals. Grinding power assumed to be 15.4 KWH/LT at motor terminals.

b. Mill Liner Wear:

0.34 pounds/LT - Autogenous Mill.
0.15 pounds/LT - Pebble Mill.

Liner Steel cost estimated at \$0.25/pound.

2.24 Pelletizing Plant

a. Fuel Cost:

Cost per LT Pellets

No. 6 Fuel Oil	
Basic Cost \$0.07/Imp. Gallon	
at Bagotville 900,000 BTU	
required per LT pellets	
174,140 BTU/Imp. Gallon	\$0.362
Freight at \$0.67/CWT to	
Albanel 8lbs/gallon used by	
C.N.R.	<u>0.277</u>
Total	\$0.639

b. <u>Additive Cost:</u>	<u>Cost per LT Pellets</u>
Bentonite	
Basic Cost \$11.50/ton f.o.b.	
Rosalind, Alberta 12lbs/LT required	\$0.069
Freight at \$1.31 CWT to Albanel	<u>0.157</u>
Total	\$0.226

c. Power:

Total Pelletizing Plant power assumed to be
15.0 KWH/LT at motor terminals.

2.3 Direct Operating Costs

	<u>Cost Per Long Ton</u>		
	<u>Crude</u>	<u>Pellets</u>	
	<u>Ore</u>	<u>Pellets</u>	<u>Cumulative</u>
2.31 Mining and Stripping	\$0.605	\$2.018	\$2.018 ✓
2.32 Concentration	0.642	2.139	4.147
2.33 Pelletizing and Loading	--	1.576	5.733
2.34 Stockpiling and Shiploading	--	0.175	5.908
2.35 General Operating Expense	--	0.468	6.376
2.36 Rail Freight	--	2.550	8.926
Total Estimated Operating Cost Loaded Aboard Vessel:			\$8.926

2.4 Distribution of Operating Costs

<u>Facility:</u>	<u>Total Payroll</u>	<u>Cost Per Long Ton of Pellets</u>			<u>Total Cost</u>
		<u>Labor</u>	<u>Supplies</u>	<u>Re-pairs</u>	
General Offices	195	\$0.380	\$0.088	--	\$0.468
Mining	404				
Ore Mining	-	0.467	0.743	\$0.320	1.530
Stripping	-	0.161	0.216	0.111	0.488
Concentration	312	0.566	1.373	0.200	2.139
Pelletizing	125	0.237	1.094	0.245	1.576
Stockpiling and Shiploading	34	0.055	0.071	0.049	0.175
Total	1070	\$1.866	\$3.585	\$0.925	\$6.376
Railroad					<u>2.550</u>
Total Estimated Operating Cost Loaded Aboard Vessel:					\$8.926

It is anticipated that operating costs during the initial period are likely to be higher than those reflected above due to preliminary mine stripping, plant and labor "break-in", and townsite operational expenses.