KERR-ADDISON GOLD MINES LIMITED
SUITE 1600-BANK OF NOVA SCOTIA BUILDING
44 KING STREET WEST
TORONTO 1, ONTARIO

105/M.

007483

November 22, 1962

MEMORANDUM:

To: Mr. W. S. Row

From: P. M. Kavanagh

United Keno Hill Mines Limited

The following are items of information re United Keno's mining operations reported to me by our Vancouver geologist, Angus MacDonald who stayed at United Keno's chief assayer's home in Elsa during his Peso Silver examination in September. I cannot vouch for the accuracy of the information.

- the Elsa mine will be almost completely finished in one year's time
- they are mining only about 50 tons a day from the Elsa now
- they are starting to pull pillars in their big Hector-Calumet mine
- presently mining 500 tons per day of 18 oz. Ag millhead grade ore from the Hector-Calumet.
- their silver grade in concentrate (lead concentrate presumably) is down to 215 ozs. from 400-800 ozs.
- sometime in September they apparently hauled 500 tons of 5 to 6 oz. Ag material from an outside property in order to meet their usual daily tonnage requirements.
- they hold 700 claims over the best ground in the Elso-Keno district.

I read in some report earlier this fall that United Keno's 1961 production had a silver grade of 41.16 ozs. per ton mined.

Paul M. Kavanagh

Paul M. Kavanagh
Chief Geologist - Exploration

PMK:ry

— Pitcher remarked to me yesterday that their concentrate is currently running about 400 oz. of silver

— with reference to my comment this morning about Pitcher, a concentrate of solely galena would assay 86.6% Pb. PMK

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OPERATING PROCEDURE

at

UNITED KENO HILL MINES LTD.

by

H. Brodie Hicks

See Page. 130.
Canadian Mining
Manual. 1963

A paper to be presented at the Metal Mining Session, Annual Western Meeting, C.I.M.,
Vancouver, October 18, 1949.

The United Keno Hill Mine

By H. Brodie Hicks

General Manager, United Keno Hill Mines, Ltd.

THE United Keno Hill Mines Ltd. is, at present, the only producing company in the Mayo silver-lead district of the Yukon Territory. While the deposits have been known for almost 45 years and are of a remarkably high grade, their remote and northerly location, aggravated by a rugged terrain, has rendered their exploitation difficult, and past attempts at mining have been, for the most part, desultory and on a small scale. The special operating conditions encountered in this area may, therefore, prove of some general interest.

Location

The company's operations are confined to the general area of Galena Hill and Keno Hill which are situated respectively some thirty-five and fifty miles northeast of the village of Mayo Landing on the Stewart River, a tributary of the Yukon River, the main artery of the Territory. From Whitehorse, the head of navigation on the Yukon River, to the confluence with the Stewart is a distance of 390 miles and from that point to Mayo Landing is a further 180 miles. Figs. 1 and 2 show respectively a generalized map of the Yukon Territory with particular reference to freighting routes and a more local map of the Mayo-Keno district.

The mining area lies on the southern flank of the MacKenzie mountains, an extension of the Rocky Mountain system which here runs in an almost east-and-west direction. Galena and Keno Hills are 5,000 and 6,500 feet in height respectively and rise to elevations of some 2,000 to 3,000 feet above the floors of the surrounding valleys. Slopes are, in general, moderate, with a few notable exceptions, and road building and maintenance would be a matter of no great difficulty but for the presence of permafrost with its various attendant difficulties.

In a latitude some 150 miles below the Arctic Circle and at elevations between 3,000 and 6,000 feet, severe climatic conditions are encountered. Winters are long, dark and cold. Due to their position on the southern flank of a valley, the mines are completely hidden from the sun for ten weeks each year, a fact which has a greater effect on morale than on any physical aspect of operation. Temperatures may be excessively low and a minimum of –81 degrees was officially recorded in Mayo during the winter of 1947. As higher elevations are attained, the winter temperature tends to moderate. Precipitation is light, amounting to an average of 11 inches per annum, and the area is generally considered as semi-arid. The ground throughout is permanently frozen, a fact which introduces several special problems. Run-off of surface waters amounts to about 65% and there are severe fluctuations in river and water-table levels. These, in turn, have important consequences in navigation, the development of water power and in mining which will be discussed further below.

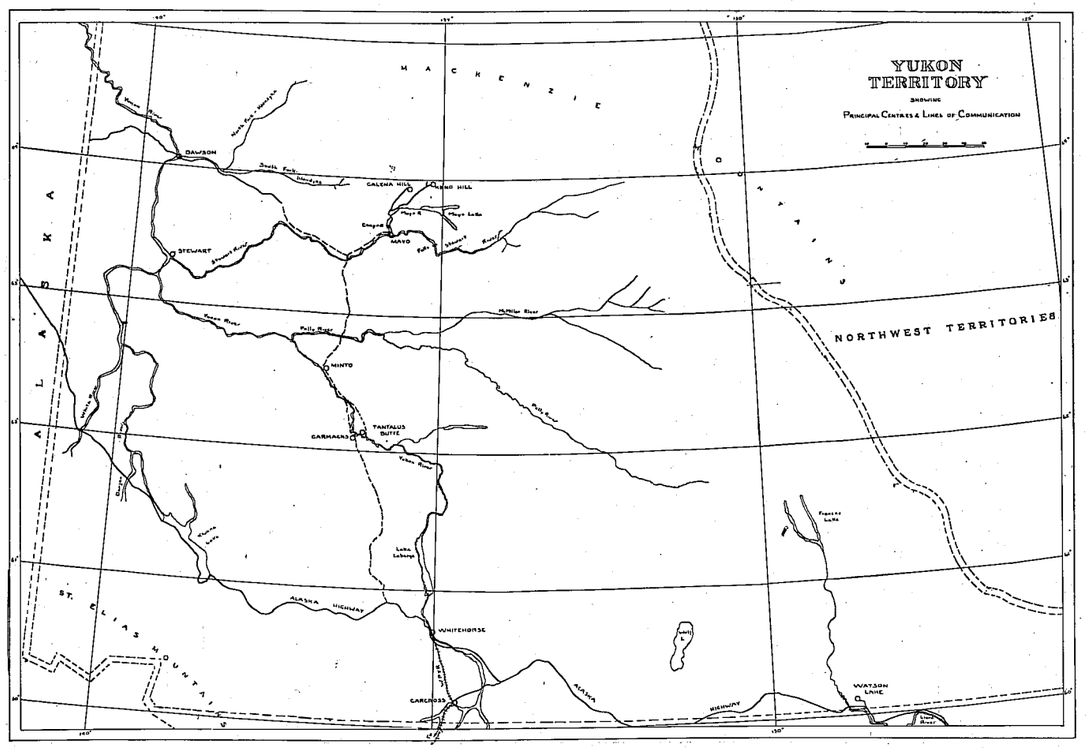

Figure 1

History

The area was first prospected by placer gold miners who, overflowing from the Klondyke stampede of 1898 covered the country with remarkable thoroughness in the early years of the present century. These men confined their attentions to creek channels and the first discovery of silver-lead ore was staked as the "Silver King" claim, in the canyon of Galena Creek on the hill of the same name in 1906. From that date until 1919, irregular, small shipments of hand-sorted ore were made from this property and, at the same time, one or two other prospects were examined without success. When it is considered that there were no roads whatsoever in the district and only a limited small-boat service to Mayo Landing, even the limited success of these early pioneers is a tribute to their perseverance and a singular comment on the high grade of the ore.

In 1919, a new discovery was made near the top of Keno Hill and a company was organized almost at once to acquire the claims. This company, Keno Hill Ltd., was a subsidiary of the Yukon Gold Co. Ltd., one of the larger placer operators of the Dawson district. Work was confined to shipping of hand-sorted crude ore, and during the following three years resulted in a production of 9,000 tons of an average grade of 204 ounces silver and 54 per cent lead. Camps were erected near the showings and a small wood-burning power plant installed in the valley of Duncan Creek. Costs were high, however, and when the original high-grade ore shoots appeared exhausted it was decided that the search and development of new shoots could not be considered economic and the project was abandoned.

In 1921, the Treadwell-Yukon Co., operated by the Bradley interests of San Francisco, entered the field. This company acquired leases from Keno Hill Ltd. and pursued a vigorous policy in taking up ground on its own account. In the course of the next 21 years, Treadwell-Yukon accounted for better than 80 per cent of the total production that had been won from the district prior to the advent of the United Keno Hill Mines. A mill was erected on Keno Hill in 1925 which handled ores from the Sadie, Ladue and Lucky Queen Mines. In 1936, when prospects appeared better on Galena Hill owing to the discovery of new high grade bodies, the mill was transferred there and treated production from the rejuvenated Silver King, the Elsa and part of the Calumet mines. Other showings were under investigation. In 1942, owing to general world conditions and in particular to lack of labor and low metal prices, operations were suspended. In all, the Treadwell-Yukon Co. mined better than 600,000 dry tons of ore averaging 71.32 ounces silver and 7.74 per cent lead.

In 1946, the entire assets of the Treadwell-Yukon Co. were acquired by United Keno Hill Mines Ltd., who have subsequently, by purchase and by staking, added greatly to the original holdings. Hope for the new venture lay chiefly in two points: firstly, improved world conditions, particularly as regards metal prices; secondly, the probability that considerably larger tonnages of ore than had been mined in the past might be available.

With regard to the latter point, the previous operators had at no time prosecuted a vigorous policy of exploration and development. During the period of their operations, numerous prospectors were active in the area who uncovered sufficient high-grade shoots to keep the mill in operation at all times. Only five drill holes had been recorded. A consideration of the position of the known ore-bodies with the general geology of the area led inescapably to the conclusion that much favorable ground remained. This conclusion has been amply justified by discoveries to date.

Economic Considerations

There are several economic factors, inherent in the location of the company's mines, which are of considerable importance in operations:

1. Transportation

The transportation route is long and difficult. Company freight normally originates at Vancouver, whence it proceeds by ocean steamer to Skagway, thence by railroad to Whitehorse, by river-boat and barge to Stewart, and by a second river-boat and barge to Mayo Landing, thence by truck to the mines. Concentrates must return by the same route, with an added handling

fig. 2

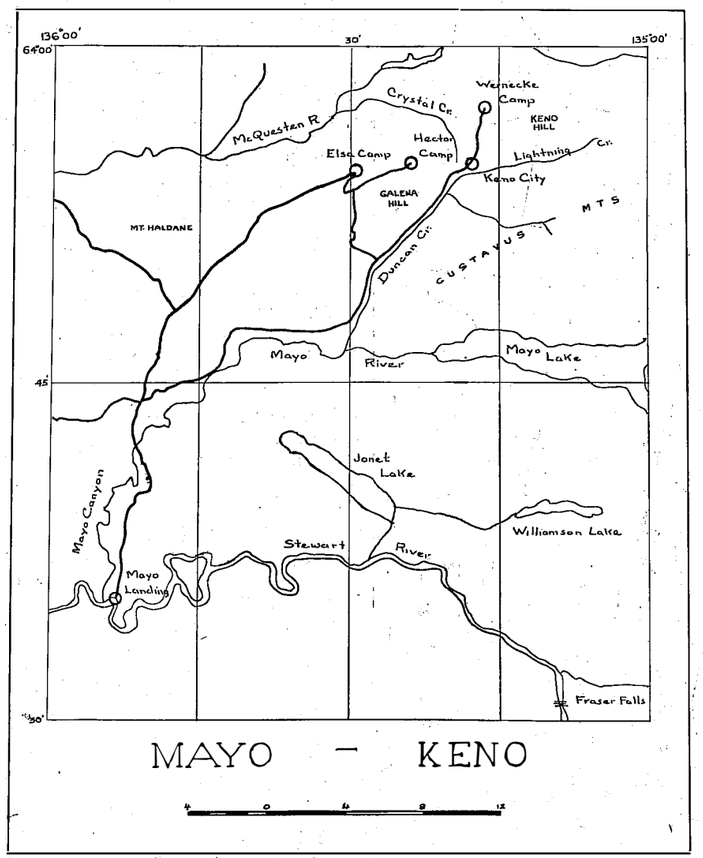

Figure 2

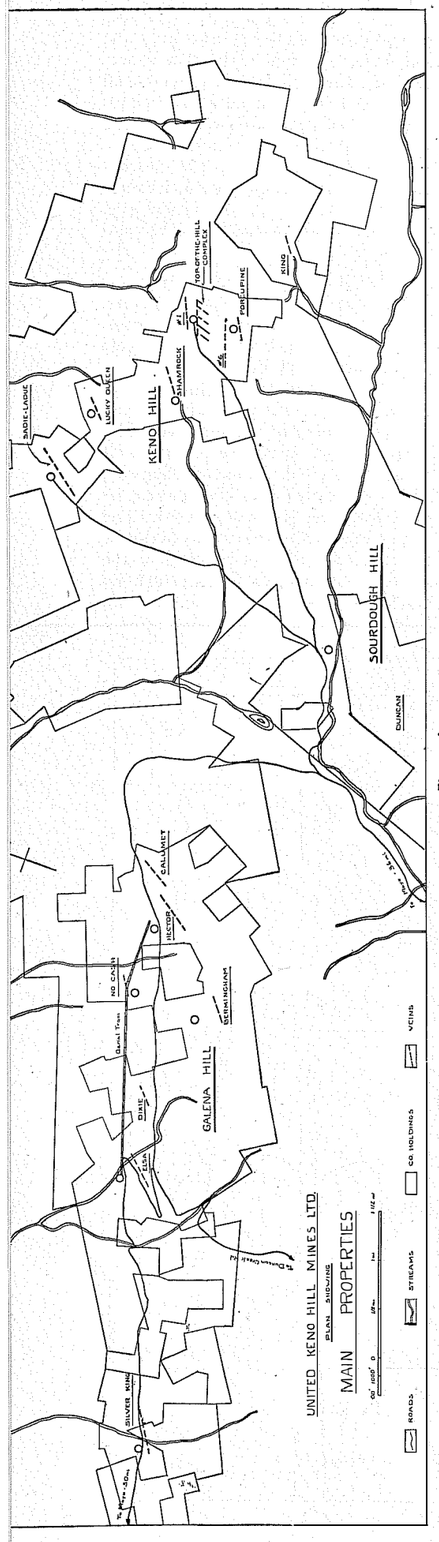

Figure 4

by rail from Vancouver to the smelter. An alternative route to Whitehorse from railhead exists by means of the Alaska Highway, but freight rates are unfavorable.

Both the rail and river legs of the route present considerable difficulties. The railroad is narrow gauge, has severe grades, and during the winter is subject to severe snow and slide conditions. On the rivers, particularly the Stewart, seasonal fluctuations in water level may seriously hamper operations. Open season on the Stewart normally extends from June 1st to September 15th or a little later and during this short period traffic may be halted or, at least, loads seriously reduced, for as much as a month at a time.

Such transportation uncertainties are a severe handicap as it is always possible that some vital freight will not be delivered or that a season's output of ore and concentrates will not all reach the smelter. The short season, at best, necessitates the carrying of a heavy supply inventory. Freight rates are high, the incoming rate varying from $100 to $150 per ton Vancouver to Mayo; while the outgoing rate on ores and concentrates, Mayo to smelter, is $37.70 per ton.

A partial solution to this problem can now be seen in the construction of roads through the Territory. The Dominion government has had under construction for the past two seasons a route from Minto, on the Yukon River, to Mayo Landing, which by-passes the Stewart River where fluctuations are most severe. This road is also currently being extended from Minto to Carmacks, whence a poor road is already in existence to Whitehorse. Completion of this system will permit by-passing of the entire river route. While it is improbable that truck freighting in this way can compete economically with the river system it is expected to supplement it, especially during low water seasons, and to permit expansion of tonnage, now limited by river carrier capacity.

2. Power

The heavy fluctuations in river level also render difficult the matter of hydroelectric power development. With the exception of the small wood-burning plant of Keno Hill Ltd., which rapidly exhausted available supplies of fuel, all power locally generated has been by means of diesel engines. Apart from high cost, local transportation conditions limit the amount of oil which can be imported and it is apparent that future expansion by the United Keno Hill Mines or by the district as a whole is impossible without some supplemental power source.

The company has made a survey of possible hydroelectric sites in the area and one or two promising localities have been determined. The Dominion government is now showing an interest in the matter and is currently engaged in more exact surveys of the sites. Best possibility appears to lie in the canyon of the Mayo river, where it appears probable that 10,000 h.p. might ultimately be developed. Other, and in some cases larger, sources are known but at the present time it appears that demand is insufficient to warrant the expense of their exploitation.

3. Stockpiling

This might have been considered under the heading of transportation but is of sufficient importance to warrant a special paragraph.

Due to the short navigable-water season on the Stewart, production of crude ore and concentrates must be stockpiled for a period extending roughly from the first of September to the first of June. This has two important consequences: firstly, in tying up large amounts of capital, and, secondly, in requiring the operator to estimate market metal prices a year or more in advance in order to arrive at an estimate of mineable ore grade.

The proposed roads will assist in alleviating both these conditions by permitting shipments at any time of the year, even though at an unfavorable freight rate.

At the commencement of navigation in June, 1949, the company's stockpile of ore and concentrates at Mayo amounted in value to $1,700,000. Had shipment during the winter been possible, a considerably larger amount would have been realised.

4. Labor

The isolation of the operation from any other large area of mining activity leads to difficulty in hiring and maintaining an adequate labor crew. There is no pool of skilled miners from which to draw. Inasmuch as underground problems are not of the simplest, the problem becomes even more serious than in other parts of the Dominion. Until other conditions change so as to attract more companies into the field, this condition will not be alleviated.

It is of interest to note that immediately north of the Galena-Keno Hills area are other known deposits of silver-lead ore of somewhat lower grade. Improvements in power, transportation and labour conditions in the district would undoubtedly result in the exploitation of these deposits and, from other indications, it is probable that further great areas would eventually be opened up.

Geology

The geology of the district and of the mines proper has been or will be discussed in other current papers; hence only those aspects having a direct bearing on mining operations will here be touched on.

The rocks of the area are classified as late pre-Cambrian and consist mainly of a thick series of interbedded schists and quartzites locally intruded by conformable greenstones and cut occasionally by acid dikes and sills. Normally, the formation strikes a little north of east and dips thirty degrees to the south, but the structure is much broken up by folding and faulting.

Ore bearing veins are of two types, locally referred to as longitudinal and transverse. With one exception all former and present producing mines have been on the longitudinal type. These are definite zones of fissuring which strike northeasterly and dip about 70 degrees to the south. The zones are strong and continuous but ore deposition along them is, generally speaking, irregular. Inasmuch as the veins vary somewhat in strike from that of the main structure they cross-cut the latter at a low angle. This has an important result for mine operation as the character of the wall rocks may vary from a hard competent quartzite to a soft, almost muddy schist.

Chief ore mineral is galena, which, when unassociated with other minerals, carries from one to three hundred ounces of silver to the ton. Less common, but important, is freibergite or argentiferous tetrahedrite, picked specimens of which may assay as high as 8,000 ounces. In some of the mines, oxidation is pronounced and a variety of secondary silver minerals have been identified. Zinc occurs fairly generally in the form of sphalerite. Gold values average 0.01 ounces.

The veins, in general, average seven feet in width although there are wide variations in both directions. Vertically, exploration has seldom extended below the 400 foot level due to lack of power for pumping water and whereas there is some evidence of pinching at or about this horizon in some mines, in others the ore appears as strong or stronger than on the surface.

The ore is not of secondary origin and as the outcrops cover a vertical span of some 3,000 feet, there is no reason to believe that at least a succession of veins may not extend to considerable depth in any one mine. To date, however, no exploration has been done with a view to locating veins which do not outcrop.

Exploration and Development

The known mineralized area extends over a length of 15 miles with widths up to five miles. Of this area, the company holds almost half the total claims, including all areas of past commercial production and, at the time of writing, all present probable producers. At the time of commencement of operations, there were some 15 possible locations in which to initiate work. Others have since been located. Fig. 4 shows a map of the producing area with the company's more important showings thereon.

Inasmuch as a mill and mining plant, in partially dismantled condition, were in existence at the Elsa mine and a mining plant at the Calumet mine which could also be used for the Hector mine, it was determined to commence operations in this area with chief attention to be paid to the Hector mine which appeared the most promising of the three. The Elsa and Calumet-Hector camps are connected by aerial tram.

Results to date on the Hector have been gratifying. Of the three levels now partially developed, the first has yielded a continuous length of ore of 1,000 feet; the second, 700 feet, and the third 550 feet, with all three faces still open. A few months ago, diamond drilling revealed the presence of a parallel vein which has now been opened on the middle level to a length of 250 feet, open at both ends. This ore averages seven feet in width on the "main" vein and slightly more on the "parallel" vein.

In the Elsa mine, development and diamond drilling has opened up a number of small but very high-grade shoots and it is now planned to institute a longer range programme of exploration laterally. At the Calumet, small bodies of ore have been located as an extension laterally to old workings and a winze has been sunk to a depth of 125 feet below the adit level and high-grade ore located. At the No Cash, another high-grade vein is presently being drifted. At the Bermingham, a 1300 foot adit has recently cut a vein which yielded considerable high-grade ore to hand miners near the surface. At the old Silver King property an adit has cut the vein to the west of the old workings and some encouraging values have been encountered. At least two other properties of merit within range of the Elsa mill await exploration.

Due to the large amount of exploration carried on in this area, but little time has been devoted to the remainder of the company's holdings. However, in the fall of 1948, bulldozing near the top of Keno Hill opened up a vein for a length of 400 feet with widths up to 11 feet and good values in gold, silver, lead and zinc. This past summer, other work in the valley of Duncan Creek revealed a vein of almost solid sulphides carrying somewhat lower values in the same minerals and some five or six feet in width. Other favorable areas on Keno Hill, in particular some adjacent to old mines, are known and await development.

It might have been possible to bring into production some of these prospects before this date. However, as noted above, the entire production of the district is limited by transportation and power difficulties and, until these are solved, only one or two mines at most will be operated.

It is worthy of note that almost without exception discoveries to date have been in areas relatively free of overburden, either in creek valleys or

Figure 3: Stockpile of lead concentrate awaiting shipment to the Trail smelter; early 1949.

above timberline. When these possibilities are exhausted there will still remain a large area, covered by permanently frozen subsoil, which will warrant close investigation.

Mining

All production of importance to date has been won from the Hector mine. The following discussion, therefore, except as otherwise noted, will cover practice in this mine only.

The mine is opened by a 1600 foot adit driven at a nominal elevation of 400 feet below the outcrop. The Calumet mine is developed through the same adit but lies 400 feet further in. Above the adit level in the Hector, two other levels have been opened at approximately equal intervals. Fig. 5 shows a plan and section of the mine workings.

Supplies to the upper two levels are handled through a small service raise, equipped with timber slide. A 7½ h.p. air-driven tugger hoist is employed.

Crosscuts and drifts are 6′ x 7′ in section and with a grade of 0.5% in favor of the load. Track is 16-lb. rail at 18″ gauge. In the greater part of the mine, close timbering is required and it is frequently necessary to protect the workmen by booming ahead. In spite of this, overbreaks up to 30% are not uncommon. The round requires from five to twenty-five holes, dependent on the type of ground and a burn cut is standard. Both Ingersoll-Rand and Gardner-Denver three-inch machines are used. On the adit level, loading is by means of a Gardner-Denver GD-9 loader; elsewhere hand mucking is employed. A two-inch air line, one-inch water line and ten-inch collapsible ventilation line are suspended from the timbers during advance.

Raises are the width of the vein and 13 feet in length. They are placed at 100-foot intervals and are driven up the dip. Close timbering is required and standard practice is to divide the raise into two compartments by means of three rows of stulls and lagging, the stulls being so placed as to tie into the timber of the subsequent stope. Where required, the hangingwall is lagged against posts placed between the stulls and held by scabs. Two men, with one stoper, is a standard crew and these men also install the timber. As the raises are normally started in the first cut of the backstope on the permanent timber, the muck is pulled through a permanent stope chute.

Both past operators and the present company have experimented with various types of stoping. Shrinkage stoping, even if practicable for other reasons, is impossible because of the tendency of the muck to freeze back in the stopes. Various open and timbered types have failed because of lack of wall support. A cut-and-fill method is the most satisfactory but even this must be supplemented with timber. The present standard, which is still under close study, may be described as a filled rill with regular timbering. Fig. 6 illustrates this method.

Taking down of backs is accomplished in two ways. In good ground, which will stand without timbering,

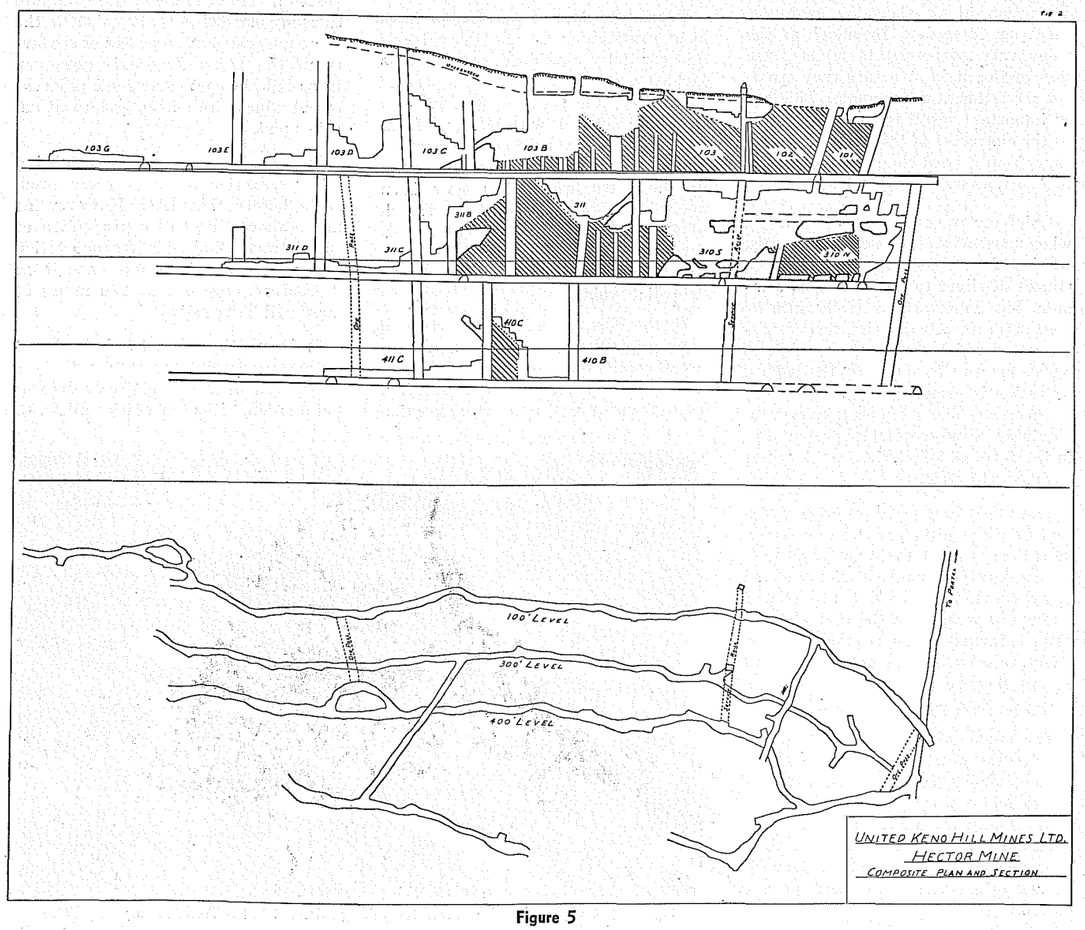

Figure 5

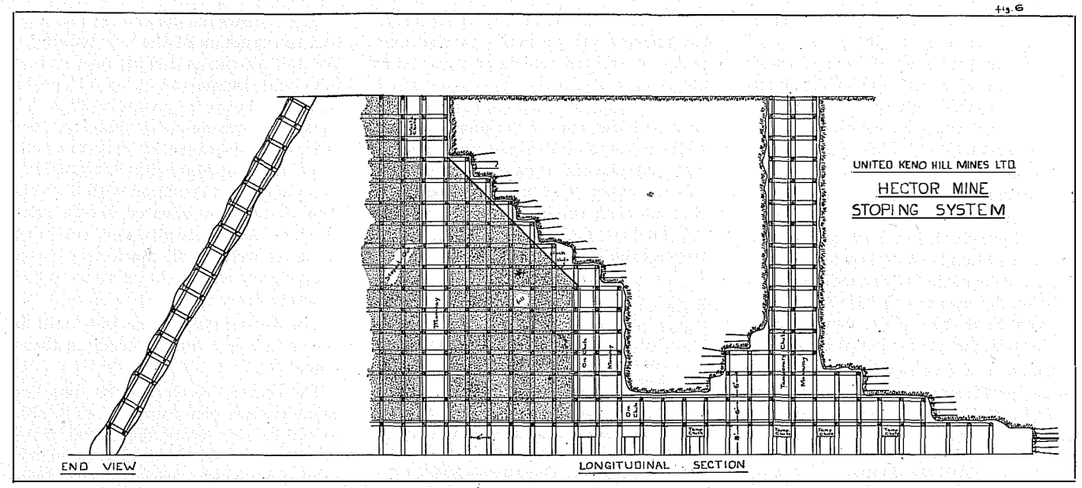

Figure 6

the drift is advanced as far as required at the time. Backs are then taken down to a total height of 17 feet. Two sets are then installed, the main drift posts being 8 feet in length and the backstope posts 6 feet in length. Both sets are lagged on top and the hangingwall is lagged where required. In bad ground, requiring close timbering, which may be regarded as the normal condition, the drift sets with 8-foot posts are installed during advance, the space required being supplied invariably by overbreak. Backs are then taken down by means of mounted leyners, the muck being broken directly onto the drift lagging with light single blasts. The backstope timbering is carried forward set by set and the muck is removed through "Chinaman" chutes.

Raises, at 100-foot intervals may be driven either before or after taking down of backs but the latter is the usual case. The raise timbering is centred over one of the drift sets so that all timbering will tie together. Midway between raises a double-chute-and-manway is erected and these serve as stope boundaries.

Breaking has been accomplished by means of both leyner and stoper type drills, but, particularly in the softer ground, emphasis is now being placed on use of an Ingersoll-Rand JA-55 jackhammer equipped with a pneumatic "air-leg." It is expected that this equipment will be made standard in the near future.

Cuts are started in both directions from the central raise until a slope of 45 degrees has been reached on each side, which is maintained. The muck does not run too well even on this steep angle, partly because of its content of sticky mud-like material and partly, possibly, because of the high content of angular galena. As soon as sufficient room has been made either vertically or horizontally, a stull is installed. Standard spacing is 6-foot centres in both directions and this spacing is rigidly adhered to both in order to promote systematic mining and also because it has been found that with relatively inexperienced crews this set pattern is more easily followed than random timbering at the discretion of the miner. Other necessary support, including hangingwall lagging, is tied to these stulls as required. The amount of ground opened at one time varies with conditions but it is usually possible to open up one entire lift provided sufficient care has been taken with timber support. Muck is removed as required during the breaking period and when this is complete the entire stope is cleaned out.

Fill for the bottom two levels may be obtained from development rock but as this is rarely available, it is usual to drive a fill raise from the main stope raise just below the upper level. After this raise has reached a sufficiently safe distance from other workings it is slashed out to provide waste rock as required. On the top level, fill is obtained in summer by bull-dozing surface gravel into the stope raises; during other seasons, it is obtained by means of short headings driven into the footwall of the stope at floor level. Flooring is 2-inch local spruce plank.

Muck on the upper two levels is hand-trammed in 20-cubic foot cars to a central ore-pass. The outlet of this pass, on the adit level, is controlled by means of an air cylinder. Haulage on the adit level is in 30-cubic foot Hammant side-dump cars, a train of seven being pulled by a Mancha "Little Trammer" locomotive, which delivers the ore to the head-bin of the aerial tramway.

At present, air at 100 pounds per square inch is supplied by means of an Ingersoll-Rand 850 cu. ft. compressor; but a Belliss-Morcom 1100 cu. ft. compressor is on hand and will be installed shortly. Water for drilling is obtained from mine seepage, which is collected in a sump on the adit level and repumped through the workings. In order to prevent stagnation and freezing during the winter, the high point of the system is fitted with a Morrison relief valve set at 60 pounds which permits flow when all other outlets are closed. During the coldest weather, individual heading lines are drained between shifts.

Steel is one-inch quarter-octagon Atlas Chippewa shank steel fitted with Liddicoat one-pass bits. Shanks are made up in the central machine shop at the Elsa camp.

Drainage water fluctuates widely with the season, being very heavy through the late spring and summer and drying up largely in winter although a flow of some 30 g.p.m. remains at the lowest point. Due to low rock temperatures, the water is always near the freezing point and during cold weather formerly caused a great deal of trouble through freezing back at the portal mouth. This has been overcome by installing a sump and pump about 500 feet from the portal mouth and beyond the influence of outside temperature. The water is trapped here and pumped through a small pipe at high velocity to beyond the entry.

Underground temperatures are, in general, slightly below the freezing point and ice crystals may be found in freshly broken faces. In general, however, this cannot be said to have too great an effect on operations. Apart from special precautions necessary

with drilling water and drainage mentioned above, and the impossibility of storing any quantity of broken ore or waste-fill underground chief disadvantages lie in such relatively minor matters as icy track, ice-covered timbers and so forth, all of which may be overcome by care and planning.

Ventilation is natural, being upcast in summer and downcast in winter, while for a period in both spring and fall circulation is poor. Dead-end headings are furnished with auxiliary ventilation by means of 16" Meco Air-Driven Fans, type CF4, connected to 10-inch Minair collapsible tubing.

Table 1 shows statistical data on mine performance during the first quarter of 1949, also certain costs for the same period.

Aerial Tram

The aerial tram between the Hector and Elsa camps is nearly three miles in length and descends a distance of 1,300 feet. An angle has been introduced so as to permit loading of the ore from the No Cash mine, about one third of the distance from the Hector and the remaining two thirds is divided into two portions by a tension station. Stationary load cable is 1⅛" diameter, return cable is ¾" diameter and the haulage cable is ⅝" diameter. Forty half-ton buckets are normally carried and make the return trip in seventy minutes.

Three operators are required, one at each end and one at the angle-station while a fourth full-time maintenance man patrols and repairs the line. In winter, extra help may be required. Bins at each end are heated and the full buckets do not become seriously frozen even in the coldest weather.

Table 1

Weekly average tons mined	762
Holes drilled	556
Manshifts worked underground	378
Tons per manshift	2.01
Cost per foot, drift advance	$27.27
Cost per foot, raise advance	36.10
Cost per ton, stoping	9.71

The above costs are direct only.
Statistical and Cost Data at Hector Mine First Quarter — 1949

Milling

Discussion of this subject is complicated by the fact that the original mill was destroyed by fire on June 11th of this year and the new mill, at the time of writing, is not yet completed. Physical description of buildings and equipment therefore, will pertain to the new structure while operating results cited will have reference to past practice in the old mill.

Fig. 7 shows the dimensions and general construction of the new buildings. The mill proper is divided into 14 foot bays with trusses on 12" x 12" posts. Studding between posts is 2" x 6", sheathed outside with shiplap, one layer of tar-saturated felt and one layer of Johns-Mansville "abestoside". The building is insulated with 3" rock-wool batts and sheated inside with shiplap. All footwalls and retaining walls as well as all machinery bases are concrete and the building has a full concrete floor.

The flow-sheet of the new mill is shown in Fig. 8 and is largely self-explanatory.

The coarse ore-bin, of 180 tons live capacity, is so constructed as to be able to receive ore from the aerial tram, directly from the Elsa mine by underground cars, or by truck delivery from other properties. The bin has three discharge chutes and is fitted with a moveable feeder discharging onto a 30" belt. This belt delivers the ore over a 3' x 5'-6" Canadian Allis-Chalmers cantilever grizzly into a 10" x 20" Traylor jaw crusher. The product from this is elevated by two 24" conveyor belts to a 3' x 6' Canadian Allis-Chalmers vibrating screen. Screen oversize drops to a 1'-8" Traylor gyratory crusher, discharge from which joins the jaw crusher product. Screen undersize is finished material and is conveyed to the fine ore bin in the mill by means of an 18" belt, 148' in length.

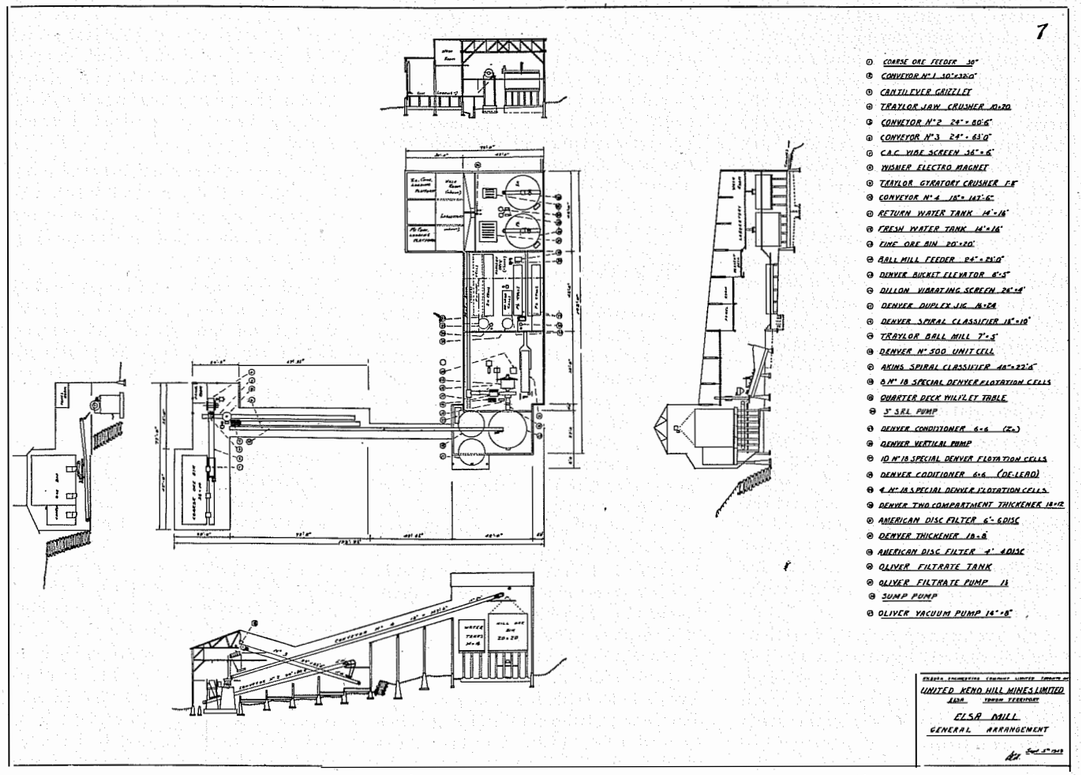

Figure 7

The fine ore bin is a wood-stave tank, 20' x 20', with a live capacity of 225 tons. Three outlets discharge onto a 24" conveyor belt which in turn may discharge directly into the ball-mill or into the jigging circuit.

When the jigging circuit is in operation, the ore is picked up by means of a 10" Link-Belt bucket elevator emptying onto a 2' x 4' Dillon screen, oversize from which returns to the ball-mill. The undersize is passed through a 16" x 24" Denver Duplex jig, the tailing from which returns to the main classifier. The concentrate is dewatered in an 18" spiral classifier and sacked. Classifier overflow returns to the main lead concentrate sump.

The ball-mill is a 5' x 7' Traylor, operating in closed circuit with a No. 500 Denver Unit Cell and a 48" Akins Submerged Spiral Classifier. The product is fed to two banks of eight Denver No. 18 special flotation cells for the bulk lead float. After conditioning in a 6' x 6' Denver conditioner, tailings from these cells go to a further bank of 10 Denver No. 18 specials for the bulk zinc float. Tailings from this bank go to waste. The zinc concentrate is further conditioned in another 6' x 6' Denver tank and is then deleaded in a bank of four Denver No. 18 special cells.

The lead concentrate is collected in a sump and pumped to an 18' x 12' Denver two-compartment thickener feeding a 6' x 6' disc American filter. The filtered cake is sacked. The zinc concentrate is similarly treated in an 18' x 18' Denver single compartment thickener and a 4' x 4' disc American filter.

The above represents the flow-sheet of the new mill. In the past only a bulk lead concentrate has been made, with recoveries in the order of (for 1948) 84.25% silver and 76.59% lead. Operating data for that year are shown in Table 4.

The company employs a full-time metallurgist and maintains a laboratory. In the past, most of the work has been concentrated in an effort to improve recovery figures and some of the data obtained are being used in design of the new mill.

It has been shown that the major part of the material which is not recovered consists of lead oxidation products or of galena coated with such products. Efforts to reactivate this material with the aid of sodium sulphide have been successful in the laboratory. The economics of the process are still somewhat dubious, however, and further test work must be performed before sulphidization can be incorporated into the mill circuit.

Better results have been obtained with cyanidation and it has been shown that, with some care, cyanidation of the tailings could be made profitable. Before adopting this process, however, with the heavy capital expenditure involved, it is planned to do further test work on recovery of the oxide lead and also to test the efficacy of jigging. The old mill circuit did not include a jig and the performance of this machine on full scale remains to be tested. It is hoped that considerable oxide lead may be recovered.

Test work on differential float has proved the desirability of making separate zinc and lead concentrates. By the addition of a deleading circuit, it is possible to reduce the silver content of the zinc concentrate to about 18 ounces per ton. Laboratory work indicates that both lead and zinc concentrates will average about 60% of their respective metals, with the former carrying 350 ounces per ton or better of silver. The zinc concentrate carries about 1% cadmium.

The possibility of smelting the concentrates locally has not been overlooked and has been given considerable study. There are many difficulties to be overcome but the problem is by no means insoluble.

The mill crew consists of a superintendent, metallurgist, three flotation operators, three ball-mill operators and six to eight sackers who also look after the crushing. Sacking of concentrates is a major item of expense but is difficult to avoid due to the high-grade nature of the product and the many handlings which it receives between the mill and the smelter.

Table 5 shows a summary of mill costs for the year 1948. Average tonnage milled during that year was 103 tons per day, which had risen to nearly 150 tons by year end. The new mill is designed for 250 tons, which will probably not be reached until early in the new year, but, at that time, considerably better costs will probably be recorded.

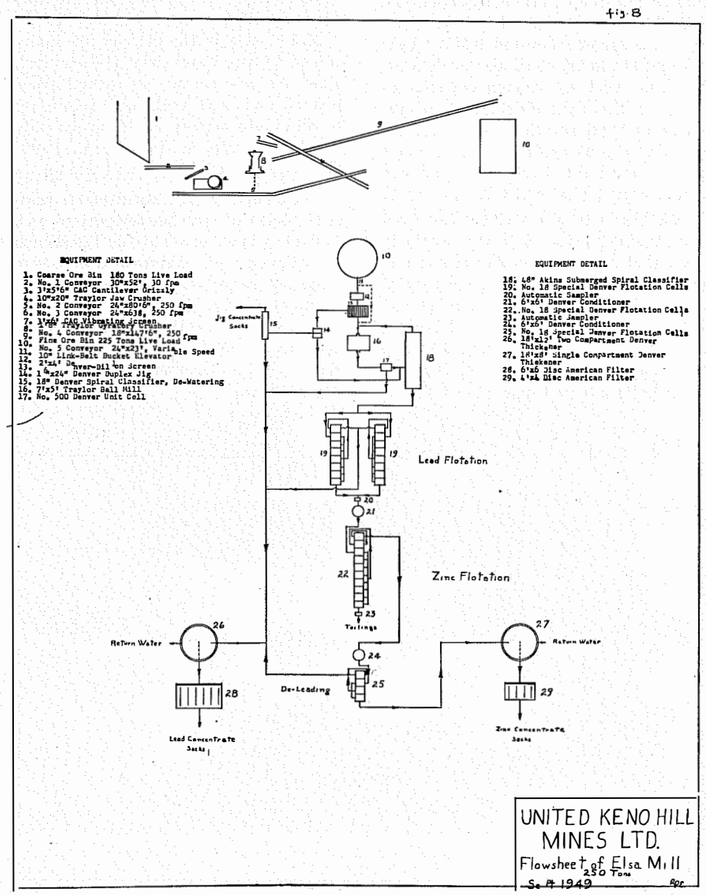

Figure 8

Table 4

Mill Operating Data for Year 1948

Dry Tons Milled	37,593
Mill Heads, Silver, oz./ton	57.32
Lead, %	8.06
Mill Tailings, Silver, oz./ton	10.62
Lead, %	2.22
Ratio of Concentration	6.67
Recovery, Silver %	84.25
Lead, %	76.59
Tons Concentrates Produced	5,638.84
Ave. Silver Content, oz./ton	322.13
Average Lead Content, %	41.18

Table 5

Mill Operating Costs for Year 1948

Supervision	$0.12
Crushing and Conveying	0.38
Grinding and Classification	0.74
Flotation	0.62
Pumping, Thickening, Filtering	0.02
Sacking and Loading	1.40
Experimental Work	0.02
Miscellaneous	0.53
	$3.83

Haulage

The operation and maintenance of the truck and tractor fleet is a major part of operations. The fleet at present consists of three Studebaker army-type 6 x 6 trucks, normally loaded to seven and a half tones; three International KB8F trucks, loaded with from eight to ten tons; one two-ton GMC truck; two Dodge four-wheel drive "Power-Wagons" with a carrying capacity of one ton; two light pick-ups; two passenger sedans; one International KB2 panel; one Caterpillar D-tractor; one International TD-14 tractor and one International TD-9 tractor.

The heavy trucks are, for the most part, maintained on a fairly regularly scheduled run between the mines and Mayo Landing. Down-load consists of ore and concentrates. Back-haul is provided by miscellaneous types of freight, chief of which are general supplies from the Mayo warehouses, fuel oil, coal, lumber from the company's sawmill, cordwood and mining timber.

At least one heavy truck is required for the inter-camp haulage, chiefly between the Elsa and Calumet camps. One of the biggest items in this regard is delivery of drinking water to the higher camp, which necessitates at least one load daily. The two power-wagons are employed chiefly for access to the smaller camps where poor roads or no roads exist. The lighter vehicles are used largely by supervisory staff and maintenance crews.

The three tractors are all fitted with bull-dozing blades and the TD-9 with an overhead loader. They are used for construction work, for filling upper-level stopes, for road building, for heavy-duty haulage, for snow clearance and, in winter, for bush operations.

Upkeep and repair work is handled largely at a central maintenance garage at the Elsa camp; a second maintenance garage is now being readied at Mayo. A good supply of parts is carried at all times.

Table 2 shows a breakdown of operating costs of heavy trucks and tractors for the first five months of the year.

Main roads in the district are maintained by the Territorial Government. They may be classed as second-grade gravel roads and, with some relocation to eliminate curves, could be put into excellent shape, as, in general, conditions are favorable to road building.

The company maintains certain minor stretches of road between camps and, in winter, is expected by the Territorial Government to maintain the seven miles of road between the Elsa and Calumet camps. This last operation is one of some difficulty due to the heavy occurrence of "glaciers" over this stretch. This term may require some explanation.

fig. 9

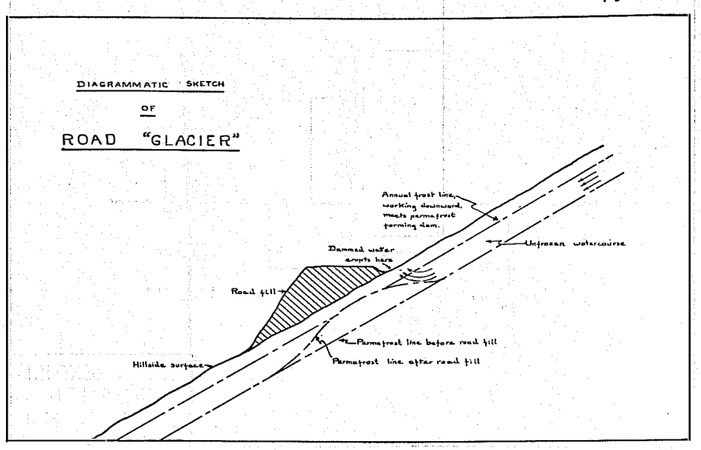

Figure 9

Table 2

Cost per hour, heavy truck fleet:	
Supervision	$0.10
Operating Labour	1.32
Operating Supplies	0.07
Repair Labour	0.55
Repair Supplies	0.76
Gasoline	1.06
Lubricants	0.07
	$3.93
Cost per hour, tractor fleet:	
Supervision	$0.15
Operating Labour	1.37
Operating Supplies	0.08
Repair Labour	0.24
Repair Supplies	0.51
Fuel Oil	0.67
Lubricants	0.08
	$3.10

A glacier, or, to use the more correct term, an "icing," occurs on sidehill roads in permafrost conditions when the insulating effect of the road fill causes a local rise in the permafrost level. The seasonal frost line eventually reaches this rise and thus dams off drainage. Water pressure builds up against this dam and eventually a series of springs breaks through on the upper side of the road, even in the most severe cold weather. The water from these immediately freezes on the road and may, if unmolested, build up to a height of tens of feet. Fig. 9 shows diagrammatically the formation of a glacier spring.

Numerous methods of combatting this condition have been suggested, including the bulldozing of a line some distance above the road to promote early freezing and localize the glaciers there, but such remedies have been unsatisfactory or only temporary and the standard Yukon method is to impart enough heat to the outflow to carry the water across the road. To effect this, the usual method is to sink an oil-drum with one end cut out, into the flow and maintain a slow cord-wood fire in it throughout the winter. Experiments are presently being planned to provide more economical heating. In the winter 1948-49, glacier control on the Elsa-Calumet Camps road amounted to more than $5,000 in labor and fuel.

Stores and Warehousing

Because of the remote location of the property and the short freighting season, at least one year's inventory of all supplies and spare parts must be carried. Maximum inventory at the close of the navigation season in 1948 was in excess of $400,000.

Receiving and general warehouses are located at Mayo Landing. All incoming freight is checked and stored here and trucked to the camp as required throughout the year.

Central distributing warehouse is located at the Elsa Camp, where heated storage for perishables is also available. At the Calumet-Hector camp, a closely controlled general inventory is maintained which is replenished daily by requisition on the Elsa. The smaller mines normally draw their requirements directly from the Elsa.

Power

All power is generated at a central diesel plant located at the Elsa Camp. Of the five engines presently installed, two were inherited from the previous operators and three have been acquired by the United Keno Hill Mines Ltd. Due to difficulty in obtaining engines at the time of inception of operations, it was impossible to standardise on any one type. It is presently planned to standardise on the Ruston-Hornsby.

The following table shows engines installed with horsepower:

Manufacturer	Horse-Power
Atlas	180
Worthington	360
Buckeye	300
Fairbanks-Morse	240
Ruston-Hornsby	475
	1,555
On order for delivery spring, 1950:	
Ruston-Hornsby	525
	2,080

Power is generated at a voltage of 440V and is stepped up by a bank of three 200 kva transformers to 2300V for transmission to the No Cash and Calumet-Hector mines. The transmission line is to be rebuilt next summer and a voltage of 12,000V will then be employed. At the present time, a voltage drop of 10% is experienced along the line.

Direct operating costs of the power plant are shown in Table 3.

Table 3

Operating Costs—Diesel Generating Plant

	Per KWH
Operating Labour	$0.0062
Operating Supplies	.0002
Repair Labour	.0016
Repair Labour Supplies	.0022
Fuel Oil	.0440
Lubricants	.0075
	.0617

Fuel oil, the most expensive single item, costs $0.373 per Imperial gallon at Mayo Landing. The oil is delivered at Skagway in tankers and from there is pumped to the storage tanks of the White Pass and Yukon Route at Whitehorse. It is brought down the river in specially constructed steel barges, designed with a flat top so that concentrates or other cargo may be handled as required. At Mayo, the oil is pumped into storage tanks of the United Keno Hill Mines Ltd., which have a present capacity of 340,000 gallons with an additional tankage of 150,000 gallons on hand, ready for erection.

From Mayo to the diesel plant, the oil is handled in a flat-topped tanker truck of special design with a capacity of 1,600 Imp. gallons. The truck is shown in Fig. 10. As in the case of the oil barges, the truck design permits handling of concentrates on the downhaul to Mayo and of other miscellaneous cargo if necessary.

Camps

The company maintains main camps at the Elsa and at the Calumet-Hector properties and subsidiary camps at various other properties presently under development.

At the Elsa are the mill, power house and central accounting and engineering office. There is a well equipped machine shop, a welding shop, pipe shop and carpenter shop, as well as maintenance garage. Compressed air for the Elsa mine is supplied by a 650 c.f.m. Ingersoll-Rand horizontal compressor, housed in the central power plant and there are also a mine storehouse and dry. Bunkhouses and cookery provide accommodation for 90 men. There are 25 family dwellings, six of which are fitted with full modern facilities. A well-equipped staff-house for single staff members is under construction.

At the Calumet-Hector camp is the main compressor building which also houses the locomotive charging equipment and is fitted for light general repair work. The mine dry houses the camp office and there is a small warehouse. Bunkhouses and cookery presently provide accommodation for 85 men and a new bunkhouse and cookery addition now under construction will bring this total to 145 men.

There are small camps with capacities of from 10 to 25 men at the Silver King, No Cash, Bermingham, Porcupine and Ladue properties. The company also owns land and buildings at Mayo Landing and at Keno City which can accommodate small crews from time to time.

Bunkhouse and cookery operation result in a considerable loss to the company due to the high cost of foodstuffs in the Yukon. A deduction of $2.25 per day is charged to each employee for accommodation, while cost to the company for the year 1948 averaged $3.60.

At the first of this year, the company contracted with a Vancouver agent to supply Chinese personnel for operation of the cookeries in the various camps. To date this system has been found most satisfactory. Quality of food prepared is excellent and there is a minimum of labor trouble from an area where traditionally there is a great deal. To date, due to carry-over of supplies and other factors, it is difficult to state whether this arrangement will result in any monetary saving, but the indications are that it will do so.

Minor camps have been heated in the past with wood-fired stoves of local manufacture which are being replaced by coal heaters. The two main camps

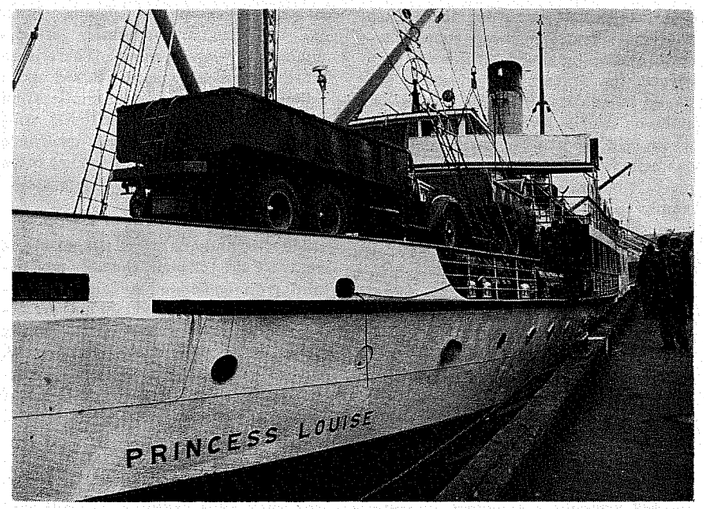

Figure 10: Combination oil tanker with capacity 1600 Imperial gallons with stakes to provide deck for backhaul of 10 tons of concentrate, aboard C.P.S.S. "Princess Louise" for shipment to Skagway thence by Yukon and White Pass to Mayo. In front International KB8f dump truck to be delivered to the same operator.

are both centrally heated, each by means of a 125-h.p. Waterous Pacific-type, low-pressure heating boiler, fitted with wood-and-coal grates. Steam is generated at a pressure of 15 lb. Camp heating cost for 1948 totalled $55,000.

Water supply, both for drinking and industrial purposes, is a problem of some importance. At the Elsa camp, during the summer, all water is obtained from Porcupine Creek, a small rivulet running through the camp. This dries up in September and the mill and power house then switch to mine drainage water which is unfit for drinking purposes. The latter must then be obtained at Flat Creek, another small stream about one mile west of the mine where a sump and pumphouse, with connecting pipe line to the camp have now been erected. In February, the mine drainage water fails and then all supplies must be obtained at Flat Creek. As the townsite is not piped, domestic water deliveries are made twice a week by means of truck or tractor and a 1,000 gallon tank erected on a trailer. The Flat Creek supply, itself, is not infallible and gives a great deal of trouble through freezing and wandering of the stream bed. Hence, as much water as possible both in the mill and power-house is recirculated in order to conserve the supply.

At the Calumet-Hector camp, there is no supply of fresh water although mine drainage is at all times sufficient for compressor and boiler operations. Domestic supplies are furnished daily to the cookery and bunkhouses either from Porcupine or Flat Creeks, dependent on the season, a distance of six or seven miles.

As the lack of water during the late winter is a matter of some concern insofar as fire-fighting facilities are concerned, the company is presently engaged in excavating a 100,000 gallon sump on the 200 level of the Elsa Mine which will feed to the main portal at campsite level through an eight-inch pipe. It is planned to make use of this supply to equip certain buildings with sprinklers as well as to furnish a large source at good pressure for hoses. At the Calumet-Hector camp, the compressor recirculation tank furnishes surge capacity for fire-fighting and, due to topography, at satisfactory pressure. The tank itself would be constantly replenished by means of the portal pump.

Labor

For the most part, men are hired at either Vancouver or Edmonton. Under the company's standard contract, their fare, amounting to about $115, is advanced and deducted from early pays. It is refunded after the employee has worked 250 shifts; after 350 shifts, outgoing fare is supplied. Not all men, of course, remain in service a sufficient length of time to qualify for the rebates. Cost to the company of this service in 1948 was $20,000.

At both the Elsa and the Calumet-Hector camps, the men have organized a social and recreational club and at each camp a building has been turned over for their use. Chief recreation is the consumption of ale, which is sold at cost. It is instructive to note that the privilege of maintaining a beverage room on each property has not been abused but has, in general, reduced the time loss and other bad features of excessive drinking. Each club carries a stock of clothing and other necessaries for their members and provides magazines, records and similar facilities. A 16 mm. movie, purchased by the company and turned over to the Elsa club, shows weekly pictures at both camps. A curling rink is currently under construction.

This paper was prepared by the author for presentation at the Metal Mining session of the Annual Western Meeting, C.I.M., Vancouver, October 17, 18, and 19, 1949.

The Territorial Government maintains a hospital at Mayo Landing toward the upkeep of which each employee contributes $3.00 per month. The company pays the salary of a full-time doctor who is resident at the Elsa camp but who also assumes charge of the hospital. A fully-qualified first-aid attendant is maintained at the Calumet-Hector camp and adequate first-aid facilities are available at the smaller, developing mines. There is no Workmen's Compensation Board in the Yukon Territory but compensation rates are fixed by a Territorial ordinance. The company carries insurance guaranteeing payment of the set rates to all injured employees.

Timber and Lumber Supply

The size and quality of timber in the central Yukon is poor, the only tree obtaining dimensions of sufficient size being a native spruce, which, on rare occasions, may show a diameter of six inches, fifty feet above the ground. Nevertheless, freight charges on lumber are such that importation is out of the question and the native material must be used.

In the past, all supplies of cordwood, lagging, mining timber and sawlogs have been supplied by local contractors. As this tends to be somewhat irregular, the company is presently considering the advisability of doing its own cutting. In general, all supplies are contracted for laid down at Mayo Landing in order to serve as a backhaul for the concentrate trucks.

The company owns a sawmill at Mayo with a capacity of 10,000 board feet per day and this supplies the bulk of the lumber used. Logs for this mill are cut under contract along the Stewart River, the present supply coming from a point 17 miles above Fraser Falls or 57 miles from the mill.

Cost of various sizes and grades of timber are as follows, delivered at Mayo:

Cordwood, 16′ lengths, per cord	$15.50
Lagging, 3″–5″ tops, per foot	.04
Lagging, 5″–7″ tops, per foot	.04½
Mining Timber, 8″ top, per foot (minimum)	.12
Sawlogs, per MBF recovered	45.50

Yukon Coal Company

In consideration of the high price and scarcity of cord-wood, the company in 1947 acquired control of a coal deposit at Tantalus Butte, across the Yukon River from Carmacks, and, with government financial assistance, has placed it on a producing basis.

The coal seam is from 9 to 14 feet wide without partings or any included foreign matter. It dips at approximately 60 degrees and outcrops on the river bank about 300 feet above water level. Although reserves have not been closely investigated they appear to be very large. BTU value averages 12,500.

A camp has been erected and the necessary mining equipment installed and the company is in position to furnish all the coal which may be required by the Territory. However, in practice, about half of the total production has been absorbed by the United Keno Hill Mines Ltd. with the bulk of the remainder going to Dawson and a small quantity to Whitehorse. Lack of proper burning equipment and uncertain transportation are hampering the more rapid development of the use of coal.

Commencing with the fall of 1948, coal exclusively has been burned in the heating boilers at Elsa and Calumet-Hector and has given every satisfaction both from the point of view of costs and also ease of handling.

Acknowledgments

The writer wishes to express his appreciation to Mr. F. M. Connell, president of United Keno Hill Mines Ltd., for permission to publish this paper. He is also indebted to numerous members of the mine staff for assistance in its preparation and in particular to Messrs. C. W. Hood and R. P. Ehrlich, who contributed drawings.