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PRELIMINARY FEASIBILITY STUDY OF A COAL MINE AT CHICAGO CREEK

Edited by

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Alaska Division of Geological and Geophysical Surveys

May 1986

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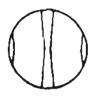
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PRELIMINARY FEASIBILITY STUDY OF A COAL MINE AT CHICAGO CREEK

Prepared for the State of Alaska, Division of Geological & Geophysical Surveys
Contract #CC10-0071

> Edited R. M. Retherford, T. K. Hinderman, and C. C. Hawley

> > April, 1986



April 11, 1986

HAWLEY

RESOURCE

GROUP, INC.

Mr. Gil Eakins
State of Alaska
Department of Natural Resources
Division of Geological & Geophysical Surveys
794 University Way (Basement)
Fairbanks, Alaska 99701

Dear Gil:

With this letter please accept ten copies of the final report, "Preliminary Feasibility Study of a Coal Mine at Chicago Creek." The originals for both this report and the summary report are already in your hands.

The results of our study are very encouraging. This is not to say that we have proven Chicago Creek to be economically viable, but we are much closer to doing so. In addition, I believe we have defined most of the critical elements and how they vary with energy needs. With our 1985 drilling program we have shown that the Chicago Creek deposit is large enough to fulfill the energy requirements of Kotzebue, the Red Dog Mine, and other villages for at least several decades. Perhaps more importantly, we have demonstrated a very low stripping ratio (1.7:1) initial pit at the southern end of the deposit.

Our calculations which include operational costs, capital costs of equipment and construction, and financing of the mine, ports, and generation facility at Kotzebue suggest that energy can be delivered to the utility at a cost which is very close to that of the current diesel plant (15 cents/kilowatt hour). This assumes that we deliver only electrical needs (not heat) and that we supply only the electrical demand of Kotzebue. Under such conditions, the required production rate from Chicago Creek is relatively low, and the unit price of the coal is fairly high (\$96/ton delivered to stockpile in Kotzebue). Such costs do not justify conversion, particularly in the face of declining petroleum prices. An important point is that for this acenario coals other than Chicago Creek coal might be obtainable at a lower cost and thus a coal-fired facility might still be competitive with a diesel-fired one. We also considered a case in which the Red Dog Mine was tied to Kotzebue with a transmission line. When this load was added, the economics changed substantially. delivered cost of coal at the higher production rate decreased to \$42/ton, and the accompanying shift in the delivered cost of energy was cut in half. In this case, the delivered price of Chicago Creek coal becomes very attractive, and the cost of energy would become low enough to compete well even with a substantial drop in oil price.

7011 Old Seward Hww Anchorage, Alaska 99% (907) 349-4673 Mr. Gil Eakins State of Alaska April 11, 1986 Page 2

Our study included consideration of the costs of construction of a transmission line from Kotzebue to Red Dog. The costs of this line, when added to the price of producing energy in Kotzebue, could deliver energy to Red Dog at a price of about 11 cents/kilowatt hour. Considering the alternatives, we believe this price would be very attractive to the operators of the Red Dog Mine.

Additional economics of mine operation are possible should, for instance, local placer mine operations be combined with Chicago Creek so that equipment and manpower are more fully utilized. Another possibility is for the mine owner to purchase and operate its own barge transportation system.

We conclude that we have identified a potentially viable method of developing the Chicago Creek coals while bringing some real benefit to the Kotzebue and the Northwest region. We have enjoyed working with you and the DGGS personnel. Best of luck in the future.

Sincerely,

Robert M. Retherford

RMR/skg

Enclosures

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Most Important Findings

Based on 1985 and previous drilling programs, the potentially mineable identified coal resource at Chicago Creek is estimated to be about 4.7 million short tons, of which 1.5 million may be mined at a stripping ratio of 1.7:1. The remaining 3.2 million short tons of coal would have a stripping ratio in the range of 4:1 to 5:1. The heating value of Chicago Creek coal averaged 6,800 Btu/lb. on an as-received basis, but the samples contained excess surface moisture and the actual heat content of the mined coal would probably be closer to 7,500 Btu/lb. Other parameters of the coal are compatible with proposed thermal use: Ash averages about 8%, sulfur about 0.8%, and fusibility temperatures all in excess of 2200°F.

A review of current and future growth trends and energy requirements for the city of Kotzebue suggests moderate continued growth. By 1990, when the 30-year period assumed for this report begins, the electrical needs of Kotzebue (not including heating) could be satisfied by 23,000 tons of Chicago Creek coal (assuming 6500 Btu/lb. and 25% plant efficiency) Thirty years later (2020), the energy needs may exceed 150,000 tons per year. To simplify mining, transportation and generation feasibility studies, this report assumes a fixed rather than an accelerating rate of production which is an average of the total forecast requirement over 30 years. We have assumed two primary cases: one based on the requirements of Kotzebue alone (50,000 tons/year average), and the other based on supplying the

electrical-energy requirements of both Kotzebue and the proposed Red Dog Mina using an average of 150,000 tons of coal per year. A simplified financial analysis was made of the coal-mining, coal-burning, and electrical-generation systems at the two production rates. The analysis assumed 10.5% interest, full capitalization within two years, amortization over 30 years, 15% return on investment, and no inflation or royalties.

Mining cost estimates assumed modern open-pit mining methods, purchase of new equipment, and maximum utilization of local labor. Estimated mining costs, including delivery of the coal to a stockpile 10 miles north on tidewater at Willow Bay, would range from \$28/ton at the higher production rate to \$74/ton at the lower production rate. The estimated cost of transporting the coal by barge from Willow Bay to Kotzebue and delivering it to a covered stockpile varies from \$14 to \$22/ton at the higher and lower production rates, respectively.

* L

Comparison of costs between (1) power generation at mine-mouth and transmitting power by wire to Kotzebue, and (2) power generation at Kotzebue showed that electrical transmission was not an economically desireable alternative. The cost of transmitting power to the Red Dog Mine from a Kotzebue-based plant, however, appears to be very competitive with an owner-operated facility at Red Dog. The study also indicated that the transmission of power to other northwest Alaskan villages near Kotzebue was costly, but so is the alternative of equalized (subsidized) village power.

A power plant location near Kotzebue was based on the following arguments: (1) barging the coal was found to be cheaper than transmitting the energy, (2) construction and operational costs for a plant at Chicago Creek would be higher than at Kotzebue, and (3) integration with the existing power system would be simpler. Appraisal of alternative plant configurations suggests that currently available rebuilt generating facilities could be installed much less expensively than could new equipment. In addition, since older, rebuilt systems tend to be smaller, multi-boiler units, they would be more adaptable to the needs of an expanding Kotzebue. We therefore examined two alternative generation systems for each of our basic demand scenarios. One alternative assumes the power is generated by newly manufactured boilers of 10MW capacity; the other alternative assumes smaller (rebuilt) 7.5KW boilers.

Finally, the cost per kilowatt bour for energy at the bus-bar was calculated for the various cases. Costs ranged from \$0.18 to \$0.07 per Kwh, decreasing substantially for the higher demand case. In comparison with the actual cost of diesel powered generation in 1984 of \$0.155, the coal-fired facility would only be marginally competitive with diesel at the 50,000 ton/year production rate. However, providing power to Red Dog and using a rebuilt plant facility could cut current rates in half and would remain very competitive despite declining oil prices. The power could be transmitted to the

Red Dog Mine for a cost of about \$0.03, resulting in a total delivered cost of around \$0.11 per kilowatt hour.

As a preliminary feasibility study, this report concludes that coal-fired generation is an attractive alternative for Kotzebue and that a mine at Chicago Creek could provide the coal. Coal could also be supplied from more distant sources; at energy requirements of 50,000 tons or less the delivered cost per ton of other coal would most probably be cheaper. In fact, it is almost certain that small amounts of less expensive coal from more distant sources could make coal-fired generation attractive for Kotzebue without the added load of Red Dog. At a higher rate of production however, as required by the combined energy requirements of both Kotzebue and Red Dog, the Chicago Creek coals would become very competitive at an estimated \$42/ton delivered or an equivalent \$3.20/million Btu's.

This study is a preliminary one, and changes in the assumptions would affect the results. Some of the factors that could increase the cost include: (1) the increasing cost of meeting environmental regulations—e.g., Surface Mining Act and EPA Air Quality Regulations; (2) lower future energy requirements of Kotzebue, and (3) lower than predicted as mined coal quality. On the other hand, other potential differences or alternatives could enhance the economics of the Chicago Creek coal. These include: (1) a possible higher average heat content of the coal suggested by differences between as—received and equilibrium bed moisture, (2) the effect of barge ownership by the

mining company or utility as opposed to the contractural arrangement considered here, (3) additional demand for coal for direct heating, and (4) the feasibility of increasing mine production slowly, beginning with a smaller operation with accompanying smaller capital outlay. If indeed this case is more realistic and energy requirements continued to grow as predicted, the costs of financing would decrease.

Overall, the estimates contained herein are considered to be within 15 or 20 percent. If we consider the end cost of delivered energy as calculated and apply a 20% factor for error, the long-range energy option of cosl-fired generation for Kotzebue still remains worthy of consideration.

Acknowledgements

The study group would like to acknowledge the help and cooperation of the people of Deering, especially the Karmun and Moto families, and those in Kotzebue, particularly John Schaeffer and the group of people at NANA Regional Corporation. Without them the field portion of this project could not have been done. We also owe particular thanks to Virgil and Mike Vial, Ken Upchurch, and Rhinehart Berg who helped a great deal with our logistics and support. Gil Eakins and his staff at the State Division of Geological & Geophysical Surveys have been very supportive of our efforts, and we owe them a special thanks for their trust and patience.

We must also acknowledge a special debt to a member of our study team, Ralph Stefano. This study incorporates some of Ralph's last professional efforts as he passed away in August of 1985. Although he knew his time was short, he was extremely generous in sharing his wealth of experience and knowledge, and this despite the daily discomfort he faced in his illness. Ralph's courage and indomitable spirit stand as an inspiration to us all.

INTRODUCTION

This report analyzes the feasibility of providing electrical power for Kotzebue and nearby villages using coal mined at Chicago Creek, south of Kotzebue Sound. The study was coordinated by Hawley Resource group Inc. and performed by their personnel and a group of engineering consultants with Alaska experience in geotechnical evaluation, coal mining, and electrical power generation and transmission. The study draws on the results of two seasons of field work by Hawley Resource Group, including drilling, geologic mapping, down-hole and surface geophysical surveys, and from previous studies of the coal resource and electric power alternatives. The project was performed under the provisions of Contract No. CC10-0071, administered by the Division of Geological and Geophysical Surveys of the Alaska Department of Natural Resources.

Location

The Chicago Creek coal deposit is on the northeastern part of Alaska's Seward Peninsula, about 70 miles south of Kotzebue (Figure 1). The proposed mine site is on Chicago Creek, about 1.25 miles east of its confluence with the Kugruk River, and about eight miles south of Willow Bay on Kotzebue Sound.

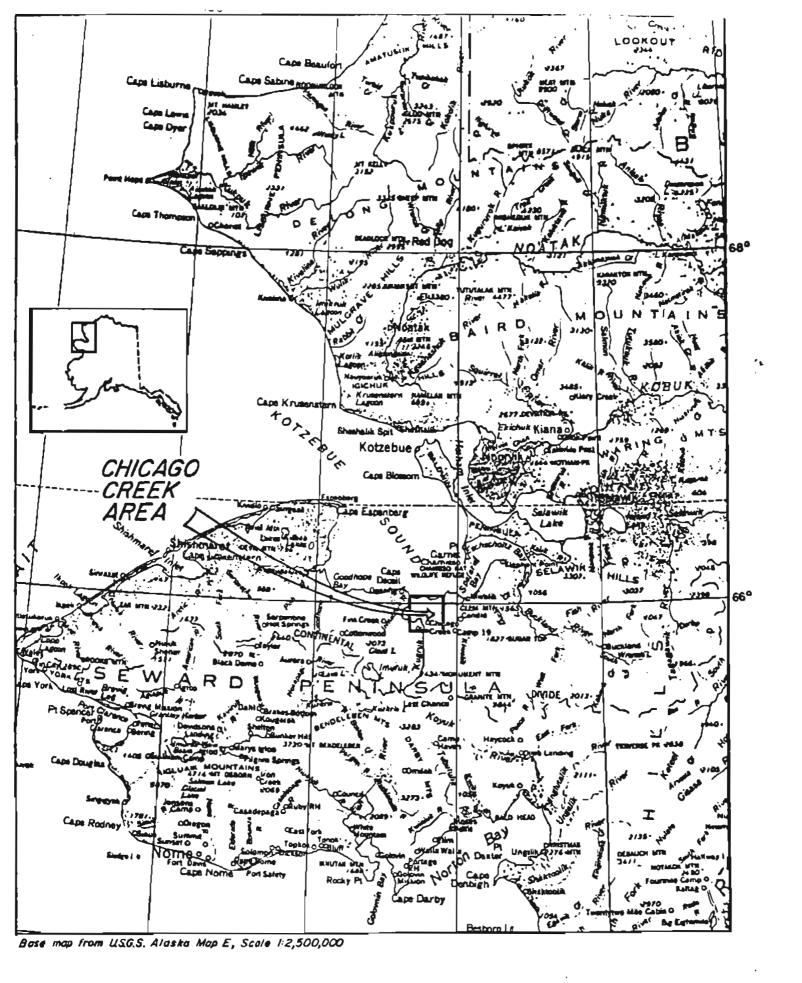


Figure 1: INDEX MAP

Access

At present the most common access to the Chicago Creek area is by air. Light aircraft can land at a 1,200-foot gravel airstrip at a gold placer mine on the Kugruk River. This strip is private and permission is required for its use. The mine and airstrip are about 1.5 miles from the project site. Vehicles and other heavy cargo must be flown to a 5,000-foot airstrip (also private) at Candle, about 15 miles to the east, and transported to the Chicago Creek area over an existing tractor-trail system.

Land Status

The lands of the Chicago Creek Coal Field (Figure 2) were selected by NANA Regional Native Corporation and the village corporation of Deering under the terms of the Alaskan Native Claims Settlement Act (ANCSA). The lands have been conveyed on an interim basis to the corporations by the U.S. Eureau of Land Management. Although technically the subsurface resources belong to NANA and the surface to the village, NANA and its villages have a cooperative agreement regarding authorization of uses of the surface and subsurface of native conveyed land. NANA, Kotzebue, and other nearby villages have a strong interest in development of local coal resources and have designated an access route through their property from Chicago Creek to the coast in anticipation of future coal development.

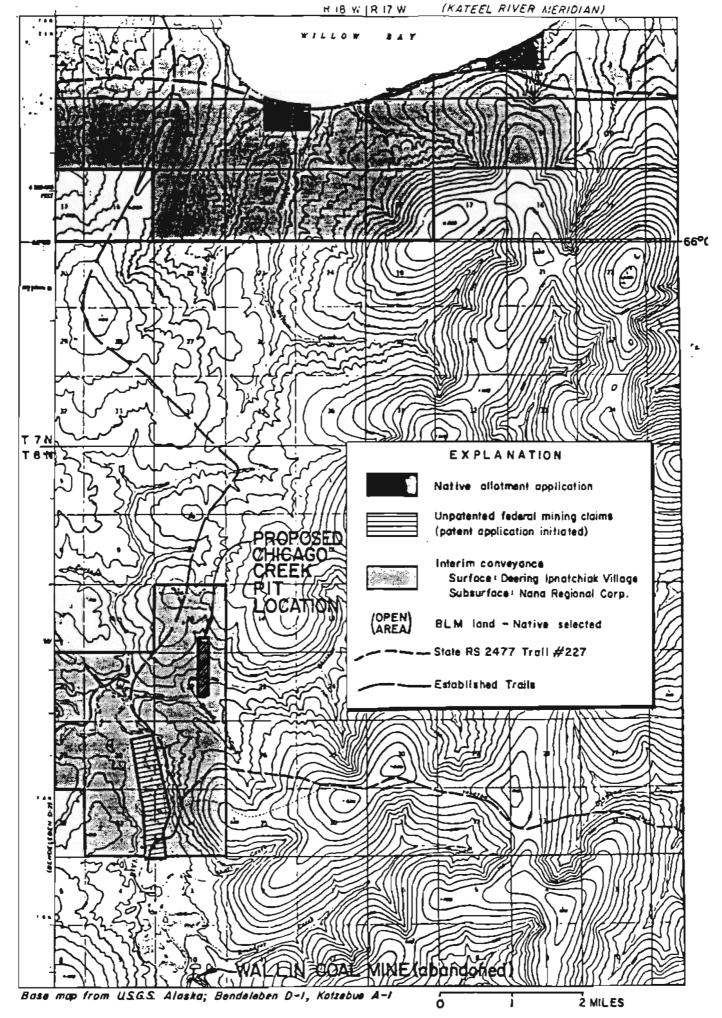


Figure 2: LAND STATUS OF THE CHICAGO CREEK AREA

Active federal mining claims (placer gold) pending patent and native allotment applications exist near the coal field. Both claims and allotments may become fee simple land; these transfers would have no bearing on the Chicago Creek Coal Mine site proper but could influence the location of construction material sites or transportation routes.

History of the Chicago Creek Coal Mine

Coal was first discovered on Chicago Creek by gold prospectors in 1902 (Moffitt, 1906). Some development work was done that year, but there was little demand for the coal until the winter of 1904-1905 when gold was discovered on the terraces above Candle Creek and the need arcse for a source of fuel for steam-thawing of placer ground. The coal deposit was staked in 1905 and the mine began production in 1908.

The mine operated during the winter months only and was sealed in the summer, probably to prevent thawing and subsequent instability of the workings. In 1908 the coal was being mined through a 330-foot shaft which was inclined at an angle of 18 to 36 degrees to a depth of about 200 feet (Henshaw, 1909). Coal was being mined at four levels at depths of 33, 80, 100, and 144 feet. The mine had an estimated total production of about 100,000 tons to 1911 when it was abandoned (Toenges and Jolley, 1947).

Other cosl mines which operated in the Chicago Creek area include the Wallin (or Rugruk) Mine and the Superior Mine about 4 and 5 miles further upstresm from the Chicago Creek Mine respectively. There is some disagreement in the literature about the size of the main coal seams at these mines, and their overall production is questionable (Dames & Moore, 1980). However, it seems clear that the seam at Chicago Creek was much larger and that its production was at least an order of magnitude larger than the other mines combined. For this reason, initial exploration efforts have focused on the Chicago Creek Mine.

Previous Investigations

The U.S. Geological Survey published several reports that dealt with the Seward Peninsula and its gold fields in the 1900's; some of these, in particular those by Moffit (1906), Henshaw (1909), and Smith and Eakin, (1911), reported on the progress of coal mining in the Chicago Creek area.

Interest in the deposit paled after 1911, but a later report by the U.S. Bureau of Mines (Toenges and Jolley, 1947) proposed a detailed plan for additional development of the deposit to provide coal for home heating for nearby villages.

During the late 1970's and early 1980's, the State of Alaska funded several programs to investigate new sources of energy and innovative ways of using traditional fuels in remote regions. One of these studies (R. W. Retherford and Associates, 1980) suggested that coal could be a cost-effective energy alternative for the Kotzebue Sound area.

The Retherford study sparked interest in the coal reserves of the Kotzebue area. In 1982, a state-funded exploration program, including 1,637 feet of drilling, was done at Chicago Creek by Denali Drilling, Inc. and Stevens Exploration Management Corporation (Manning and Stevens, 1982). In 1983, a continuation of the program by C. C. Hawley and Associates, Inc. included 2,800 feet of drilling (Ramsey and others, 1983).

The Present Study

The study described in this report began in December, 1984. Personnel involved were C. C. Hawley, R. M. Retherford, T. K. Hinderman, and J. P. Hawley, and W. E. Shoemaker of Hawley Resource Group, Inc., and the following engineering consultants: Ralph R. Stefano, R. W. Retherford, R. W. Christensen, John Wood, Henry Springer, and Thomas D. Humphrey, all Professional Engineers. John Rense and Burton Greist of NANA Regional Corporation provided information on Kotzebue

and the NANA Region, and Nancy Hanneman of Fairbanks operated the down-hole geophysical equipment.

The late Ralph Stefano, of Stefano and Associates, Inc., was an experienced mechanical engineer who had worked in Alaska since the early 1950's and was responsible for or involved in the design of nearly every coal-fired power plant built in Alaska since that time. R. W. Retherford, an electrical engineer, has consulted in the state since 1950 in the design of transmission lines and power plants throughout Alaska. R. W. Christensen, consulting engineer, has over twenty years of experience in geotechnical engineering, including construction projects all over Alaska. John Wood is a mining engineering graduate of the University of Alaska with 15 years of experience in mining and construction in Alaska including several years as the chief mining engineer at the Usibelli coal mine near Healy. Henry Springer of the Alaska Department of Transportation has been head of the Department of Transportation's Nome office for a number of years and has a great deal of experience in the design and construction of northern transportation systems. Thomas D. Humphrey is an electrical engineer with experience in the construction of innovative electrical transmission systems in remote parts of Alaska. Because of the contract deadline, it was necessary to obtain most of the consultants' input before the field phase of the 1985 program.

John Wood wrote the original draft of the open pit mine section of the report, and R. W. Christensen drafted the section on geotechnical

considerations. R. W. Retherford and Thomas D. Humphrey had most of the input into the electrical transmission section, Ralph Stefano and R. W. Retherford wrote most of section on the power plant, and Nancy Hanneman wrote the original section on down-hole geophysics. The rest of the report was written by personnel of Hawley Resource Group, Inc., who also edited the consultants sections for inclusion in the flow of the report, and who must bear final responsibility for errors or omissions.

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Field studies were done in June and July of 1985 to refine the information on reserves and the geology of the coal deposit. A track-mounted air-rotary drill, contracted from Thrasher and Associates of Nome, was mobilized to Candle in a Hercules aircraft and walked overland to Chicago Creek. In all, 50 rotary holes were drilled for a total of 7,709 feet, and the cuttings were logged as the holes were drilled. A total of 224 feet in 9 holes was cored, and 151.8 feet were recovered. Some of the holes sloughed or froze shortly after drilling, the rest, a total of 5,353 feet, were geophysically logged using a down-hole probe which recorded natural gamma radiation and gamma-gamma formation density.

Basic Assumptions of Study

Basic assumptions, common to all facets of the investigation, are:

- 1) The mine and power plant are each assumed to have a 30-year life span.
- 2) Equipment costs are based on current prices, and all costs are for new rather than used equipment.
- 3) Existing and commonly used technology are chosen over more innovative methods which have not been proven in northern Alaska.

Fluid bed combustion reactors were not evaluated because of criteria number (3), although their potential for lower discharges of sulfur and nitrogen oxides and rapidly developing commercial applications suggest that they should be evaluated in the future. Comments in the report call attention to alternative technology or to areas where possible savings could be made. Some simplifying assumptions, such as the constant annual production rate, have been made to avoid complicated scenarios based on future trends which are difficult to forecast. These simplifying assumptions were also chosen to yield a conservative result.

MARKET DEMAND

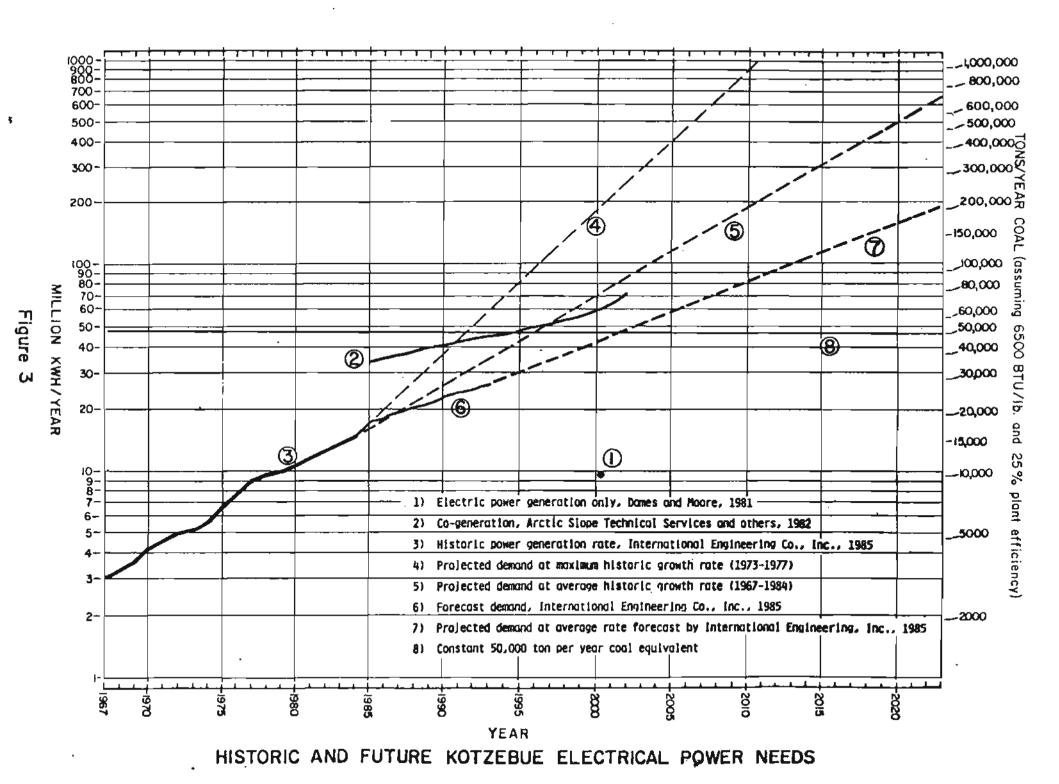
Recent reports by Dames and Moore (1981, 1983), Arctic Slope Technical Services (1982), Arctic Slope Consulting Engineers (1984), and International Engineers, Inc. (1985) contain estimates of electrical load growth for Kotzebue. Some of the studies also cover direct-heat energy demands for Kotzebue and both electrical and heating demands for nearby villages.

The idea of providing power from a central source to the villages of the region is an appealing one, but the economics of a transmission net are difficult because of the relatively long distances between villages. The transmission net, however, might provide a savings over the state's current power-equalization subsidy if the Chicago Creek-Kotzebue interconnection were available. The possibility of an additional power demand at the Red Dog Mine project and its effect on the Chicago Creek-Kotzebue interconnection is also evaluated in the Electrical Transmission section. Red Dog currently plans to generate its own power, but the mine would consider buying power from a reliable commercial source if it came on-line in time at a competitive price.

In addition to use in electrical power generation, coal can be burned for direct heat. Chicago Creek coal could be delivered in bulk to major users in the Kotzebue area and distributed in sacks to smaller or more remote consumers. The degree to which it would be used is difficult to forecast. If the price were low enough it could be an attractive alternative to oil, but the use of coal would entail the additional labor of clinker disposal. It could be burned directly in existing wood stoves, but oil-burning units would have to be converted or replaced.

For the purposes of this study we have chosen to base the demand forecasts on the most conservative case, that of supplying electrical power for the immediate Kotzebue area. The most recent and authoritative study on the electrical demand for Kotzebue is the International Engineering Co., Inc. (1985) study. Forecasts based on that study are discussed below; Table 21 in the section on Electrical Transmission lists the best estimates of power needs of all the villages considered in the study. Electrical and space heating demand forecasts for Kotzebue and the surrounding villages from the other studies are given in Appendix A.

Figure 3 summarizes Kotzebue's historical electric power needs from 1967 through 1983 and shows projected demands from other studies. It also shows three long-term demand projections based respectively on maximum historical growth, average historical growth, and the most conservative forecast.



The base case for this study assumes an annual coal production of 50,000 tons. A constant average rate greatly simplified the planning and costing of the mining operation, and the use of a fixed, round number facilitated other costing. According to power demand projections shown on Figure 3, 50,000 tons of coal equivalent at 6,500 Btu/lb. would be needed for power generation in about 1992 based on the maximum historic growth rate (1973-1977); by 1996 at the average historic generation rate (1967-1984), or about 2002 on the International Engineering Co., Inc.'s (1985) projected growth line. Assuming cogeneration needs (Arctic Slope Technical Services and others, 1982), the equivalent of 50,000 tons of coal would be needed by about 1995. To assess the sensitivity of the project to variations in production rates, cost projections were also made for increased production rates and varying energy needs.

GEOLOGY

Regional Setting

Much of the northesstern Seward Peninsula is underlain by a low-grade metamorphic complex of probable Paleozoic age. The stratigraphically lower parts of the unit consist of chlorite-rich metapelite which grades upward into interlayered graphitic metaquartzite, micaceous marble and minor metapelite. These rocks are in turn overlain by chlorite and albite schists with lenses of metabasite (Till, 1983). Most of the sequence was formerly thought to be Precambrian in age, while some of the carbonate units were correlated with Cretaceous rocks (Sainsbury, 1974). More recent work by Till suggests that most or all of the basement rocks are probably closer to mid-Paleozoic and may be early Devonian, but for the present their ages must be considered as questionable.

In the Chicago Creek area (Figure 4), a green metapelite unit (Pzg) subcrops east of the coal deposit and grades up into a mixed unit (Pzs, Pzcs, and Pzc) which mainly occurs to the west. The coal deposit occurs at the transition between rock types with greenschist to the west and a gray, locally calcareous unit to the east (Plate 2).

To the east of the Chicago creek area, the crystalline metamorphic rock units are juxtaposed against, and locally overlain by, Cretaceous sediments of the Yukon-Koyukuk province. According to Patton, (1973)

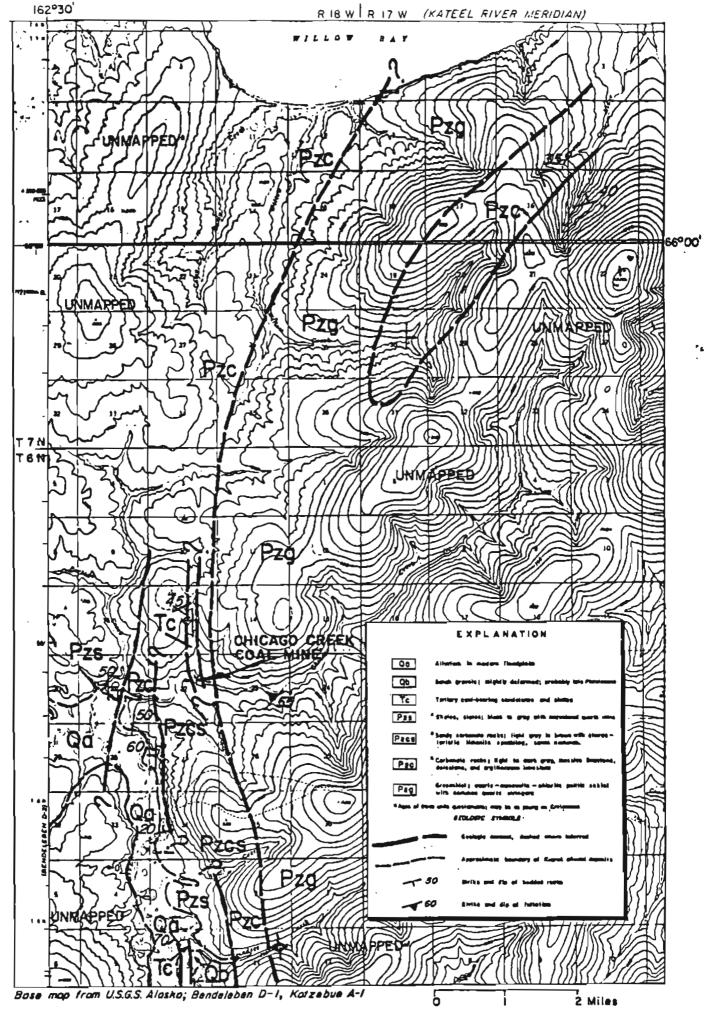


Figure 4: GEOLOGY OF THE CHICAGO CREEK AREA

these sediments are locally cosl-bearing, and in the past, the Chicago Creek cosls have been correlated with them. Based on palynology (Haga, 1984) and geologic similarity to other cosl deposits of known age, however, it seems more likely that the cosl bearing sediments of the Chicago Creek area are Tertiary (Ramsey and others, 1983) in age.

Chicago Creek Area Geology

Bedrock in the Chicago Creek area is mantled by loess, colluvium, and tundra. The geology and reserve estimates discussed in this section are therefore mainly based on information from the drilling programs. Plate 1 locates drill holes and summarizes the data available from each hole. Plate 2 is an interpretive geologic map of the bedrock units as they occur beneath the overburden and also shows representative cross-sections. Graphic drill log diagrams are included on sections on Plate 1 and in Appendix B.

Lithologic Units

Five bedrock units are distinguished in the Chicago Creek area. Some of the coal beds and clay partings were seen in drill core, descriptions of the rest of the units are based on examination of rotary cuttings.

Gravel, Sandstone and Siltstone

The stratigraphically youngest unit in the Chicago Creek area consists primarily of interbedded, poorly consolidated gravel, sandstone, and siltstone. The sequence is distinctly more coarse-grained than the principal cosl-bearing unit. Its gravels are polymictic, with well-rounded pebbles of quartz and other resistant rocks. The unit truncates the largest coal bed in some areas, and most of the drill holes in it encountered metamorphic basement rocks at a shallower depth than was common for the basement rocks of the main coal-bearing unit. It is therefore inferred to be in fault contact with the coal-bearing sequence. It is, however, possible that it is an alluvial deposit which was deposited in crosscutting channels.

In the southern part of the map area, the unit contains relatively unaltered wood fragments and therefore appears to be significantly younger than the coal sequence. Samples of the wood from one of the southern drill holes have been submitted to the U. S. Forest Service Forest Products Laboratory of Madison Wisconsin and have been identified as willow (Salix). Dave Hopkins of the University of Alaska, who has had considerable experience with surficial geology on the Seward Peninsula, feels that the unit is most likely of Pleistocene age (personal communication, 1985).

Gray and Brown Siltstone, Mudstone and Sandstone

The coal beds of the Chicago Creek are contained in a sequence of poorly consolidated gray and brown siltstone and mudstone with local sandy beds and rare layers of rounded, polymictic gravel. The unit is notably micaceous, especially towards the bottom of the sequence. It contains medium-to-dark-brown carbonaceous layers, many of which grade into coal beds. Towards the bottom, the unit appears to grade into weathered schist and then into fresh schist.

Lignitic Coal

The coal beds of the Chicago Creek area range in thickness from a few inches to about 100 feet. Most of the mineable reserves are contained in a single large bed which is as much as 100 feet in apparent true thickness, though some of this thickness may be due to structural repetition. Based on thermal value (Btu) and carbon content, the coal is lignite. It is dark brown to black in color; some of it is vitreous when fresh, although most has a dull luster when it dries out. Some of the coal has a fragmental texture, as if it has been brecciated and healed. Rare concretions of pyrite were seen locally.

As observed in core, the coal is commonly highly fractured, with pieces ranging from less than an inch to several inches in diameter. The coal beds have scattered partings of soft, gray clay and rare thin stringers and blebs of hard, reddish-tan material with a bony consistency which was referred to as bone in the logs. The largest coal bed has a distinctive parting near its top which averages about three feet in thickness, and small partings were common in the lower parts of the various beds.

Six samples of Chicago Creek coal from the Densli Drilling program were submitted for palynological examination (Haga, 1984). The results were only marginally satisfactory due to the lack of a reference section for the Tertiary of northwestern Alaska, and to the lack of diagnostic forms in the samples. It was determined, however, that the samples have a relatively cool, temperate pollen assemblage. Four could only be dated as Tertiary to Quaternary, but the fifth is of probable Tertiary age. A Tertiary age seems to be reasonable based on the geologic similarity to other dated coal deposits elsewhere in Alaska.

Green and Gray Schist

The coal-bearing section is bounded on the west by a heterogeneous quartz-mica schiat unit. The schiat is predominately green in color but much of it has up to 1% disseminated sulfide minerals and is weathered to a reddish-yellow color. It also locally contains gray and black interbeds. Parts of the unit are quartzose and hard to

drill. Other sections, including some only a few feet away from the quartz-rich portions, are considerably softer and drill quite easily.

Gray to Black Schist

A relatively homogeneous, gray-to-black, quartz-mica schiat unit which has local calcareous phases underlies the gravel unit east of the main coal-bearing section. The same unit appears to form the basement for the main coal-bearing section. The green and gray schiat unit and the gray to black unit alternate elsewhere in this part of the Seward Peninsula where seen in exposures along the streams. It is likely that they are of similar age, probably early to middle Paleozoic.

Structure

The cos1-bearing sediments occur in a narrow, north-trending, structural basin with little topographic expression. As shown on cross-section E-E' and the geologic map (Plate 2), the basin is less than 100 feet wide on the surface at the southern end. It has been traced along strike for about 8,000 feet. The basin continues an unknown distance to the north, and although it appears to be pinching out to the south. Coal occurs at the Wallin Mine, about on strike four miles to the south of the last known occurrence at Chicago Creek (Figure 4).

The 1985 drilling was concentrated in the southern end of the known trend, along approximately 3,600 feet of strike length shown on Plate 2. This part of the basin is bounded on the west side by a fault which juxtaposes the Tertiary sediments with the green and gray schist unit. The fault dips to the west at angles ranging from 85 to as little as 15 degrees, thus part of the coal deposit has a capping of crystalline basement rocks (Section D-D').

1

Roles drilled on the east side of the basin on projections of some of the coal beds encountered the coarse-grained gravel and sand unit, which therefore appears to cut some of the Tertiary formations. Based on the shallow depth of the bedrock basement under the gravel unit and the linear nature of the contact, it is assumed that the eastern side of the basin is bounded by a normal fault, with the east side moved up relative to the basin. It is also possible that the gravel unit is a post-coal fluvial channel which has eroded the coal bed, and that the shallow basement is due to a combination of original topographic relief and a steep dip. Most of the evidence appears to favor the fault hypothesis, as shown on the geologic map and sections C-C', D-D' and E-E' (Plate 2). If present, the fault probably continues to the north of the dashed portion shown on the plate, but there are no drill data to show its location.

The east-west striking transverse faults shown on Plate 2 are inferred from abrupt changes in the thickness and positions of the coal beds.

The most dramatic of these changes occurs about 300 feet to the north of Chicago Creek, where holes drilled on a projection of a very thick portion of the main coal bed encountered only significantly thinner coal beds (Sections B-B' and C-C'). Lignite beds typically are very irregular in thickness along strike, but the change in this case occurs in less than 100 feet.

The partings within the beds and the stratigraphic sequence in the coal-bearing sections are similar on both sides of the inferred transverse fault so the sequences appear to be the same. The thinning is probably due to different erosional levels on a bed which thins and thickens up and down dip. The movement of the fault cannot be resolved with the present information; the thick portion of the main bed may either be down dip of the smaller shallow bed to the north of the fault, or it may have been up dip and been eroded away. The other transverse faults to the north result in apparent east and west movements of the stratigraphic section of the basin but it is not known whether these offsets result from actual strike-slip motion or from the effect of different erosional levels on a dipping sequence which has had differential dip-slip movement.

The coal-bearing sediments of the Chicago Creek area were probably deposited in a topographic basin formed by earlier tectonism along the same atructure that caused their subsequent intense deformation.

Coal Quality

Thirty-six samples of drill core and three samples of the rotary hole cuttings from the 1985 program were submitted for proximate analysis to the Mineral Industry Research Laboratory of the University of Alaska in Fairbanks. The samples were tested for heating value (Btu/lb.), moisture, volatile matter, fixed carbon, ash, and sulfur. As the samples contained a significant amount of surface water, equilibrium moistures were done on five samples to give a better approximation of expected true bed moisture. The averages of the results of the tests are shown in Table 1, and the complete results are given in Appendix C.

TABLE 1
Averages of Proximate Analyses of Chicago Creek Coal

Basis *	Moisture (%)	Volatile Matter (%)	Fixed Carbon (%)	Ash (I)	Heating Value (BTU/Lb.)	Total Sulfur (%)
			Core Samples	**		
1	38.64	29.27	27.54	8.55	6,400	0.82
1 2 3		43.38	45.28	13.36	10,505	1.34
3		48.07	51.93		12,105	1.64
4	28.83	30.95	32.43	7.78	7,708	0.83
		Cu	ttings Sample	g ++		
1	41.49	24.30	27.95	6.26	6,323	0.56
1 2		41.52	47.66	10.82	10,788	0.95
3		46.59	53.41		12,092	1.07

^{1 --} as received

^{2 --} moisture free

^{3 --} moisture and asb free

^{4 --} equilibrium bed moisture

^{**} average of 36 samples except 4, which is average of 5 samples

⁺⁺ average of 3 samples

TABLE 2
Ash Fusibility (degrees F)

Oxidizing Atmosphere

Reducing Atmosphere

Sample No.	Initial Deformation	 Softening 	Fluid	Initial Deformation	 Softening 	Fluid
DH- 1-82-150'-160'	2360	2460	2465	2290	23 85	2400
DH-11-82-1187-1307	23 95	2410	2460	2310	2330	23 4 5
DH- 4-82- 73'- 78'	l 23 2 5	23 53	2360	2225	2285	23 00
	[] 	_	<u> </u>		

TABLE 3
Washability Analysis of Sample DH-4-82/73.5'-80.0' Chicago Creek
(all results on a moisture-free basis)

ACTUAL PRODUCTS CUMULATIVE FLOAT						CU		LATIVE INK				
Product	Wt Z	Ash Z	Btu/15 	Total Sulfur		t 7	Ash Z		Total Sulfur		7	Ash X
Float-1.30	96.01	4.02	11,234	.97	9	6.01	4.02	11,234	.97	100.	00	4.10
1.30-1.40	2.83	5.14	11,233	.95	9	8.84	4.05	11,234	.97	3.	99	5.90
1.40-1.60	0.69	6.24	11,114	.94	9	9.52	4.07	11,233	97	1.	16	7.76
Sink-1.60	0.48	9.94	10,491	.94	10	0.00	4.10	11,230	.97	i o.	.48	9.94

The ash fusibility tests indicate that the coal could be used without significant problems in any type of firing system. The higher density fractions from the washability tests were identified as fusinite; washing would not significantly reduce the ash content of the sample tested.

Resource Estimation

According to currently used definitions (Wood, 1981) the term resource will be used in this discussion rather than reserve since the term reserve is restricted to deposits which have been proven capable of being mined economically. The cost at Chicago Creek at present is properly classed as a demonstrated resource the definition of which implies a reasonable level of geologic confidence in the quantity present. Demonstrated resources are further divided into measured (high level of assurance) and indicated (moderate level of assurance) classes. The relative density of drill holes and sample analyses from the southern part of the Chicago Creek deposit justifies the classification of the cost in segments I, II, and III (Plate 2) as measured demonstrated resources whereas the cost to the north (segments IV, VA, and VB, of Ramsey and others, 1983) should only be considered as indicated.

Volumes for the resource figures shown in Table 4 were calculated in a similar manner to the volume calculations for the open pit mine plan (Appendix D). The tonnage figures assume a density factor for the coal of 80 Lbs/Cu. Ft. Using this approach, and based on the data amassed through the 1985 field season, the Chicago Creek area contains a demonstrated resource of at least 4.7 million short tons of coal within 300 feet of the surface (Table 4). The measured demonstrated coal resource in segments I, II, and III includes about 2.5 million short tons.

The 4.7 million ton figure is about 1 million tons larger than the previous estimate of Chicago Creek coal resources (Ramsey and others, 1983), a reflection of the discovery of increased strike lengths of thicker and more continuous coal beds in Segments I and II (Plate 2). Magnetometer surveys conducted in the fall of 1984 (Appendix G) suggest that the Tertiary section continues to the north for at least an additional mile. Assuming an average bed thickness of 20 feet the additional mile of strike could contain an additional 1,690,000 tons of coal. The district probably contains still more coal in extensions of the Chicago Creek basin to the north and south, and additional undiscovered parallel coal basins may also exist.

TABLE 4

Coal Resource Estimation
(See Figure 3 for location of segments)

		MINEABLE		ļ]	!	1	
	CROSS-SECTION ISTATION # DR I BOLE # USED		IAVE. BED ITHICKNESS (FT)	DENSITY FACTOR	PREVIOUSLY HINED (TONS)	MINING DEPTH (FT)	DIP DEFTH (FT)	DEHONSTRATED COAL RESOURCE SEORT TOMS)
IA	15008 13008 11008 8808	800	37.5	80 1b/ft ³ 12,000 1b/ton	ZHOH BHOH BHOH BHOH BHOH BHOH BHOH BHOH	100 200 300	65 196 360	78,000 1 235,000 1 459,000
13	7008 5008 2508 1308	700	85.0 		100,000	100 200 300	92 229 360	218,960 545,020 910,000
(Le	OTAL OF IA AND ss 100,000 ton reviously mine	4	'			100 200 300		196,960 680,220 1,369,000
IIA	130N (420N (510N (650	83,0 	ы	AONE	1 0 0 2 0 0 3 0 0	103	
115	620H 890H 1100H	730	34.0	Ħ	340K	100 200 300	83 195 310	82,400 193,600 307,770
SUBT	OTAL OF ITA AN	DIIB				100 200 300	; 1 !	304,675 711,520 1,153,700
III i	1240N 1350N 1570K 1820N	840	18.0	86	HONE	1 0 0 20 0 3 0 0	83 1 195 1 298	50,200 117,900 180,230
IV	7-82 8-82	1,200	28.0	48	I BYON	100 200 300	141 281 424	
VA I	7-63 8-63 f	1,000	29.0	16	HONE	100 200 300	141 283 424	219,960 441,480 661,440
VB	9-83 chru 1 14-83	2,300	20.0	н	NORE	100 200 300	141 283 424	
ALL	TOTAL SEGMENTS	6,300	n/a		N/A	100 200 300		1,220,735 3,045,790 4,714,380

^{*} U.S.G.S. Definition, 1980; Includes both Measured and Indicated Resources

Down-Hole Geophysics

During the 1985 field program, 5,353 feet of rotary drill holes were geophysically logged using the natural-gamma and gamma-gamma-formation- density techniques. The natural-gamma instrument measures gamma radiation, which tends to be concentrated in clays and shales but is nearly absent from coal layers, resulting in fairly clear-cut contrasting geophysical signatures of the units of primary interest. The gamma-gamma log measures the interaction of source-supplied gamma radiation with mass elements of adjacent formations to determine relative densities. This is usually also a good determinative method since coal densities are commonly considerably lower than those of the adjacent beds. The combination of these two logging techniques accurately measures coal intervals and shaley partings within a sedimentary sequence.

A Well Reconnaissance, Inc. Geologger (Model Number 8036) was used to log the holes. It was mounted on a generator-equipped Bombardier-tracked vehicle. A 6-foot gamma-ray scintillator probe with a non-stretching cable provided accurate depth measurements for correlation of the geophysical logs with the lithologic (rotary cuttings) logs.

Interpretations of the logs were made based on characteristic deflections (magnitude, shape, noise intensity, etc.) and subsequent comparison with lithologic logs. In general it was difficult to make lithologic correlations from hole to hole without the aid of the lithologic logs, but specific lithologic breaks within individual holes were easily locatable and, in general, were within a few feet of the depths shown on the corresponding cuttings logs. Lithologic correlation of the five basic rock units using generalized geophysical signatures from hole to hole within the prospect area was also fairly reliable. A more complete discussion and the original logs and interpretations are contained in a supplementary report, the complete contents of which are listed in Appendix G.

MINING PLAN

Although some consideration was given to other mining methods, modern environmentally acceptable open pit mining practice appears to be by far the most economical. This is especially so within the thicker sections of the seam where stripping ratios are less than 2:1. The following discussion is therefore developed around an open pit design where waste from one section of the pit is backhauled to a previously mined section and used to reclaim the pit to near former topographic contours later. Costs are expressed in 1985 dollars and, while amortization of equipment is included, the cost of financing is not.

Initial Development of the Mine

Initial development of the mine will require the construction of a haul road, coal stockpile pad, airstrip, camp facility, and diversion ditch (Figure 5). Haul-road and camp construction will take place over a 2-year period. Heavy equipment, fuel, and temporary camp facilities will be delivered to Willow Bay in the fall. The next spring before breakup, the equipment and camp will be moved cross country to the campsite. Airstrip and haul road construction will take place the first summer using gravels from the bars and floodplains of the nearby Kugruk River or suitable material from within the pit area. The same equipment will be used for this initial development as will later be used to strip and mine the coal.

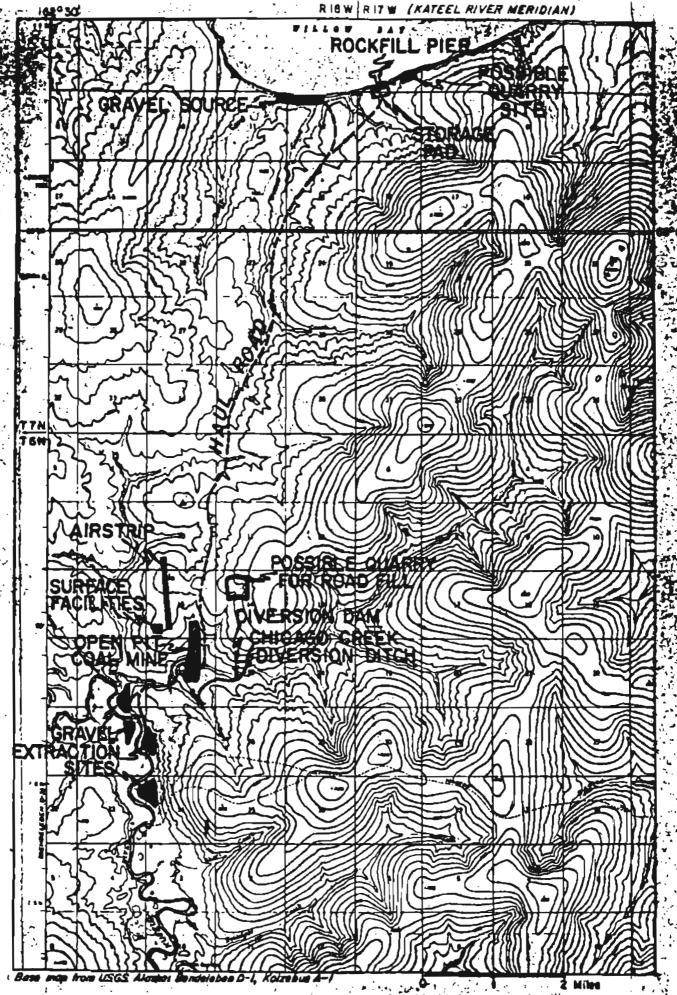


Figure 5. PROPOSED FACILITIES - CHICAGO CREEK COAL MINE

Earthfill Structures

The largest and earliest earthmoving effort will be construction of the road. The road will be about 10 miles long, built as a gravel overlay averaging 35 feet in width and 5 feet in thickness. About 350,000 cubic yards of gravel will be required. A straight section wider than the rest will be built near the camp facility to serve as an airstrip. The road will require five months to build. Gravel pads will also be constructed for shop-generator, fuel storage, and bunkhouse areas. A pad suitable for coal stockpile will be laid down at the terminus of the road at Willow Bay. A ditch approximately 5,000 feet in length and small diversion dam will be constructed on Chicago Creek upstream from the pit area. Approximately 115,000 additional yards of gravel will be needed for these purposes. A total gravel resource base of 500,000 yards is assumed for construction (Table 5). Because a majority of the annual heavy hauling will take place in April while the roadbed is still frozen, road-design requirements can be minimized.

The cost of this construction (including limited funds for temporary camp, planning, engineering, and environmental baseline studies over a 2-year period) is estimated to be \$4.6 million (Table 6).

TABLE 5

Gravel Requirements for Road, Airfield, Camp, and Pad Construction

			Approximate Cubic Yards (X 1,000)	Totals
1.	Roa	d (10 Miles X 35 Feet X 5 Feet)		350
2.	Oth	er		
	A.	Extra Material for Airstrip (35° X 5,280° X 5°)	34	
	B.		19	
	c.			
		(200° x 350° x 10°)	26	
	D.	Camp Road Complex (35' X 3,000' X 5')	19	
	E.	Willow Bay Storage Pad	15	
		Miscellaneous	<u>37</u>	<u>150</u>
		TOTAL		500

TABLE 6

Site Improvement Costs

Year [(5 Months)

Road & Airstrip Construction:

1.	Field Labor	\$1,050,000
2.	Equipment Cost	1,000,000
	Home Office & Salaries	220,000
4.	Air Transportation	50,000
5.	Culverts & Bridges	100,000
	Temporary Camp Costs	150,000
	Water Supply System	100,000
	Drain Fields	150,000 \$2,820,000

Year 2 (5 Months)

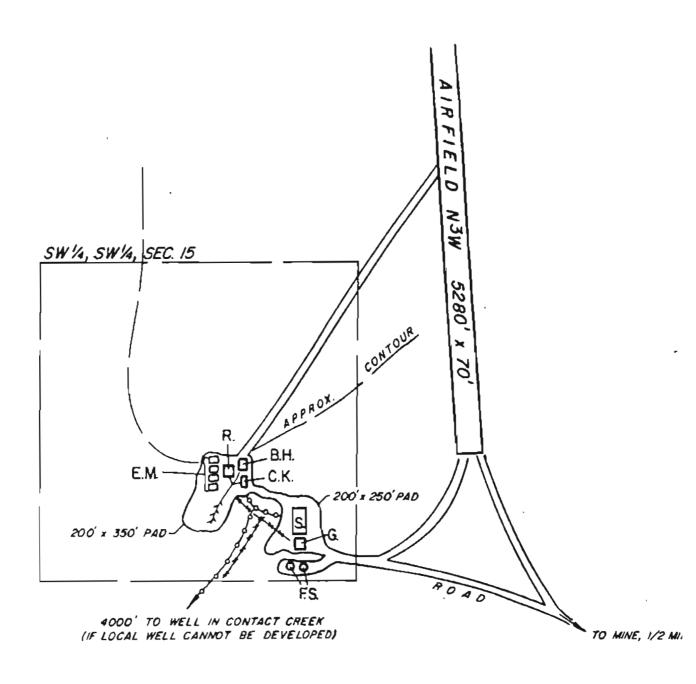
Continued Construction & Overburden Stripping at Normal Annual Operation Cost (See Table 13)	1,553,000
Contingency (15%)	233,000
Subtotal	1,786,000
TOTAL SITE IMPRODUMENT COSTS (TRAPS 1 & 2)	\$4.606.000

Permanent Camp Facility

The permanent camp has complete facilities for 20 men and includes a 60-X-140-foot shop-warehouse (Figure 6). Construction materials, as well as permanent fuel storage tanks, are to be delivered to Willow Bay during the fall of Year 1. The initial camp will have diesel generators with waste heat utilization. In future years, a small coal-fired system would eventually provide prime power. The permanent camp would be finally constructed during the spring and summer of Year 2, concurrent with the onset of coal stripping activities. Full occupancy is planned for early part of Year 3 when the first coal mining would actually begin. The permanent camp is estimated to cost \$1.8 million (Table 7).

Design of the Open Pit

The proposed pit (Figure 7) is to be developed as a truck-shovel-loader operation with haul-back of waste occurring as the mine proceeds. The initial open pit will be at the southern end of the drill reserves near the historic Chicago Creek mining operation. The latest reserve and overburden estimates would indicate that initial development of the pit would logically commence in Segments IB and IIA (see Table 5 and Figure 7) where stripping ratios are 1.7 and 1.6:1 respectively. Taking advantage of the lower topography of the Chicago Creek valley, the pit could



EXPLANATION

F.S. - Fuel Storage

S. - Shop (6000 sf) and Warehouse/Office (4000 sf)

B.H. - Bunkhouse (2500 sf)

C.K. - Cafeteria - Kitchen (1500sf)

R. - Recreation (1000sf)

E.M. - Future Employee Modules

G. - Power Supply

Gravel Pad

Electric Distribution

Water Supply

Drainfield

Scale: 1" = 400'

SKETCH OF PROPOSED CAMP FACILITIES Figure 6

TABLE 7

Permanent Camp Costs

	•		
Initial Costs:			
Cafeteria/Bunkhouse Fac			
Bunkhouse	2,500 SP		
Cafeteria & Kitchen			
Recreation	1,000 SF		
Shower	750 SF		
•	5,750 SF @ \$ 85/SF	-	\$ 488,750
Shop/Warehouse/Office			
Warehouse/Office	4,000 SF @ \$ 60/SF	= 600.000	
Shop (3 Bay,			
60' X 100')	6,000 SF @ \$120/SF	- 720,000 -	960,000
	,		•
Utilities	>		
Generator (2 - 150	KW);		
Switch Gear (2 - 5	O KW)	150,000	
Transmission System		50,000	
Water Hookup		50,000	222 222
Sewer Hookup		50,000 =	300,000
Fuel Tanks (Bladder) 1	25,000 GAL @ \$60/GAL	-	75,000
TOTAL	INITIAL COST		\$1,823,750
ANNUALIZED IN	ITIAL COST (30 YEARS)	•	\$ 60,792
Annual Costs:	V N P 15 V P 17	Λ D	\$ 36,000
Supplies (Food) \$20/	Man-Day X 15 Men X 12	O DEAR	<i>a</i> 30,000
Electrical Generation	•		
Fuel1. 15.0 Gal/Hr	X 12 Hrs/Day		
X 150 Days	X \$1.25/Gal	33,750	
_			
2.5 Gal/Hr	X 12 Hrs/Day		
X 150 Days	X \$1.25/Gal	5,625	
0 0 5 0 1/7	In		
	X 24 Hrs/Day	16,125	
X 215 Days	x \$1.25/Ga1	10,123	
Maintenance		27,750	
Reserve to Replace @	10 Years	15,000	98,250
	, 		•
Miscellaneous Maintenan	ce		50,000
	TOTAL		\$ 184,250
	CONTINGENCY		27,637
IATOT	ANNUAL COST		211,890

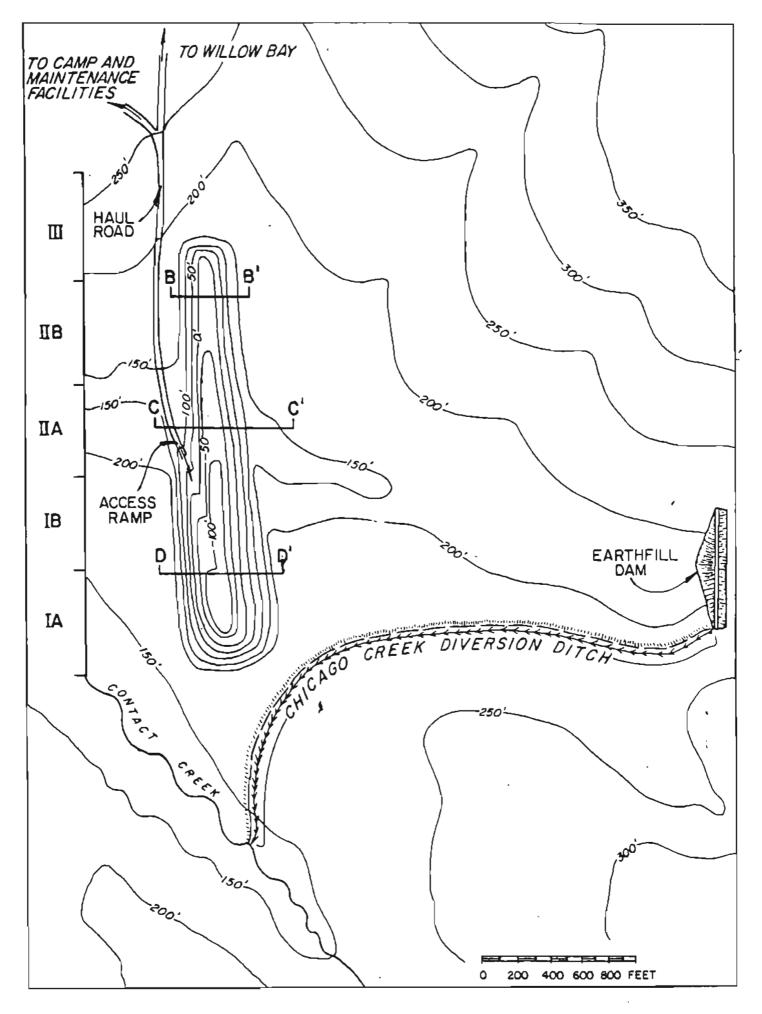


Figure 7: THIRTY-YEAR PIT AND ASSOCIATED STRUCTURES

TABLE 8
Summary of Open Pit Data

		SEGMENTS					AVE.	TOTAL
		IA	I IB	IIA	IIB	III		VALUE
Average Coal Thickness	(Ft)	37.5	85.0	83.0	34.0	18.0	51.5	<u> </u>
Average Dip		 45	51	47	69	70	56	1
Depth of Overburden	(Ft)	15.0	15.0	25.01	25.0	25.0	21.0	
Total Vertical Depth	(Ft)	300.0	300.0	250.01	200.0	200.0	! !	
Dip Depth	(Ft)	360.0	360.0	250.01	195.01	195.0	; !	
Length	(Pt)	800.0	700.0	650.0	730.01	840.0	744.0	3,720
Stripping Volume (X 1000 Yd3)		1,832	 1,566	993	679	781	! ! !	 - 5,851
Mineable Coal Volume (X1000 Tons)		459	910	610	194	118	1 1 1	2,291
Years to be Mined (@ 50,000/Yr)		9.1	18.2	12.2	3.91	2.4-	 	 45.8
Stripping Ratio		1 4.0:1	 1.7:1 	1.6:1	 3.5:1 	6.6:1	1 12.55:1 1 *	
		1	1	l1	1			

^{*} Weighted according to coal volume.

commence development in IIA and move southward into IB. Initially, excavated waste rock would be used as road base material, but excess or unsuitable material could be stockpiled just downstream of the operation and adjacent to the access ramp.

Ultimate pit depths of 300 feet below the surface are planned for Segments IA and IB, decreasing to 250 feet below surface in IIA partly because of topography and to 200 feet in IIB and III. Coal and wall rock alike are permanently frozen, suggesting slopes should remain reasonably stable and little, if any, ground water will be encountered. Therefore, the pit highwall has been designed at a slope of 1/2 to 1. These slopes in similar material have been used successfully at the Hesly and Matanuska coal operations.

If slope failure occurs, it will probably be along or behind the footwall of the seam. Stripping no more than two years in advance will allow the toe of the seam to be buttressed. Also, if massive sudden slope failure does occur, it will only destroy a maximum of two years' supply of stripped coal. In a typical year, ample time would remain in August and September for remedial slope repairs should they become necessary (See "Operations' Activities -- Stripping & Mining").

Access into Segment I/Pit I will be gained by cutting a shallow access slot to the south along strike and building a haul road at a maximum 15% grade into the pit highwall. The pit would have a long enough strike length to allow haul roads along the highwall without having to

cut further access slots of any magnitude. Representative cross-sections of the pit are shown in Figure 8.

Operations

The short mining season, relatively small demand, remote location, short ice-free barging season, and shallow waters of Kotzebue Sound will require creative solutions if the delivered price of the coal is to be kept at a minimum. One of the best methods of achieving this will be to sequence the mining and transporting events according to climate and ground conditions. Stripping and mining activities will be restricted to the spring and summer months in order to take advantage of the long hours of daylight and warm weather and to minimize equipment maintenance. In a typical year, operations will begin in early April when the exposed coal bed will be mined and hauled to Willow Bay and stockpiled. This mining and hauling will take one month. All heavy haulage over the road to Willow Bay will be complete by early May before spring thaws. The crews will then begin to strip the overburden for the next season's mining which will continue for 2 to 3 months, depending on the depth of pit. Stripping and reclamation operations will be completed by September 1.

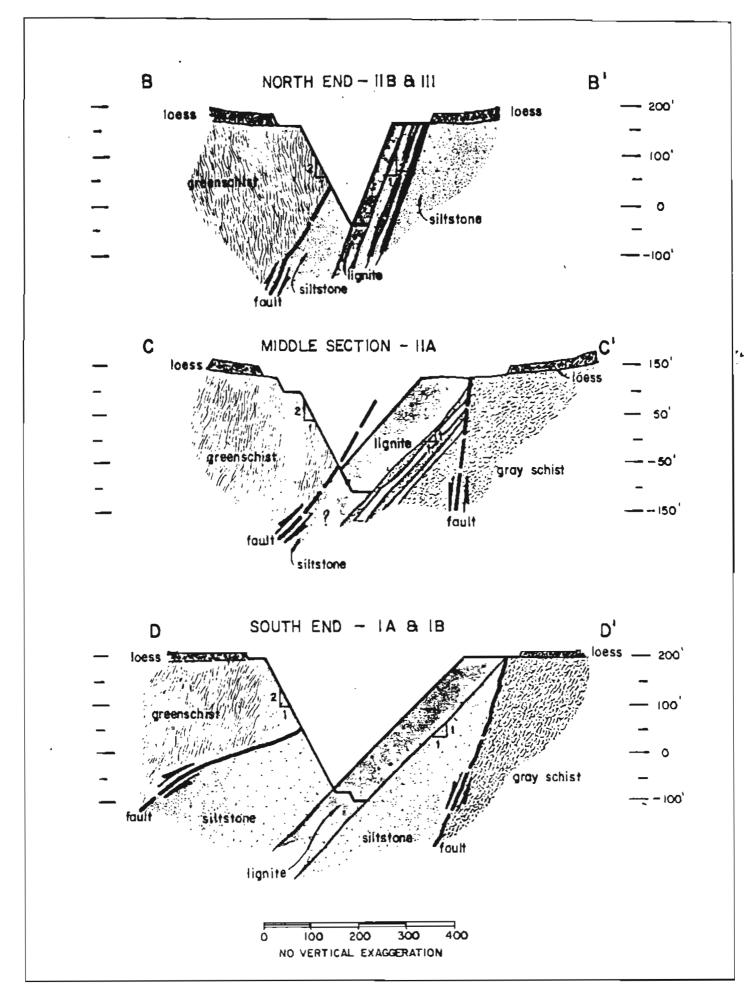


Figure 8: TYPICAL CROSS SECTIONS OF THIRTY-YEAR PIT (see Figure 5 for Plan View)

A summary of proposed mining and stripping operations are presented in Table 9. Stripping is so scheduled that at least one year's coal supply, but no more than two (see pit design discussion) is exposed before the summer's stripping is complete. Due to the low stripping ratios, there will be some years when stripping activities will not be necessary.

Equipment Selection

Several characteristics of the project suggest that new, proven construction equipment should be selected. Equipment yearly use time is low--averaging 1,000 hours annually. Volume to be moved is also small--2,549,000 cubic yards of overburden and 1,500,000 tons of coal over 30 years, or 85,000 cubic yards and 50,000 tons annually. Although annual use is low, any equipment downtime in this remote location will have a significant impact on production and expenses. Therefore, new equipment, rather than good used or rebuilt used equipment, has been specified for the project. The equipment suite (Table 10) selected is time proven in Alaskan conditions at places such as Healy and on the North Slope.

Stripping cost estimates assume that the rock is to be both drilled and blasted and further ripped and/or ripped and pushed prior to loading. Drilling and blasting will be accomplished by a rotary drill and truck utilizing ammonium nitrate powder (Table 11), while ripping

TABLE 9
Mining and Stripping Summary for Segments IB & IIA

Year	Months Operational	Coal Production (tons)	Stripping (cy)
1	5.0	BUILDING HAUL ROAD AND AIRSTRIP	
2	4.0	BUILDING CAMP AND	
3	2 5	PORT FACILITY	130,000
4	3.5 3.5	50,000	130,000
5	3.5	50,000	130,000
5 6	3.0	50,000 50,000	130,000
7	1.0	50,000	95,000
8	3.0	50,000	25,000
9	1.0	50,000	25,000
10	3.0	50,000	25,000
11	1.0	50,000	
12	2.0	50,000	12,500
13	1.0	50,000	
14	1.0	50,000	
15	3.0	50,000	Coal Stockpile
16	3.0	50,000	95,000
17	3.5	50,000	130,000
18	3.5	50,000	130,000
19	3.5	50,000	130,000
20	3.5	35,950	
		14,150	130,000
21	3.5	50,000	130,000
22	3.5	50,000	130,000
23	3.0	50,000	95,000
24	3.0	50,000	95,000
25	3.5	50,000	130,000
26	3.5	50,000	130,000
27	3.0	12,750	
		37,250	95,000
28	3.0	50,000	95,000
29	2.0	50,000	64,600
30	2.0	50,000	64,600
31	2.0	50,000	32,300
32	1.0	50,000	

TABLE 10

Equipment Ownership & Operating Costs

	Purchase Price	Cost/Hour 2/	Cost/Year 2/
350 Payhaulers			
2 - Operating	\$ 733,860	\$161.64	\$161,640
1 - Standby	366,930	36.69	36,690
Cat 245 Backhoe	510,850	91.90	91,900
Cat D-9L (2 EA)	479,251	108.62	108,620
Cat D-7	217,350	54.00	54,000
Cat 16G Blade	296,100	55.74	55.740
Cat 988 Standby	90,000	9.00	9,000
Rotary Drill	269,000	60.00	30,000
Anfo Truck	55,000	15.00	7,500
Coal Drill	20,000		2,500
Lube-Welder Truck	88,00 0		10,000
Boom Truck	84,500		10,000
Fuel Truck	30,000		5,000
Lowboy	60,000		10,000
Pickups (2 EA)	30,000		7,000
Suburban (1 EA)	20,000		4,000
Miscellaneous Equipment	20,000		20,000
Shop Equipment	150,000		15,000
TOTAL EQUIPMENT COST	3,521,952		
TOTAL YEARLY EQUIPMENT	COST		\$638,590

^{1/} FOB Willow Bay

2/ Does not include operators' wages, interest, taxes, or insurance, based on 1,000 hours per year.

TABLE 11

Powder Costs

\$.36/L	<u> </u>	***	
Add 1 CAY Discol R St 25/CAY	. or	\$36.00/100	Lb.

At a power factor of 1, this yields \$.37/cy
Yearly Cost = \$.37/cy X 2,559,000 cy = \$946,830 ÷ 30 = \$31,561

and/or ripping/pushing will utilize D-9L dozers. A Cat 245 backhoe with a Cat 988 loader standby will load, and four International 350 sll-wheel drive Payhaulers with an extra one for standby will haul the coal and waste. The dumpsite will be policed by either one of the D-9. or a D-7. All of this equipment is off-the-shelf production line equipment with long successful record of use in similar arctic environments and is readily operable by the local labor force. The 350-type Payhaulers will come equipped with both 50-ton coal boxes and 21 cubic yard rock boxes, so they can haul both coal to Willow Bay in the spring and then switch over to rock hauling for stripping operations.

A 10-year life is planned for all equipment. This corresponds to about 10,000 total hours (or 1,000 hours average per year), which falls well within manufacturer's recommendations for this type of usage. We have assumed the equipment would be replaced twice with an equivalent equipment spread. However, by the end of 10 years, both the general characteristics of the operation will be well worked out and additional details of the deposit will be proven through exploration drilling. If necessary, new types of equipment reflecting advanced technology or a change in mining plans or sequence or production rate can be conveniently brought into the operation at this time. In other words, there is built-in flexibility in this approach, as compared with planning a 30-year operation around a single expensive piece of equipment such as a large dragline.

Labor

A total craw size of 12 is planned for the mining operation during a 3-month field season with year-round office staff of three stationed in Kotzebue (Table 12). A fully burdened wage rate of \$35/hour is used in the analyses which includes all overtime and employer's contributions. The superintendent/engineer, foreman, and shop foreman are key people to the field operation and should be paid year-round to insure their availability; possibly they could also help operate Kotzebue facilities in the winter. A winter caretaker should be retained at the mine to prevent vandalism. A year-round home office staff of three is detailed. Although all of the hourly employees will probably be local hire (Kotzebue or vicinity), it is very likely that several of the initial salaried and year-round crew will need to be brought in from outside the immediate area, prior to training of local people for salaried jobs. Care should be taken to see that their salaries are sufficient to insure that they remain long enough to successfully train a resident staff. The average annual production costs developed in this study are summarized in Table 5, which shows that the average annual cost to strip and haul 50,000 tons of coal to stockpile at Willow Bay, with no provision for royalties or taxes, is \$1.5 million.

TABLE 12

Yearly Labor Costs

Summer Field Labor: # 1 - Superintendent/Engineer # 1 - Mining/Stripping Foreman 3 - Truck Drivers 2 - Operators 1 - Laborer # 1 - Shop Foreman 2 - Mechanics 1 - Cook 1 - Cook Helper/Bullcook		
12 - TOTAL		
12 X 1,000 Hrs Each X \$35/Rr Avg	\$327,600	
Winter Salaries (2 X \$4,500/Mo X 7 Mos)	63,000	
Winter Caretaker (1 X \$1,500/Mo X 7 Mos)	10,500	
TOTAL MINE LABOR COSTS		\$401,100
Home Office in Kotzebue (w/benefits): 1 - Secretary/Receptionist 1 - Accountant 1 - General Manager	\$30,000/Yr 60,000/Yr 80,000/Yr	

TOTAL ANNUAL HOME OFFICE + MINE LABOR COST = \$571,100

\$170,000/Yr

TOTAL HOME OFFICE COST

Summary of Costs

The average annual cost to strip and haul 50,000 tons of coal to stockpile at Willow Bay, with no provision for royalties or taxes, is \$1,553,000 (Table 13). Total capital investment costs amount to \$9,926,000 (Table 14). Mining development and production costs for three production rates are summarized in Table 15.

TABLE 13
Annual Operation Costs--Chicago Creek Mine

Permanent Camp	\$	211,890
Mine Labor		401,100
Home Office Labor		170,000
Equipment Ownership & Operating Cost		638,600
Powder Cost		31,500
Air Transportation		50,000
Home Office Rent & Utilities	_	50,000
TOTAL ANNUAL OPERATION COSTS	\$1	,553,000

TABLE 14

Total Capital Investments--Chicago Creek Mine

Site Improvements	\$ 4,606,000
Equipment	3,520,000
Permanent Camp	1,800,000
	\$ <u>9,926,000</u>

TABLE 15
Summary of Costs--Chicago Creek Open Pit Mine

ı.	Development Costs	A 50,000 <u>Tons/Year</u>	B 100,000 Tons/Year	C 150,000 Tons/Year
	A. Exploration, Environmental, and Feasibility Studies B. Capital Costs:	\$1,400,000	\$1,400,000	\$1,400,000
	1. Site Improvement 2. Equipment 3. Permanent Camp	4,606,000 3,521,000 1,800,000	4,606,000 3,960,000 2,000,000	4,800,000 4,547,000 2,200,000
	Totals	11,327,000	11,966,000	12,947,000
II.	Annual Production Costs	1,553,000	2,356,000	3,188,000

GEOTECHNICAL CONSIDERATIONS

Geotechnical factors influence design and construction of the open pit mine, camp airstrip and haul road, an earthfill dam diversion structure for Chicago Creek, and the coal handling facilities at Willow Bay.

Open Pit Mine

12

The open pit mine will have a highwall slope of 1/2(H) to 1(V), with intermediate benches 15 to 30 feet wide. The footwall slope will be 45 degrees (the dip of the coal seam) unless slope failures cause it to become flatter.

Very little is known of the engineering characteristics of the soil and rock strata that will be exposed in the mining operation. What is known is qualitative in nature and may be summarized as follows.

Within the depths of interest, the soil and rock is permanently frozen, except for the active layer which is probably on the order of five feet thick. The overburden averages about 25 feet in thickness and consists primarily of ice-rich silt and organic material with occasional ice wedges. The underlying rock includes coal, lignite, shale, siltstone, claystone, and schist. The condition of the rock appears to vary from poorly cemented and/or weathered to intact.

The overburden soils will be unstable when thaved. However, the height of slopes in this material (about 25 feet) are such that the slopes may be self-healing or, at the worst, should require only minor maintenance.

The stability of slopes in the rock is more difficult to assess. Poorly cemented, soil-like, rock might require much flatter slopes than planned to be stable when thaved. However, the thawing process will take place gradually so that, if slides occur, they will be in the form of shallow sloughing rather than deep-seated, massive slope failures. The thawing and sloughing process in such very weak rock could result in a retreat of the slope face on the order of five to ten feet per year.

The dip of the rock beds probably precludes any massive slope instability of the highwall, unless there are other major discontinuities that dip to the east. On the other hand, the bedding planes are unfavorably oriented with respect to stability of the footwall. In this case, sliding may occur if and when thawing reaches a weak discontinuity. However, unless sloughing or slides occur, the freeze-thaw cycle will only penetrate a limited distance into the slope. This phenomenon is equivalent to the surface active layer and should be limited to a distance of ten feet or less into the slope.

In summary, it appears that the planued highwall and footwall slopes are realistic. Even if the rock is very weak, the permafrost condition will limit the extent of slides that can occur at any one time. The amount of slide debris that is likely to be generated under these conditions should not significantly interfere with coal production.

Haul Road, Airstrip, and Gravel Pads

1

The haul road, airstrip, and pads will consist of 5-foot thick gravel fill. Source material for construction of these fills may be gravel from the Kugruk River bars and floodplains or crushed rock from nearby outcrops, or both. At this time, the volume of fill material available from rock outcrops has not been evaluated, nor has the relative economics of using river gravel versus crushed rock.

Summer construction is planned for these facilities. Depending upon the material source(s) used, whether the material is frozen or unfrozen, and the mining plan, ripping and/or blasting may be required to obtain the necessary fill quantities. If river gravels are used, it may be possible to excavate some or all of the fill material by stripping relatively large areas to shallow depths. On the other hand, mining relatively confined areas to greater depths will probably require blasting and backhoe excavation. Rock outcrops may be rippable if the rock is poorly cemented or highly weathered; if not,

blasting will be required. A more detailed investigation is required to evaluate the relative economics of the various potential fill-material sources and develop a mining plan.

If unfrozen gravel or rock is available in sufficient quantities, it will be possible to construct compacted fills that will remain stable and require relatively little maintainance thereafter. However, if the fill material contains ice, compaction efforts will be largely ineffective. In this case, the fills will have to be regraded and recompacted after the ice melts. This process will occur throughout the construction season and during the following summer.

The 5-foot fill thickness will reduce, but not prevent, future thawing of the underlying in-situ soil. However, for their intended use, these fills should function adequately with some maintenance. After one or two freeze-thaw cycles, the fills and the underlying in-situ soils within the active zone should become quite stable. The long-term performance of the fills can be enhanced by minimizing disturbance to the surrounding tundra and maintaining good surface drainage.

Coal Handling Facilities at Willow Bay

The coal handling facilities at Willow Bay will include a gravel pad for stockpiling coal, a conveyor system, and a barge dock. The gravel pad will be constructed in the same manner as described in the

preceding section, with additional provisions for the collection and treatment of runoff water and leachate from the stockpile.

Piles will be installed to support the conveyor system and to construct bresting dolphins for the barges. Onshore, the piles will be installed in permafrost as adfreeze piles. Depending upon the nature of the permafrost (soil or rock type and ground temperature), the piles may either be driven or placed in augered holes with slurry backfill. Offshore, the piles will be driven into unfrozen soil. Design and installation methods for piles in these conditions are relatively straightforward but will require a more detailed plan of the facilities and site-specific geotechnical data.

Earthfill Dam and Diversion Ditch

Chicago Creek will be diverted around the mine by constructing an earthfill dam and diversion ditch. Material for construction of the earthfill dam will be obtained from the same sources as that for the haul road and gravel pads. A dam constructed solely of this material is likely to leak excessively. Therefore, some type of impervious surfacing will probably be required on the upstream face. Natural impervious materials do not appear to be available locally, so it will probably be necessary to use geotextile material for this purpose.

Creation of a pool of water behind the dam and water flowing through the diversion ditch will degrade the permafrost in these areas. This will result in instability and erosion of the thawed soils and may require frequent maintenance until these areas adapt to the changed environment.

Observations From the 1985 Exploration Season

As in past field programs, the chief objective of the 1985 work was to define the coal resource and, as such, incidental geotechnical information remains qualitative. However, the great number of holes drilled in the vicinity of the proposed pit has increased our subsurface geologic understanding and our confidence in the general stability of the material there. In addition, a placer gold evaluation of the Kugruk River floodplain, which was done for a private client subsequent to completion of the coal program, provided excellent information on the character of the gravels there. The following comments are therefore made as an update to the geotechnical information base.

It appears that the stability of the pit walls, and particularly the hanging wall, will be very good. This observation is based on the following data: (1) the Tertiary shales which enclose the coal section are relatively dry, consistent in dip and homogenous in character; (2) portions of the highwall will be supported by the more

well-indurated Paleozoic greenschists; and (3) the unstable saturated-loss blanket is significantly thinner on the south side of Chicago Creek where the greatest portion of the demonstrated resources have been defined.

In the mine area, the only significant gravel resources defined to date are currently restricted to the Kugruk River valley. During the placer evaluation program, 32 holes were drilled to bedrock. Of these holes, only two were found to be thawed. The holes were spaced along the margin of the river for approximately two miles; depth to bedrock averaged about 15 feet. Typically, the sandy gravels of the Kugruk alluvium were overlain by 2-4 feet of organic-rich silts and silty gravels. The frozen material could be ripped by a large Cat and, with care, the pits could be developed in such a way that water in-flow could be minimized. Aufeis is a regular and extensive phenomenon along the Kugruk River and should be planned for during early spring gravel extraction.

Other gravels available include a small resource on the beaches of Willow Bay. These may be useful for an overlay on the proposed docking causeway. Gravels discovered on the southern end of and in contact with the coal reserve are yet too poorly defined both in character and extent to be appraised, but could possibly provide a good source from within the waste area itself.

Other 1985 observations pertain to the continued possibility of quarrying the weathered Paleozoic schists or Tertiary shales for roadbase material. Initial development of the coal will require a cut into the north-facing valley wall of Chicago Creek. The material overlying the coal here is a combination of schist and shale and might provide an easily developed source of material while beginning the exposure of the coals.

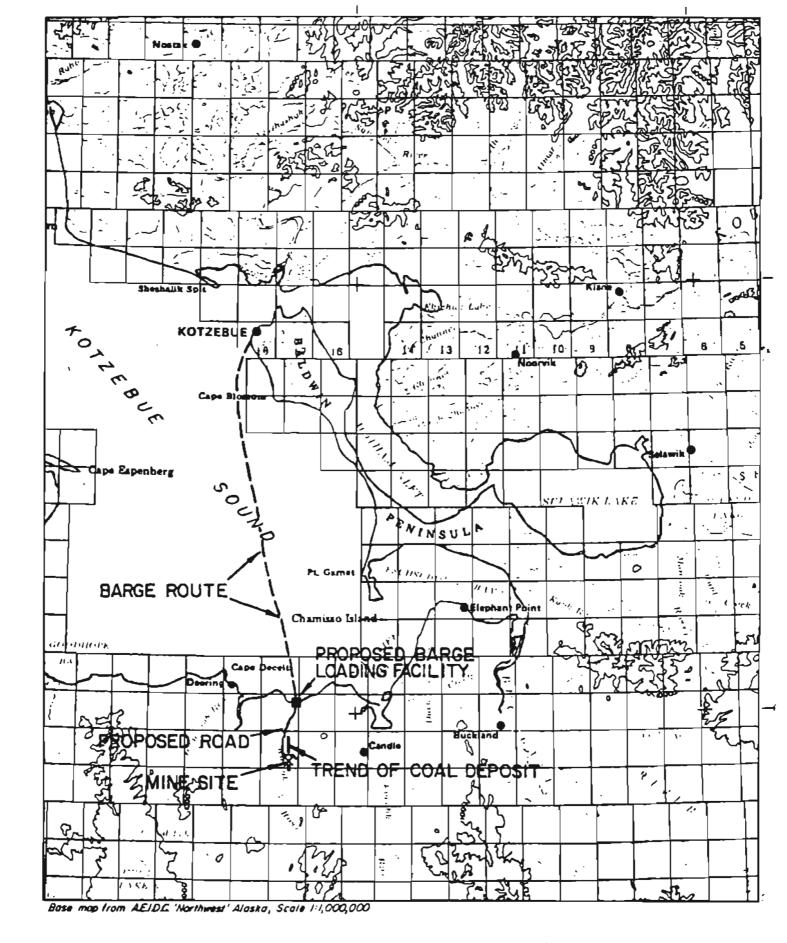
COAL HANDLING AND TRANSPORT

Assuming that the power plant is built south of Kotzebue, it will be necessary to transport the coal out of the mine area. There are several transportation options, including railroad, road, air transport, and hovercraft. These options are impractical because of the small scale of the operation and/or the low unit value of the commodity. A winter ice road is not feasible across Kotzebue Sound because of pressure ridges and annual construction and maintenance expense.

The option chosen for consideration in this report, selected because it utilizes proven, existing technology, is a combination of truck transportation to Willow Bay and tug and barge transport from Willow Bay to Kotzebue (Figure 9). This option requires a road from the mine to the coast; this road is probably required for bringing in equipment and supplies, regardless of the coal transportation option. As in the mine section, an annual production rate of 50,000 tons of coal was used as a base case.

Willow Bay Facilities

At the Willow Bay site, coal would be held in a stockpile area which would consist of a level gravel pad. Facilities for drainage and treatment of runoff water may be required. A pad of about 90,000 square feet would hold the entire season's production of 50,000 tons.



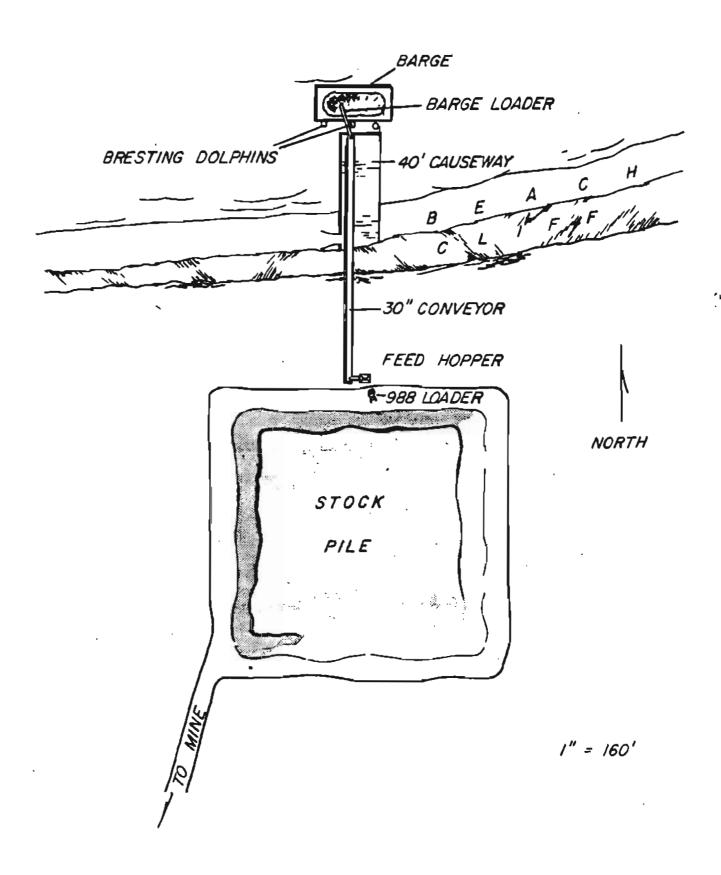
LOCATION OF PROPOSED CHICAGO CREEK COAL MINE WITH TRANSPORTATION ROUTES

piled to a depth of 30 feet, and allow 20 feet of working room on all sides. The coal would be hauled from the mine site using mine trucks and stockpiled by one of the mine s D-9 bulldozers. In this study, the costs of the stockpile and of stockpiling have been included in the mining costs.

Loading of the coal at the Willow Bay site would be done using a conveyor system fed by a Cat 988 loader. It is assumed that the mine's loaders would be available at the time of the loading operation. Only operating costs are, therefore, included in loading expenses.

Barges would be moored at a dock facility to allow loading regardless of the tides. Rigorous design parameters for the conveyor system and the barge dock cannot be specified without on-site engineering studies. The sketch plans and profiles shown on Figures 10 and 11, however, drawn using topographic maps, oblique photographs, and input from the 1983 field crew, are accurate enough for preliminary cost estimates.

The docking facility would be kept as simple as possible to minimize costs. Mike Swalling, of Swalling Construction Company, an Anchorage-based firm with experience in marine construction, suggested dredging a slip in the beach, possibly in a notch previously faced with sheetpiling (personal communication, 1985). This would probably have to be cleaned every year but would be relatively safe from ice



PLAN VIEW: WILLOW BAY PORT FACILITIES
Figure 10

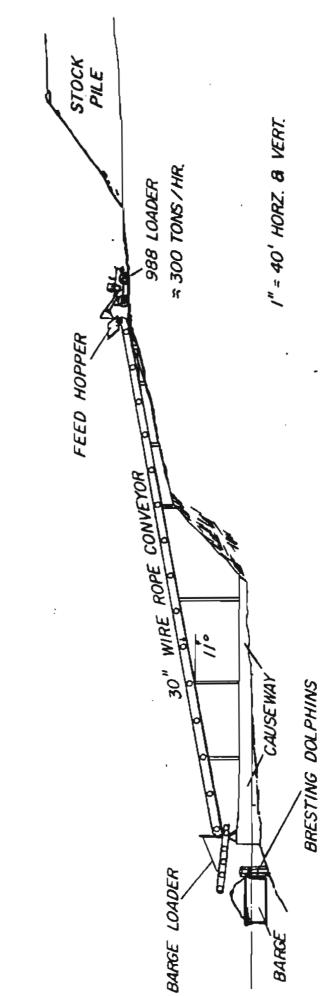


Figure 11

SOUTH-

-NORTH

damage. Swalling suggested a facility of this type could be constructed for approximately \$750,000 or possibly less. If a more elaborate facility is required, an L- or T-shaped breakwater with sheetpile or piling berths for instance, costs would be more on the order of \$1,500,000 to \$2,000,000. On-site engineering, oceanographic, and ice studies will be required before design specifications for a dock can be finalized. For this study, we have chosen a conservative alternative of a short pier with dolphins at an approximate cost of \$1,000,000.

Preliminary costs and design factors for the conveyor system obtained with the help of Van Ooteghem Equipment Company of Anchorage. The conveyor would be a 250-foot-long and 30-inch-wide wire-rope system with a hopper feeder and a telescoping barge loader. Preliminary cost estimates are about \$1,000,000.

Barging

All barging would take place during the ice-free season, which typically extends from mid-July to mid-October. It is assumed that a commercial marine transportation company will be used. A previous study (Arctic Slope Engineers, 1984) has concluded that purchase of a tug and barge might save money, particularly if used equipment is available. The uncertainties in that approach, however, make the costs difficult to identify, so for this study, a conservative approach using existing equipment known to be available was chosen.

Barging costs that have been quoted in previous studies range from \$17.78 to \$62.80 per ton. The costs are based on the use of various combinations of tugs and barges ranging in cost while underway from \$8,500 to \$15,000 per day. Some of the studies assume an entire day to load the barge and another to unload, while another (Arctic Slope Engineers 1984) assumes an unloading rate of 420 tons per hour using a method similar to that proposed in this study. The higher cost figures in the previous studies seem to be based on the inclusion of large capital costs, the use of uneconomic sizes of barges, or the assumption of unrealistically slow loading and unloading times.

Using the equipment described above, it should be possible to load the barges at a rate of about 300 tons/hr, and a similar rate should be attainable in unloading. Using this rate, and assuming the use of a tug and two tandem 2000 ton barges traveling at a speed of 100 miles/day, it would be possible to move 50,000 tons of coal in about 22 days of continuous operation. We obtained a tentative telephone quote from Crowley Maritime Corporation of Portland to move the coal using equipment such as this for a total cost of \$400,000. This figure is based on a rate of \$8,000 per day and assumes travel time to and from Portland. The use of an additional set of barges would allow the tug to be underway more or less continually, and would allow a significant contingency for weather and other delays at the same or reduced cost.

Kotzebue Facilities

Shallow draft barges can be unloaded at existing facilities in Kotzebue. A proposed port facility at Cape Blossom (about 10 miles south of Kotzebue) could also potentially be used, allowing for the use of large-tonnage, deep-draft barges. Because of the costs of truck transportation, however, there is appreciable cost savings if the unloading facility is close to the stockpile site. It is therefore assumed that construction costs of a separate barge docking facility will be offset by savings in transportation and other costs, and that the unloading will be done at a new facility located just south of Kotzebue and immediately adjacent to a stockpile site.

The unloading is assumed to be done by a wheeled loader similar to that used in the loading operation. Although in practice some sort of specialized barge unloading equipment may prove to be cost effective, proven existing technology was again chosen for the purposes of this study.

The loader and two trucks will unload the coal and transport it to the stockpile site. The coal will be stacked by a D-7 Cat. If the barge transportation can be done after mid-August, the D-7 Cat and some of the trucks from the mine will be available. We have, however, assumed purchase of a loader, as one will be needed on a year-round basis to feed the plant.

There are several factors that must be considered in selection of a stockpile site, including environmental and scenic considerations, cost and availability of lands, and length and location of land transportation routes. It is assumed for this study that the storage facility will be located south of Kotzebue and adjacent to the power plant. The primary environmental concerns are wind-blown dust and run-off water. Because of these factors, and the necessity of keeping the coal from freezing in the winter, it is assumed that the storage facility will be enclosed by a simple, uninsulated structure. The storage facility will have to be about the same size as the holding facility at Willow Bay, about 90,000 square feet.

Transportation Costs

Capital costs of the transportation equipment are shown in Table 16, and transportation costs for the cost are summarized in Table 17. The costs in the tables are for the base-case production of 50,000 tors per year.

TABLE 16

Capital Costs of Transportation System

Willow Bay

Conveyor System \$1,000 Dock Facility 1,000

Kotzebue

Dock Facility	1,000,000
Stockpile Site	800,000
Loader	200,000

Total \$4,000,000

TABLE 17
Transportation System Operating Cost Summary

Annual Operating Costs

Willow Bay

988 Loader Conveyor/Barge Loader	(\$ 91/Eour) * (\$ 50/Eour)	\$14,560 8,000	\$ 22,560
Kotzebue (Unloading)			
988 Loader 2 Trucks D-7 Cat	(\$ 91/Hour) (\$120/Hour) (\$ 68/Hour)	14,560 19,200 10,880	44,640
Tug and Barge Costs	Subtota1		67,200
Rental and Operation			400,000
	Annual Total		\$467,200

^{*} Operation costs include labor at \$35/hour.

If the annual production were to be increased to 100,000 tons, the loading and unloading facilities, would still be adequate but more stockpile space would be needed, increasing the capital costs to about \$5,000,000. The cost per ton of loading and unloading would not change significantly so that figure would double. Barge costs could be reduced because only one trip to and from Portland would be necessary, but it would probably not be possible to realize any economies of scale from larger barges due to the draft limitations at the Kotzebue end. Calculations based on these assumptions indicate that it should be possible to move 100,000 tons of coal for an annual operating cost of about \$774,400.

Assuming an annual production of 150,000 tons, still more stockpile space would be needed, and the loading and unloading facilities would probably not be adequate to load the barges at an effecient rate, especially as two tugs might be necessary to move the tonnage during the region's short shipping season. A capital cost on the order of \$7,000,000 would therefore be required for the transportation facilities. The operational cost of loading and unloading would again increase in a linear manner but an extra Portland-Kotzebue-Portland run would be required if a second tug were utilized. If that were the case, 150,000 tons of coal could be moved for an annual operating cost of something like \$1,001,600. Transportation costs are summarized in Table 18.

TABLE 18

Annual Transportation Costs at Varying Production Rates

	50,000 tons/year	100,000 tons/year	150,000 tons/year
Capital Costs	\$4,000,000	\$5,000,000	\$7,000,000
Operating Expenses	467,200/TR	774,400/YR	1,001,600/YR
Nominal Cost/Ton *	\$9.34	\$7.74	\$6.60

^{*} Excluding financing costs.

FINANCIAL ANALYSIS OF DELIVERED COAL COSTS

While there is not enough hard data available to determine a final selling price for Chicago Creek coal as delivered to the power plant stockpile south of Kotzebue, it is possible to project a reasonably accurate range of selling prices (in 1985 dollars), using the following parameters:

- 1. Not taking inflation into account.
- Assuming that 80% of the hard capital and development costs are borrowed at an average rate of interest of 10.5%.
- 3. Assuming that the development costs and interest are amortized evenly over the estimated 30-year life of the mine.
- 4. Assuming that the current tax rates and laws stay the same.
- 5. Assuming that the coal is mined by the resource owners and is therefore not subject to a royalty.

Determination of Mining Costa

A range of price-per-ton figures can be determined at different annual production rates for the cost of mining the coal and delivering it to the Willow Bay stockpile site using the cost information in the section on the open-pit coal mine.

Case 1 -- 50,000 Tons Per Year

Capital Costs (Table 15) Development Period Interest			\$ 9,926,000 1,329,300
Total Development	Costs		14,859,300
Financing - 80% of Capital Costs			7,940,800
Actual Capital Re	equired		\$ 4,035,300
Annual mining and operating costs	would be as	follows:	
Direct Operating Expense Insurance and overhead Interest (Average) Amortization of Development			140,000 827,300
Total			\$ 3,543,600

Assuming that the mine owner invests \$2,192,500 in Year 1 and \$1,842,800 in Year 2, a \$578,000 yearly after tax cash flow would be required to generate a 15% return on investment. It is assumed that this would be the minimum acceptable return to an investor. The coal price necessary to generate the desired return can be determined as follows:

Desired Cash Flow	\$ 578,000
Add in Annual Debt Reduction	360,800
	938,800
Less Amortization	335,300
Net Profit Requirement	\$ 603,500

Assuming a 50% effective rate of tax, the owner would need to generate a pre-tax profit of \$1,207,000. Sales costs would be determined as follows:

Annual Mining and Operating Profit Requirements	Expenses.	•	•	•	•	•	•	\$ 3,499,300 1,207,000
Total								\$ 4,706,300

\$4,706,300 divided by 50,000 tons annually indicates a per-ton price of \$94.13.

Case 2 -- 100,000 Tous Per Year

Capital Costs (Per Development Period	Summary).	•	•	•	•	•	•	•	•	•	•	•	•	•	\$ 14,330,000 _1,413,300
To	tal Develops	ent	E (Cos	ts)									15,743,300
Financing - 80% of	Capital Cos	ts	•	•	•		•	•	•	•	•	•	•	•	11,464,000
Ac	tual Capital	R	equ	111	red	1									\$ 4,279,300

Annual mining and operating costs would be as follows:

Direct Operating Expense	•	•	•	•	•	•	•	•	•	4	•	•	\$ 3,400,000
Insurance and Overhead													190,000
Interest (Average)	•	•	•	•	•	•	•	•	•	•	•	•	876,300
Amortization of Development	Co	вt	B	٠	٠	•	•	•	•	•	•	•	344,800
Total													\$ 4,811,100

Assuming that the mine owner invests \$2,337,800 in Year 1 and \$1,941,500 in Year 2, a \$613,200 annual after tax cash flow would be required to generate a 15% return on investment. It is assumed that

this would be the minimum acceptable return to the investor. The cosl price necessary to generate the desired return can be determined as follows:

Desired Cash Flow	
Less Amortization	344,800
Net Profit Requirement	\$ 650,500

Assuming a 50% effective rate of tax, the owner would need to generate a pre-tax profit of \$1,301,000. Sales costs would be determined as follows:

										4,811,100 1,301,000
	To	tal						•	\$	6,112,100

\$6,112,100 divided by 100,000 tons annual production yields a per ton price of \$61.12.

Case 3 -- 150,000 Tons Per Year

Capital Costs (Per Summary)		
Total Development Costs		17,147,000
Financing - 80% of Capital Costs	•	12,480,000
Actual Capital Required	\$	4,667,000

Annual mining and operating costs would be as follows:

Direct Operating Expense													4,600,000
Insurance and Overhead	•	•	•	•	•	•	•	•	•	•	•	•	953,900
Interest (Average) Amortization of Development	C -	•	•	•	•	•	•	•	•	•	•	•	•
wmotfingfion of peastobment	Co	RC	•	•	•	•	•	•	•	•	•	•	384,300
Total													\$ 6,138,800

Assuming that the mine owner invests \$2,569,100 in Year 1 and \$2,097,900 in Year 2, a \$669,100 annual after tax cash flow would be required to generate a 15% return on investment. The coal price necessary to generate the desired return can be determined as follows:

Desired Cash Flow	
Less Amortization	364,900
Net Profit Requirement	\$ 720,200

Assuming a 50% effective rate of tax, the owner would need to generate a pre-tax profit of \$1,440,400. Sales costs would be determined as follows:

Annual Mining and Operating Profit Requirements				
Total				\$ 7,592,200

\$7,592,200 divided by 150,000 tons annual production indicates a per-ton price of \$50.53.

If mining costs and rates were better defined, a more detailed economic analysis might yield a lower price per ton. As an example, any financing, rather than being smortized over a 30-year period, would probably be repaid over a 20-year period. The interest would therefore be larger during the early years of the loan period. Higher interest figures would result in lower income taxes and increased cash flow. Because of the time value of money, higher early year cash flows would permit the owner to generate a 15% return on investment while charging less for the coal.

In addition, the reduction in corporate tax rates now before Congress would, if passed, reduce the project's effective tax rates from 52% to 45%. This would reduce price requirements as follows:

Annual Production	Cost Reduction Per Ton
50,000 tons	\$2.20
100,000 tons	\$1.20
150,000 tons	\$.90

Given the potential areas of price reduction, a range of projected prices is as follows:

Annual Production	Per Ton Price Range
50,000 tons	\$87.50 - \$97.50
100,000 tons	\$57.00 - \$63.50
150,000 tons	\$47.00 - \$52.50

Determination of Transportation Costs

Using the same factors and requirement for 15% return on investment that were used for the cost of mining, and referring to the capital and operating figures developed in the transportation section, the per ton cost of transporting the coal to Kotzebue would be determined as follows:

	ANNUAL	RATE OF PRODUCT	CION
	50,000 Tons	100,000 Tons	150,000 Tons
Capital Costs:			
Capital Costs (Per Summary)	\$4,000,000	\$4,000,000	\$7,000,000
Construction Period Interest	210,000	<u>262,500</u>	<u> 367,500</u>
Total Development Costs	4,210,000	5,262,500	7,367,500
Financing	3,200,000	4,000,000	5,600,000
Actual Capital Required	\$ <u>1,010,000</u>	\$ <u>1,262,500</u>	\$ <u>1,767,500</u>
Annual Operating Cost:			
Direct Operating Expense	\$ 467,200	\$ 774,400	\$1,001,600
Interest (Average)	244,600	175,400	245,600
Amortization	140,300	175,400	245,600
Total Costs	\$ 852,100	\$ <u>1,255,500</u>	\$ <u>1,675,200</u>
Determination of Net Profit Re	quirements:		
Desired Cash Flow	\$ 153,800	\$ 192,300	\$ 269,200
Add in Annual Debt Reduction	106,700 260,500	133,300 325,600	186,700 455,900
Less Amortization	140,300	175,400	245,600
Net Profit Required	\$ 120,200	\$_150,200	\$ 210,300

Again assuming a 50% effective rate of tax, transportation prices would be determined as follows:

	50,000 Tons	100,000 Tons	150,000 Tons
Annual Operating Costs Profit Requirement (2X)	\$ 852,100 240,400	\$1,255,500 300,400	\$1,675,200 420,600
Total	\$ <u>1,092,500</u>	\$ <u>1,555,900</u>	\$ <u>2,095,800</u>
Cost Per Ton	\$21.85	\$15.52	\$13.97

With possible reduction in tax rates, and with more detailed feasibility information, these costs could probably be reduced.

A range of projected prices is as follows:

Annual Production	Per Ton Price Range for Annual Transportation Costs
50,000 tons 100,000 tons	\$20.50 - \$22.50 \$14.50 - \$16.50
150,000 tons	\$13.00 - \$14.50

The total averaged delivered coal cost for various production rates are shown below (Table 19). The cost includes delivery of the coal to the stockpile adjacent to the power plant located about one-half mile south of the Kotzebue airport. In addition to the effect on price that variable financing arrangements can have, the most obvious factor in reducing cost will involve production rate. A doubling of production rate reduces the unit price by nearly 35%. The 150,000 ton/year case, which approximates production rates to meet the

TABLE 19
Total Delivered Coal Costs

	PRODUCTION RATE					
Cost			150,000 Tons/Year			
Category	50,000 Tons/Year	100,000 Tons/Year				
Mining	74	47	28			
Transportation]			
	22	16	14			
Total Cost			}			
\$/Ton						

electrical needs of both Kotzebue and the Red Dog Mine, decreases the unit price more than one-half.

The unit prices are considered to be conservative because of: (1) the possibility of more attractive financing packages, (2) potential savings that could arise from owning and operating the barge system, and (3) the mining costs can likely be reduced somewhat as additional information is gathered.

POWER PLANT

Many factors enter into planning of a power plant, some of which cannot be determined without extensive further study. By considering the various alternatives, however, and drawing on the consultants experience, a reasonable choice of facilities and location can be identified for a base-case cost study.

Site Selection

There are two general siting possibilities which were considered in developing this study--(1) Mine-mouth and (2) Kotzebue.

Although a mine-mouth plant would be at the site of the resource, a transmission line would have to be built from the mine to Kotzebue and the power plant would have to be constructed and operated at a remote site. If the coal is transported to Kotzebue, construction and operation of the power plant would take place in the vicinity of a developed community with an already operating, successful electric utility.

Construction and operation of a coal-fired power plant in a region remote from developed communities and completely dependent on the comparatively primitive infrastructure related to the proposed coal mining operation, will definitely increase construction and operating costs, and will add the coordination problems of operating an

integrated power system with major power plants 100 miles apart tied together by a single transmission line. There will also be added personnel problems associated with hiring and keeping qualified persons in isolated locations.

For the purposes of this section only a Kotzebue plant location is considered. A specific location requires detailed study and community involvement to consider the potential impacts relating to coal utilization, possible waste heat uses, employment opportunities and other monetary impacts, and many other environmental and socio-economic factors. A preliminary choice has been made for this study of a location about one mile south of the airport near the presently used waste disposal area.

General Plant Requirements

The potential market for electrical energy has been discussed in the earlier section on market demand. The requirements shown vary from about 4,000 KW (today's peak requirement in Kotzebue) to 20,000 KW in 30 years.

Generating unit sizes now used in the Kotzebue diesel-electric plant vary from 500 kW to about 2,000 kW. This allows an efficient operation of units to match the varying electrical loads of the community. Addition of coal-fired facilities to the system in an efficient manner would require that unit sizes be selected which would

perform acceptably under the typical loading which might be expected.

Modern steam-powered electric generating units maintain relative high

efficiency over a wider range of loading than diesel-electric units so

that larger units can be prudently installed.

The proposed power plant, located as specified above, would utilize the Chicago Creek coal which would be delivered to Kotzebue by the methods described in the section labeled on transportation. A coal stockpile at the plant site must handle nearly a year's supply (barge transport can operate only about three months during late summer) and should be covered to eliminate problems from wind and snow.

The power plant must either use the salt water of Kotzebue Sound or air for condenser cooling.

Air quality requirements have not been established, but it is assumed that 0.10 grains/Standard Dry Cubic Foot of gas corrected to 127 CO₂ for particulates and 307 opacity is acceptable.

Remanufacturing enterprises can provide a wider range of unit sizes at prices substantially less than new equipment available (Appendix B). Each remanufactured plant or equipment package is unique; a case-by-case analysis is therefore required to provide correct perspective for comparing to more conventional solutions. Some intriguing possibilities were investigated briefly by the team (including the recently shutdown Knik Arm Power Plant owned by Chugach

Electric Association, Inc.), but it is beyond the scope of this report to do more than point out the factors involved with remanufactured units, including operating costs and the local economy:

- 1) Remanufactured units could reduce initial plant cost by 50%.
- 2) Careful analysis must be made to compare relatively efficiencies of new versus remanufactured units. A loss of 20% in efficiency could absorb all the gain of a lesser investment.
- 3) Because of their slightly lower efficiency, remanufactured plants will require somewhat greater amounts of fuel. This in turn will require more production at the mine (more labor) and may also effectively reduce the cost of th coal on a per ton basis.

Other power-plant options which must ultimately be considered include the use of evolving technology such as fluidized-bed combustion. Small fluidized-bed plants are currently being used in industrial applications in many parts of the world and the technology is rapidly developing. A brief overview of some aspects of fluidized bed technology is given in Appendix F. In keeping with the basic assumptions of this study, however, we have chosen a conventional system basing our analysis on a new, conventionally fired plant sized at 10,000 KW (single unit) which will support an average annual energy use equivalent to 50,000 tons per year of Chicago Creek coal.

Equipment Requirements

The following discussion is based on the construction of a newly manufactured plant. The plant should be sixed to output 10,000 KW of electric capacity from a condensing unit with provision for extracting steam at 10 psig for heating feed water. Total throttle flow to the turbine will be from 140,000 to 160,000 pounds per hour of 650 psig/7500F steam. To handle soot blowing, blow down, and miscellaneous radiation and leakage losses, the boiler selected should have a steam capacity of about 180,000 lbs./hr. There should be standby capacity of 180,000 lbs./hr.

The size of air and gas handling equipment will depend on the amount of excess air needed for optimum firing. This in turn will depend on the moisture content and general quality of the fuel. It is assumed that the exhaust gas flow will vary from 210,000 to 220,000 lbs./hr. at full boiler output.

Special attention must be given to firing methods to be sure of obtaining the necessary turn-down ratio. The retention time needed for fuel particles to burn completely in the furnace depend on their size, shape, and moisture content—the greater the moisture content and/or size of the particle, the longer the time required for firing. For this reason, those firing methods that provide longer retention

times, such as keeping the fuel on grates, are to be preferred to those methods which burn in suspension -- especially where moisture contents are high.

The type of firing best suited to the characteristics of Chicago Creek cost would probably be one employing a chain-grate stoker, provided it can be uniformly loaded with fuel across its entire width. By varying the speed and height of the bed together with the flow of combustion air, the heat release from the grate could follow load requirements. A major advantage of this type of firing lies in its automatic and continuous discharge of ash off the end of the chain and in its ability to handle clinker formation.

Another possible form of firing would be pile-burning in four fuel-cells, arranged two by two. The cells could be arranged to closely control the flow of both undergrate and overfire combustion air. Although ash removal would be manual, the ability to shut down one cell at a time for cleaning without disturbing the other cells would permit ash removal to be accomplished with little or no change in steam pressure or release of pollutants to the atmosphere. This combustion method would be limited to fuels with less than 50% moisture and an ash and dirt content of less than about 3%.

High furnace temperatures are essential for clean combustion. These should be in the 1500°F to 1600°F range for optimum firing. Above this value there is some danger of slagging the dirt and sand on tube

surfaces. At lower values, gases are apt to enter the boiler convection section prior to complete burnout resulting in the issuance of smoke to atmosphere. The furnace should contain an adequate amount of refactory surface to stabilize temperature.

The use of over-fire air jets is also helpful but careful design is required to obtain adequate penetration and turbulence. The "spilling" of low pressure air into the furnace, especially if unheated, will lower combustion quality.

An air heater will be needed to furnish combustion air at an elevated temperature of about 400°F. This could be of the regenerative plate or the tubular type, the latter being the more common. Additionally, the latter type will permit the installation of a gas bypass damper between stages without the need for special ducting. In addition to facilitating the bypass of the heating surface during start-up, the arrangement permits the automatic controlling of the leaving gas temperature to avoid dew point condensation.

By placing the heater between the boiler outlet and the mechanical dust collector, the size of the latter would be minimized. The basis for sizing would be a pressure drop of 3.5" to 4.5" of water column at maximum design flow. The output of the mechanical dust collector is connected to the induced draft fan which must assure the maximum design flows at the pressure drops decessary for the proper operation of the whole combustion and exhaust system.

The sixing of the air heater to obtain heat recovery between gas temperature limits at the boiler outlet, and the dew point approach, eliminates the need for an economizer.

The boiler selected for the plant should be one which provides flexibility for the design of a boiler assembly best suited to the characteristics of the fuel. Such a unit would probably be erected on site. There is at least one manufacturer who makes suitable units in shop-fabricated modules which can be shipped to the site and erected with a minimum of field labor.

Black-start capability for this power plant is considered necessary. A location immediately adjacent to the existing diesel plant in Kotzebue might preclude additional facilities, but the location assumed for this report requires the assurance of such a self-contained electrical supply. The use of auxiliary steam-turbine drives for functions such as boiler feedwater pumps should receive careful consideration. During start-up, power will be required for emergency lighting, power for supplying fuel to the grates, and feedwater to the steam drum. Also, an unscheduled outage during normal operating conditions will require a means of feeding water to the steam drum that is independent of the generated electricity. This capability can be most reliably supplied by installing a combination of auxiliary steam turbine drives and in-plant emergency electrical generating units and batteries.

Coal Quality and Sizing

Coal quality is adversely affected by high moisture content, excess dirt and sand, and/or other inert materials. Unless some form of drying is employed, the moisture content will be established by the as mined condition. To avoid degradation, open storage should be avoided in favor of closed storage. Closed conveyors are preferred to open types which are directly exposed to the vagaries of weather. The plant requirements described above provide for coal moisture contents up to 50% although tests of the Chicago Creek coal samples to date indicate less moisture than this.

Inclusion of dirt, sand, and/or other inert materials is largely a matter of care exercised in its handling. Proper training and supervision of personnel involved in such handling can minimize the inclusion of such unwanted items.

Size preparation of the coal at the power plant would probably be more energy efficient than off-site preparation because of the availability of coal generated electricity rather than a diesel generated supply. This advantage, however, would be offset by less noise and more handling efficiency at the plant site if off-site sizing is used.

Environmental Considerations

Environmental standards that are to be met by this power plant must be established by appropriate regulatory authority and the local community. Such standards have not been set for this potential development; however, the following comments are made based on what is believed to be reasonable assumptions:

For this study, an air quality standard of 0.10 grains/standard dry cubic foot of gas (corrected to 127 CO₂) for particulates and 307 opacity is used. It is intended that this standard can be met by the requirements listed in preceeding paragraphs if the coal moisture content does not exceed 307. For higher moisture contents, options would include the installation of coal drying equipment, a dry charged-bed scrubber, or a bag house. Wet scrubbers were not considered feasible because of waste discharge problems.

Suitable charged-bed dry scrubber equipment is manufactured by the Combustion Power Company of Menlo Park, California. In these units, the charged media bed of selected gravel is contained within two concentric cylindrically shaped vertical vessels specifically constructed with louvres to permit the passage of the flue gases. The bed moves continuously downward to the bottom, where a small portion of it is removed and discharged pneumatically back into the top. The media is cleaned in the process.

Because of the continual recirculation of a portion of the media, it is claimed that the unit has a higher tolerance for operation at dew-point temperatures than other types of dry cleaning devices—especially if a small exchanger is used to heat the recirculating media. It is also claimed that availability will be virtually 100%, particularly if a spare blower is installed for media recirculation.

Handling of fly ash by pneumatic reinjection into a furnace has become common practice—justified on the basis of improving combustion. In reality, the improved combustion is hard to identify and is accompanied by an increase in particulates discharging from the stack. If reinjection is employed, it will be accomplished by feeding the ash and unburned combustibles uniformly into the fuel stream.

Water quality standards are primarily concerned with the discharge of toxic wastes. Major enterprises engaged in the treatment of water for boiler feed and other industrial purposes have developed complete lines of chemicals for controlling toxicity in the discharges to make them environmentally acceptable. Specific treatments are developed for the particular chemistry of the water available for makeup.

A major discharge source from a power plant such as the one described herein (using a condensing cycle) will come from the cooling tower blowdown fluids where a closed loop is employed to obtain condenser

cooling water. This waste water source would be eliminated if approvals are obtained for once-through cooling using the salt water of Kotzebus Sound.

Noise levels are a concern of neighborhoods adjacent to power plants.

It is assumed that this coal-fired power plant will produce no more noise than the diesel-electric plant which it will likely displace.

Preliminary Construction Cost Estimate

The following costs are approximate only and must be revised to suit design criteria as they become better identified (Table 21). The final estimated construction cost includes the power plant, its stepup substation, and covered storage for the coal stockpile. For the purpose of comparing the cost of energy at an increased use rate, estimated costs for a second unit addition to the plant are also included in the table.

TABLE 20

Construction Cost Estimate (1985 Basis)
10 MW Power Plant - Kotzebue

		(\$1,000°s)
Item Description	1st Unit	2nd Unit
Land and Land Rights	75	0
Roads	85	0
Site and Yard Improvements	95	0
Intake and Structures:		
Piling and Concrete Structures	100	50
Traveling Screen, Pumps, and Piping	85	85
Structural:		
Foundation and Sub-Structure	400	400
Building and Structural Steel	500	500
Concrete and Miscellaneous Metal	400	400
Covered Coal Storage	500	1,000
Mechanical:		
Turbine-Generator	2,000	2,000
Steam Generator (Boiler) and Auxiliaries	7,200	7,200
Machinery, Pumps, and Equipment	1,200	1,200
Instruments and Controls	780	780
Mechanical Work and Piping	1,700	1,700
Coal and Ash Handling	1,200	1,000
Circulating Water and Plumbing Systems	500	300
Water Treatment	420	300
Precipitator	2,500	2,500
Electrical:		
Switchgear and Control	400	400
Wire, Cable, Conduit and Motor Control Center	300	300
Lighting and Distribution	300	200
Substation (Stepup)	800	700
Subtotal Direct Cost	21,540	21,015
Engineering	4,000	3,000
Contingencies	500	500
Interest During Construction	781	750
Construction Management	480	300
Freight and Misc. Expense	1,000	1,000
Total Construction Cost	28,301	26,565
Dollars (\$) Per KW	2,830	2,657

ELECTRICAL TRANSMISSION

Electrical transmission lines are used to transmit relatively large amounts of energy from one point to another by means of wires. These wires, supported above the ground at safe heights, provide an electrical path for energy transfer. Experience with construction and operation of such lines in Alaska provides the background for the estimates and comments made in this section.

The following chapter begins with a discussion of the basic information, assumptions, and costs involved in the economic analysis of transmitting power in Northwest Alaska. Using this information, a comparison can be made between barging coal to Kotzebue from Chicago Creek versus the transmission of energy from a mine-mouth power plant to Kotzebue. Based on this comparison and other reasoning, we select Kotzebue as the most probable power plant location. However, to show how the cost of delivering energy is affected by a central power facility feeding an expanding net of users, a series of examples of transmitting energy from a plant based at Chicago Creek to various combinations of towns and villages is included.

Economic Factors

The annual cost of operating and paying for a transmission line is expected to be added to the price of the electricity which it

transfers from one point to another. For preliminary estimating in this report, the following cost estimates and assumptions are made:

Assumptions of annualized operational costs as a percentage of investment:

An additional important factor which enters into the following calculations is the coal to electricity ratio of 6500 Btu per 1b. w/heat rate of 13.652 Btu/Kwh. or 2.1 lbs./Kwh.

Figure 12 shows the location of many of Northwest Alaska's villages and towns and possible transmission line interties. Table 21 which is in part derived from Figure 3 in the "Market Demand" chapter can be referred to in order to obtain the current and future energy needs of various villages.

Figure 12: LOCATION OF POSSIBLE ELECTRICAL TRANSMISSION ROUTES

TABLE 21

Electrical Needs for Kotzebue, the Red Dog Mine, and Nearby Villages

Location	1985	1990	2000	2010] 2020
Kotzebue (1)	-		-¦	-¦	-¦
Mwb	1 15,000	j 23,000	44,000	72,000	1150,000
Tons *	15,690	24.060	1 46,030	75,330	1156,930
Red Dog Mine (2		1		i	1
Mwb	1110,000	110,000	1110,000	110,000	1110,000
Tons *	1115,080	1115,080	115,080	1115,080	1115,080
Noatak (3)	1		1	1	1
Mwh	660	7 90	j	j	i
Tons *	6 90	830	†	j	
Kiana (3)	1	1	1	1	1
Mwh	860	1025	1	1	
Tons*	900	1080		j	i
Selawik (3)	1	Ì	1	İ	1
Mwh	961	1145		 	1
Tons*	1 1,005	1 205	1	j -~-	1
Noorvik (3)	1	1	1	Ì	i
Mwh	1 1,065	1 1 27 0			1
Tons*	1,114	1340		i	İ
Buckland (4)	1		İ	Ì	ĺ
Mwh	374	455			
Tons*	3 9 1	1 470	j	j	1
Deering (5)	1	1	1	ĺ	1
Mwh	374	445			
Tons*	391	470			
Teller (2)	1	1	1	1	1
Mwh	640	l 765	1		
·Tons*	670	1 800			1
Nome (2)	I	1	1	1	1
Mwh	1 20,300	28,650		1	
Tons*	21,315	30,080	1		l

⁽¹⁾ Developed from International Engineering Co., 1985

⁽²⁾ Data from Cominco Sources

⁽³⁾ Developed from Alaska Power Administration data

⁽⁴⁾ Developed from data in Internatinal Engineering Co., 1981

⁽⁵⁾ Estimate based on visit by Robert M. Retherford in 1985

^{*} Assuming 6500 Btu/lb and 25% plant efficiency.

Coal Transport vs. Transmission Lines for Kotzebue's Needs

If the assumption is made that costs for the construction and operation of a coal-fired power plant would be the same whether located in Kotzebue or at Chicago Creek, the remaining consideration would be to determine whether electricity for the community of Kotzebue could be delivered at less cost by transmission line or by barging coal to produce an equivalent amount of electricity in Kotzebue.

Using the economic factors of the preceding section, a simple comparison can be made of the electrical transmission costs vs. the cost of barging coal. The transportation study which appears in a preceding chapter of this report estimates that coal may be delivered to Kotzebue for \$22/ton for 50,000 tons and \$14/ton for 150,000 tons. For the purposes of comparison, these estimates are extended to include a 24,000 ton case which approximates Kotzebue's near-term energy needs for 1990, the beginning of our study period. At 24,000 tons a \$36/ton price is estimated for the transportation cost.

Electricity delivered by wire:

Investments = 122 mi. X \$100,000 + 2 substations @ 10,000 Kva X \$100 = \$13,200,00 = \$13,200,00 = \$1,848,000 Energy Del'd = 23,000,000 Kwh (24,060 tons cos1 eq.) Unit Cost = \$1,848,000 / 23,000,000 = \$0.080/Kwh

Electricity with coal delivered by barge:

Coal Transport = \$36/ton X 24,060 tons = \$866,000

Energy Del'd = 23,000,000 Kwh

Unit Cost = \$866,000 / 23,100,000 = \$0.037/Kwh

Using 48,000,000 Kwh or 50,000 tons of coal equivalent, unit costs would be as follows:

Unit Cost by Wire = \$1,848,000 / 48,000,000 = \$0,039/Kwh
Unit Cost by Barge = \$(50,000 X 22) / 48,000,000 = \$0.023/Kwh

Even with the higher energy requirement, the cost of delivering electricity by wire is nearly double that of delivering the amount of coal needed to produce the same amount of electricity under the assumptions used above.

Other benefits, such as less investment and lower operating costs, would accrue to the operation of a generating plant in Kotzebue. This would argue even more strongly for the location of the plant there.

Example of Variation of Transmission Costs with Distance and Load

The above analysis forms the justification for this report's assumption of barging coal to Kotzebue; however, it overlooks the shifts in economics as distances and loads are varied within the system. As an example, it is useful to consider the additional load of Red Dog and how it might affect the relative cost of transmission of energy from Chicago Creek to Kotzebue and Red Dog. Let us first

assume a mine-mouth plant at Chicago Creek and a transmission extended through Kotzebue to Red Dog. With the additional electrical load added to the Kotzebue requirement, and with the added costs of investment, operation and maintenance for the transmission system to Red Dog, the transmission costs of energy are estimated as follows:

Electricity delivered by wire to Red Dog --

```
Investments
                = 92 \text{ mi. } X \$100.000 + 3 \text{ mi. } X \$1,500,000
                    + 1 Substation @ 15,000 Kva X $100
                                 $15,200,000
Annual Costs
                = 14.00 x $15,200,000 = $2,128,000
Energy Del'd
                = 110,000,000 Kwh
Unit Cost
                = $2,128,000 / 110,000,000 = $0,019/Kwh
Plus Kotzebue
 Investment
                - $13,200,000
Additional
 Substation
 Requirement
                = $15,000 Kva at Chicago Creek @ $100
                                 $ 1.500,000
```

1

Total delivered by wire to Rotzebue and Red Dog -

```
Investments = $15,200,000 + $13,200,000 + $1,500,000  
= $29,900,000  
Annual Costs = 14.00% % $29,900,000 = $4,186,000  
= 29,000,000 (Kotz.) + 110,000,000 (RD)  
= 139,000,000 Kwh  
Unit Cost = $4,186,000 / 139,000,000 = $0.030/Kwh  
Coal Req. = 146,000 tons
```

Now let us compare this cost with a cosl-fired power plant located in Kotzebue and energy transmitted to the Red Dog Mine by wire. The following unit costs develop:

Unit cost assuming barge transportation of coal to Kotzebue --

146,000 tons coal @ \$14/ton = \$2,044,000 freight (\$2,044,000 + \$2,128,000) / 139,000,000 = \$0.030 Kwh

In this case, the cost of delivering energy by wire as compared to a combination of wire and barge transport is very close. The comparison demonstrates that as load grows transmission costs/Kwh decrease. The primary reason that transmission costs approach the costs of coal barging is that, although a relatively larger quantity of energy is involved, the cost of transmitting the energy does not increase appreciably, whereas the costs of shipping do increase as a larger tonnage of coal is moved. Please note, these simple calculations disregard a few minor factors such as energy losses in the transmission system.

Additional Effects of Added Loads through Various Transmission Nets

Using the preceding methods for estimating costs, and again assuming a mine-mouth plant located near Chicago Creek, additional simple approximations for average transmission costs and coal requirements to include other interconnections can be made:

Chicago Creek-Kotzebue-Red Dog System (CC-K-RD) with Nome and villages of Teller, Deering, Buckland, Noorvik, Selswik, Kiana and Nostak —

Averaged Unit Cost = \$0.043/Kwh Cosl Requirement = 192.000 tons

CC-K-RD with the villages of Deering, Buckland, Noorvik, Selawik, Kiana, and Noatak only --

Averaged Unit Cost = \$0.035/Kwh Coal Requirement = \$152,000 tons

Chicago Creek-Kotzebue (CC-K) connection only with villages of Deering, Buckland, Noorvik, Selawik, and Kians --

Averaged Unit Cost = \$0.081/Kwh Coal Requirement = 36.000 tons

Same connections as preceding example except that transmission costs and coal requirements are calculated by assuming that Kotzebue pays all charges related to the transmission line between Chicago Creek and Kotzebue, and the villages share all costs related to the lines connecting the villages to the main CC-K intertie only --

Kotz. Unit Costs = $\frac{$0.064/\text{Kwh}}{30.000 \text{ tons}}$

Village Unit Costs = \$0.179/Kwh Coal Requirement = 6,000 tons

Comments

1) It is clear that transmitting electricity for Kotzebue alone by wire from Chicago Creek is much more expensive than transporting the coal necessary for generating the same amount of electricity in Kotzebue.

- 2) This exercise has shown that the costs of transmitting energy by wire approach an economically favorable level, as increased loads such as Red Dog are considered.
- 3) A transmission line from Chicago Creek to Kotzebue would allow the villages along the way to be interconnected at an overall cost though relatively high would probably still be less than the "power cost equalization" subsidy now provided by the State of Alaska.

ESTIMATED COST OF ELECTRICITY

The coal-fired power plant discussed in an earlier chapter is a single unit, 10,000 Kw modern steam-turbine powered generating station designed to operate in the particular conditions of the Alaskan Arctic at Kotzebue.

A plant location near the Kotzebue load center and existing generating plant provides the best opportunity for coordination with existing facilities and reducing risks from any catastrophic event. It is assumed that operation of the whole power system is by the existing utility organization.

The following tabulation (Table 22) with explanatory notes provides a preliminary estimate of costs which would accrue to the coal-fired facility under the several alternatives summarized:

TABLE 22
Projected Energy Costs-Coal-Fired Power Plants in Kotzebue

		KOTZEBUE ONLY		KOTZEBUE & RED DOG	
Plan	t Data (Alternative)	(A)	(B)	(c)	(D)
1. 2. 3.	Unit No./Size Kw New or Rebuilt Cost Est. (\$1,000's)	1/10,000 N 28,301	1/ 7,500 R 9,750	2/10,000 N 54,866	3/ 7,500 R 28,275
4. 5. 6.	Net Mwh Delivered Heat Rate-Btu/Kwh Lbs. Coal per Kwh	48,000 13,652 2,1	48,000 15,000 2.3	139,000 13,652 2.1	139,000 15,000 2.3
7.	Coal Consumed - Tous	50,400	55,200	146,000	159,850
Annu	al Costs (\$1,000's)				
8.	Amortization a b	2,731a 1,823b	941 a 628b	•	2,729a 1,821b
9. 10. 11. 12. 13. 14.		990 40 20 96 4,838 8,619a 7,711b	900 40 20 96 5,299 7,200a 6,887b	-	
Net Electricity Cost					
16.	Net Mwh Delivered	48,000	48,000	139,000	139,000
17.	Cost per Kwh (\$):	.179a .160b	.150a .143b		

(See following page for explanatory notes to this table.)

EXPLANATORY NOTES TO TABLE 22

- Indicates the number of units in the plant and the unit size in Kw.
- 2. Indicates new (N) or remanufactured (R) units.
- 3. Estimated costs are developed as follows:

New unit costs are taken from Table 21 of this report.

Remanufactured unit costs are based on the \$1,300/Kw estimate supplied by Mr. Eric Haemer in a letter dated December 1, 1985 (See Appendix E, open-file report). For the multiple unit plant of Alternative (D), the price for the second and third units was taken as 95% of the \$1.300/Kw for the single unit.

- 4. The Net Mwh delivered for Alternates (A) and (C) is that of the projected demand at the average historic growth rate (Figure 3) for the year 1995. This energy requirement will require a coal tonnage of about 50,000 annually.
- 5. The heat rates for Alternative (A) and (B) are developed from the assumption that a 25% efficient coal-fired power plant is reasonable for modern machinery in Kotzebue. The heat rates for the remanufactured units is increased by 10% to account for older equipment characteristics.
- 6. Using a heat value of 6,500 Btu/lb. for the coal from Chicago Creek and the heat rates of the respective Alternatives gives the lbs. of coal per Kwh as follows:

13,652 Btu's are required for each Kwh produced by the Alternative plants (A) and (B). 13,652/6,500 = 2.1 lbs. of coal for each Kwh.

- 7. Coal consumed is determined by multiplying Item 4 by 1,000 (to get Kwh), then multiply by 2.1/2,000 to get tons of coal required.
- 8. Amortization of investment is based on 9% interest for a 30-year period, paid back in monthly installments for the "a" option. The "b" option assumes that 5% interest for a similar period is available. The respective annual factors are 9.65% and 6.44%.
- 9. Production expense is the operating and maintenance costs estimated for coal-fired power plants in the Arctic.
- 10. The value of the man-hours required for the plant operation and maintenance.
- 11. Miscellaneous fixed annual expenses.
- 12. Miscellaneous variable annual expenses (supplies, etc.).
- 13. Fuel costs taken from Tables 18 and 19 of the report.
- 14. Item 13 times Item 7.
- 15. The sum of Items 8, 10, 11, 12, and 14.
- 16. Same as Item 4.
- 17. Item 15/Item 16.

The existing diesel-electric generating plant in Kotzebue has reported power costs for 1984. Calculation of current diesel electric costs is as follows:

TABLE 23
Current Diesel Plant Costs

Plant D	eta	
1.	Unit No./Ave. Size Kw	7/950
2.	Net Mhw Delivered	14,247
3.	Average Net Heat Rate (Btu/Kwh)	10,600
	Diesel Fuel (1,000 Gals.)	1,118
Annual	Costs (\$1,000's)	
5.	Depreciation and Interest	159
6.	Operator Expense (w/o fuel)	668
7.	Maintenance Expense	131
8.	Fuel Cost	1,261
9.	Total Aunual Cost	$\frac{1,261}{2,219}$
Net Ele	ectricity Cost	
10.	Net Mwh Delivered	14,247
11.	Average Cost per Kwh (\$)	0.156

These figures can be used for comparison to the calculated costs for coal-fired generation in the previous pages. It is clear that, unless a cheaper source of coal is found, it does not make sense to convert to a coal plant on the basis of Kotzebue's electrical energy requirements alone. However, an intertie to Red Dog would create a substantial savings in delivered power to both Kotzebue and Red Dog.

Explanatory Notes to Table 23:

- 1. The Kotzebue Electric Association (KEA) Diesel Plant in 1984 included 2-500 Kw, I-1025 Kw, I-1000 Kw, and I-1800 Kw diesel-electric units, plus 2-900 Kw diesel-fired gas turbine-electric units.
- 2. Actual energy delivered to the KEA electric distribution system in 1984.
- 3. Calculated from average Btu content of a gallon of diesel fuel (135,295 Btu) times number of gallons consumed (1,118,000 gallons) then divided by the net Kwh delivered (14,246,800).
- 4. Fuel consumed during 1984, taken from KEA records.
- 5. Taken from KEA records for 1984. This item can be compared approximately to the amortization costs of Table 22, Option (b), open-file report.
- Table from REA records and includes operating labor, insurance, taxes, and miscellaneous expense.
- 7. Taken from KEA records and includes all maintenance expense.
- 8. Taken from REA records and shows an average cost of about \$1.13 per gallon.
- 9. Sum of Items 5, 6, 7, and 8.
- 10. Same as Item 2.
- 11. Item 9 divided by Item 10.

THE PERMITTING PROCESS AND ASSOCIATED ENVIRONMENTAL STUDIES

Because most applications for permits require full plans of operation, including much technical data, hydrologic information, engineering designs, reclamation plans, and baseline studies—all of which satisfy the reviewing agencies involved, preparation of applications requires a minimum of 1 to 2 years of planning time. Processing of permits includes public notices and public hearings which can be done concurrently for various permits. Allowing for possible controversial issues that would extend permitting schedule, 18 to 24 months of processing time should be anticipated for receiving all authorizations to proceed.

Permit Descriptions

Development of the Chicago Creek coal, which could involve a mining operation, power plant, access road, and port, will require permitting through various local state and federal agencies. The full permitting plan would require systematic coordination and timing of public notices and public hearings.

This section provides generalized information regarding the types of authorizations, standards to be met, and baseline studies that will be required for the proposed development of the Chicago Creek coal. Further permits may be required for any special circumstances that may be encountered, such as historic sites or endangered species.

Surface Mining

Surface cost mining programs in Alaska are regulated by the Division of Mining, Department of Natural Resources, State of Alaska. Regulations found in 11 AAC, Chapter 90 were developed pursuant to the Alaska Surface Coal Mining Control and Reclamation Act (AS 41.45).

Application for a permit to mine coal will require environmental assessments of all phases of the impacted area, including but not limited to, the following:

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Cultural and Historic Resources
Hydrology
Geology
Ground Water
Surface Water
Alternative Water Supply Information
Climatological Information
Vegetation
Fish and Wildlife Resources
Endangered Species
Soil Resources
Land Use

Minimum standards set out by the Act include, but are not limited to, the following:

- 1) Reclamation must occur as contemporaneously as practicable.
- 2) Backfilling and grading must follow coal removal according to an approved time schedule.

- 3) Final slopes must not exceed in grade the approximate pre-mining slopes.
- 4) Backfill and grading must achieve a minimum static safety factor of 1.3.
- 5) All acid-forming, toxic-forming or combustible materials remaining after mining must be covered by a minimum of 4 feet of non-toxic, non-combustible material.
- 6) Topsoil must be segregated, stockpiled, and redistributed upon reclamation.
- 7) Drill holes must be capped, cased, sealed, or backfilled to prevent acid or other toxic drainage from entering ground or surface water, and to minimize disturbance of the prevailing hydrologic balance.
- 8) Surface drainage from disturbed areas must be passed through sedimentation ponds or a treatment facility or otherwise meet state and federal water quality laws and regulations.
- 9) All surface areas must be protected from erosion and air and water pollution derived from mining operations.

Air Quality

Compliance with the 1970 Clean Air Act would require an assessment of existing air quality in the vicinity of the project sites, a pre-construction ambient air quality monitoring system and preparation of applications for a "Prevention of Significant Deterioration (PSD) Permit" and a "Permit to Construct-Air", regulated by the Alaska Department of Environmental Conservation.

Water Quality and Use

The U.S. Environmental Protection Agency administers the NPDES (National Pollutant Discharge and Elimination System) program under the authority of the Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977. Under this program, EPA regulates point source discharges into a waterway.

The Alaska Department of Environmental Conservation must authorize the discharge of wastewater into or upon all waters or land surface of the state.

A water rights permit is required for use of public water and is authorized by the Alaska Department of Natural Resources.

The Corps of Engineers administers regulations of work such as construction of structures, excavation or fill in "navigable waters of the United States" under Section 10 of the Rivers and Harbors Act.

The Corps of Engineers also regulates, under Section 404 of the Clean Water Act, the discharge of dredged or fill material into U.S. waters, including wetlands.

Solid Waste

DEC administers solid waste disposal permits for proposed methods of operation of a facility to dispose of solid waste.

Fish and Wildlife

The Alaska Department of Fish and Game must approve any proposal to alter the natural stream flow or bed, or use of equipment in rivers, lakes, or streams considered to be important for anadromous fish.

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Dam Structure

The Department of Natural Resources (DNR) must approve construction of any dam structure over 10 feet high or that impounds over 5 acre-feet of water.

Tidelands Use

DNR issues temporary permits and permanent tidelands leases for structures or uses of tidelands. A tidelands lease for a permanent structure would be issued under a competitive bid.

Coastal Zone

The Governor's Office of Management and Budget coordinates permitting, public notices, public hearings, and agency review for authorization required by the Alaskan Coastal Zone Management Plan. The proposed plan must be consistent with the State Coastal Zone Management Plan. At this time, there is no approved local coastal zone plan for the area.

Native Authorizations

A permit to operate and to develop the coal must be acquired from the NANA Regional Corporation.

Environmental Observations of the Project Area

No specific environmental baseline studies have been carried out in the Chicago Creek area; however, regional studies by the State Divison of Fish & Game contain some relevant data on fish habitat, migratory birds, and populations of large mammals. Regional and village native corporations, in conjunction with the University of Alaska's game management specialists, maintain data files on the many local reindeer herds. In the Kotzebue area, historic data and current information on climatic conditions, air and water quality, ground water, and other conditions will help decrease the amount of baseline study necessary.

Several observations on the general ecology of the Chicago Creek area were made by project geologists:

Animala

- 1) <u>Pish</u>: According to Deering villagers, salmon do not migrate up the Kugruk much beyond its mouth. Grayling, Whitefish, and Dolly Varden are present in the Kugruk. (See MacLean & Delaney, 1978). No fish were seen or reported in Chicago Creek itself.
- 2) Birdlife: Birdlife is prolific in the area. Waterfowl observed included Canadian geese, trumpeter swans, sandhill cranes, mallard and pintail ducks, and Arctic looms.
- 3) Small Mammals: Observed were red backed voles, ground squirrels, and fox. Local residents reported porcupine, land otter, beaver, and wolverine.
- 4) Large Mammals: Observed were moose, brown or grizzly bear, and caribou. Most of the "caribou" sightings were probably local reindeer herds.

Plants

The landscape in the Chicago Creek area is characterized by a treeless rolling tundra. Willow and alder grow along the stream courses only occasionally reaching 10 feet in height. The tundra blanket of sphagnum moss, dwarf willow, etc. is a very effective insulator, normally allowing seasonal thaw depths of only 2 to 2 1/2 feet. When this blanket is disturbed, thawing advances rapidly and can cause erosion.

Potential Environmental Impacts

The most likely significant environmental impacts of a coal mine and power plant would probably arise from:

- 1) Air contaminants from the power plant: Possible solutions include use of a fluidized bed boiler design which could effectively decrease sulfur levels in the powerhouse stack as well as burn the coals more efficiently. Ash can be controlled using standard electrostatic precipitators and/or a baghouse.
- 2) Water quality at Chicago Creek: Diversion of Chicago Creek will be necessary to avoid pit water problems. The diversion will need to be designed to avoid discharges from the mine.
- 3) Erosional effects arising from disturbance of tundra: A good understanding of the sensitive nature of the tundra to mechanical and/or thermal disturbance will allow roads and structures to be placed without significant erosion.
- 4) Increase in extra curricular human activities in the mine site area: Regulation and monitoring of such activities will be necessary.

RECOMMENDATIONS

The projected delivered costs of power to Kotzebue and the Kotzebue area for coal are sufficiently attractive that more definitive feasibility study is justified. Such a study should include an onsite geotechnical study, mining of a bulk sample to help resolve equilibrium moisture questions and allow a better determination of coal-burning characteristics, and an air quality survey in Kotzebue.

Early in this investigation, we opted for conventional steam boiler construction rather than a fluid bed reactor. Fluid bed reactor technology is, however, developing rapidly, and improvements are being made in operation and maintenance as well as initial design configuration of units. Based on this rapid development, a definitive feasibility should include fluid bed as well as new and remanufactured conventional boilers. The choice of conventional vs. fluid bed units should be made in conjunction with site air quality information. Chicago Creek lignite contains much less sulfur than mid-continent coal, but has a higher content of sulfur than most Alaska subbituminous coal. The use of fluid bed technology has theoretical advantages over conventional boilers in both SO2 and NOx that deserve examination.

Other important future work should include:

- 1) Comparative economic studies should be made with other coals, both inside and outside Alaska.
- 2) Low interest financing options available to government entities should be reviewed as well as leveraged tax-driven private financing.
- 3) Last, but perhaps most important, once the above studies are completed, a Northwest Alaska regional power study should weigh the benefits of siting a generation facility in Kotzebue as opposed to other areas and should consider in more detail the various transmission intertie options and their benefits.

REFERENCES CITED

- Arctic Slope Consulting Engineers, 1984, Western Arctic Coal Development Project for State of Alaska, Dept. of Community & Regional Affairs & Alaska Native Foundation Contract #85-108.
- Arctic Slope Technical Services, Inc., with Ralph Stefano Assoc. and Veco, Inc., 1982, Coal fired cogeneration, district heating and other energy alternatives feasibility assessment: Report prepared for the Alaska Power Authority.
- Barnes, F. F., 1967, Coal Resources of Alaska, U.S. Geological Survey Bull. 1242-B.
- C. C. Hawley and Associates, Inc., Ramsey, J., Retherford, R., Hickok, B., and Williams, J., 1983, Northwest Alaska Coal Investigation for the State of Alaska, Div. of Geological & Geophysical Surveys, Contract #CA20344, 71pp.
- Dames and Moore in association with Resource Associates of Alaska, Inc., 1980, Assessment of coal resources of northwest Alaska, report prepared for the Alaska Power Authority.
- Dames and Moore, 1981, Assessment of the Feasibility of Utilization of Coal Resources of Northwestern Alaska for Space Heating and Electricity-Phase II: Report prepared for the Alaska Power Authority.
- Dames and Moore, Feldman, M., Mann, C., Young, L., 1983, An Economic and Technical Assessment of the Marketability of Western Arctic Slope Coals for State of Alaska, Div. of Legislative Finance.
- Haga, Hideyo, 1984, Micropaleo Consultants, Bonita CA: Letter describing palynological determinations.
- Hawley Resource Group, Inc., 1985, Preliminary Feasibility Study of a Coal Mine at Chicago Creek CC10-0071 for the State of Alaska, Div. of Geological & Geophysical Surveys, 135pp.
- Henshaw, F. F., 1909, Mining in the Fairhaven precinct in mineral resources of Alaska, report on progress of investigations in 1980: U.S. Geological Survey Bulletin 379.
- International Engineering Co., Inc., 1981, Reconnaissance Study of Energy Requirements and Alternatives for Buckland, Chuathbaluk, Crooked Creek, Hughes, Koyukuk, Nikolai, Red Devil, Russian Mission, Sheldon Point, Sleetmute, Stony River, Takotna, and Telida: Report prepared for Alaska Power Authority.

- _______, 1985, Construction Work Plan--1985-86: Report prepared for Kotzebue Electric Association.
- MacLean, R. F. and Delaney, K. J., 1978, Alaska's Fisheries Atlas Vol. I & II: Alaska Department of Fish & Game.
- Moffit, F. H., 1906, Gold mining on the Seward Peninsula in Mineral resources of Alaska, report on progress of investigations in 1905: U.S. Geological Survey Bulletin. 284.
- Patton, W. W., Jr., 1973, Reconnaissance geology of the northern Yukon-Koyukuk province, Alaska: U.S. Geological Survey Professional Paper 774-A.
- R. W. Retherford Assoc., 1980, Assessment of power generation alternatives for Kotzebue: Report prepared for the Alasks Power Authority.

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- Sainsbury, C. C., 1974, Geologic map of the Bendeleben quadrangle, Alaska: Anchorage, Alaska, The Mapmakers.
- Smith, P. S. and Eakin, H. M., 1911, A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska: U.S. Geological Survey Bulletin 449.
- Stevens Exploration Management, Inc., Manning, K. H. and Stevens, D. L., 1982, Chicago Creek and Norton Sound area coal exploration programs, report prepared for State of Alaska Division of Geological & Geophysical Surveys.
- Till, Allison, 1983, Poster titled "Paleozoic Rocks of the Seward Peninsula -- New Insight": Alaska Geological Society Symposium, April 1983, p. 25.
- Toenges, A. L., and Jolley, T. R., 1947, Investigations of coal deposits for local use in the Arctic regions of Alaska and proposed mine development: U.S. Bureau of Mines Report Inv. 4150.
- Wood, G. H. Jr., 1981. Historical review of current progress in coal resource estimation in the United States: Geological Society of America Bulletin, Part 1, v. 92.

CONVERSION FACTORS

I. Weight/Density

- 1 1b. = 2,205 gr. = 2.2 Kg.
- 1 ft 3 (Chicago Creek coal) = 80 lbs. (approx.) or a density of 1.28 gr./cm³
- 1 yd 3 (Chicago Creek coal) = 2,160 lbs. = 1.08 short tons

II. Volume/Area

$$1 m^3 = 35.31 \text{ ft}^3 = 0.76 \text{ yd}^3$$

 $1 m^2 = 1.196 \text{ yd}^2$

III. Energy Equivalents

- 2.1 lbs. Chicago Creek coal (@ 6,500 Btu/lb.) = 1 Rwh @ 25% plant efficiency
- 1.8 lbs. Chicago Creek coal (@ 7,500 Btu/lb.) = 1 Kwh @ 25% plant efficiency
- 0.1 gal. (0.6 lbs.) diesel fuel (≈137,000 Btu/gal) = 1 Kwh @ 25% plant efficiency

APPENDIX A

Electrical and Space Heating Demand Tables

TABLE A-1

Coal Required for Electrical Generation (Kotzebue and Surrounding Villages *)

	1	2
1983		19,667
1988		22,091
1993		24.847
1998		27,988
2000	11,245	•
2003	•	31,566
2008		35,647
2013		40,311

- 1. Dames and Moore, 1981.
- 2. Arctic Slope Engineers, 1982
 - * Includes Kotzebue, Buckland, Deering, Kiana, Noorvik, and Selawik

TABLE A-2

Coal Required for Direct Heat *
(Kotzebue)

	1	2
1983 2000	20.343	16,905

- 1. Dames and Moore, 1981.
- 2. Arctic Slope Engineers, 1984.
 - * Includes cooking and hot-water energy demands.

TABLE A-3 Coal Required for Direct Heat * (Kotzebue and Surrounding Villages **)

	1	2
1983		24,247
1988		27,238
1993		30,642
1998		24,518
2000	26,492	
2003		38,935
2008		43,975
2013		49,732

- 1. Dames and Moore, 1981.
- 2. Arctic Slope Engineers, 1984.
- * Includes cooking and hot-water energy demands.
 ** Includes Kotzebue, Buckland, Deering, Kiana, Noorvik, and Selawik

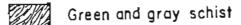
APPENDIX B

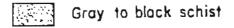
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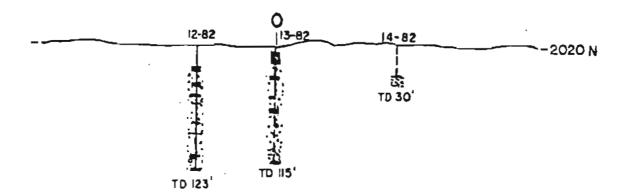
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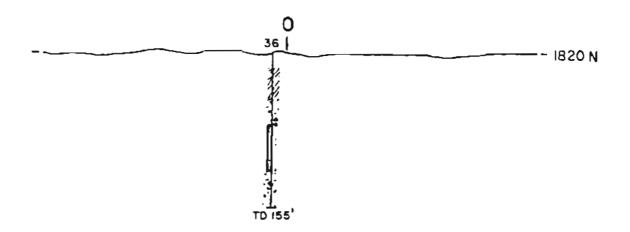


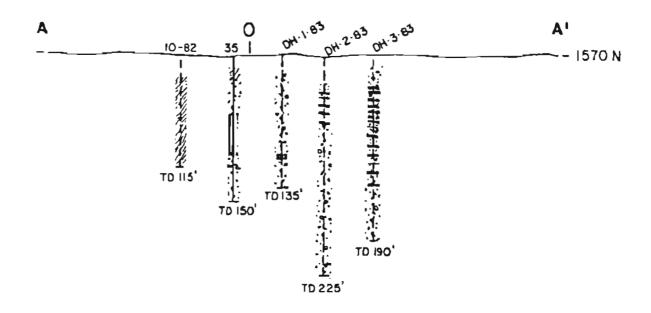


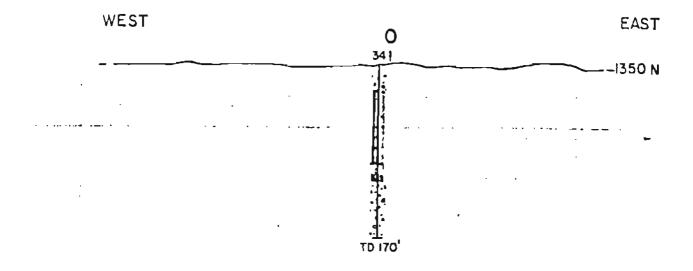


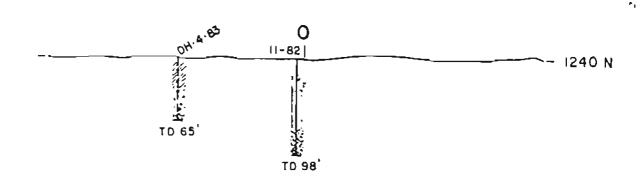


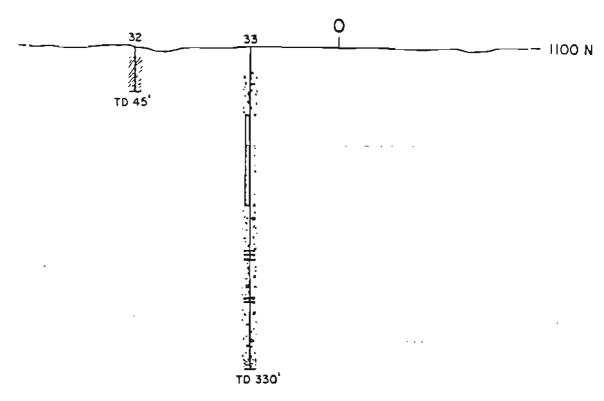




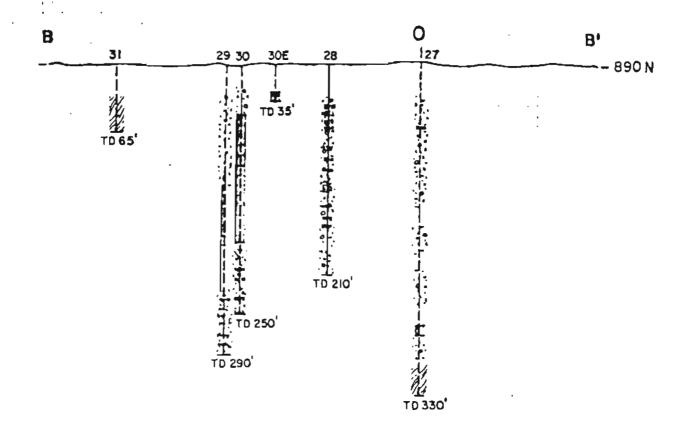


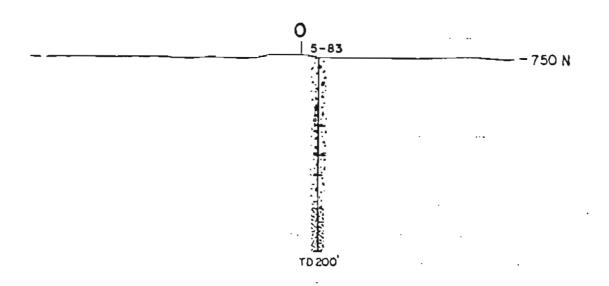


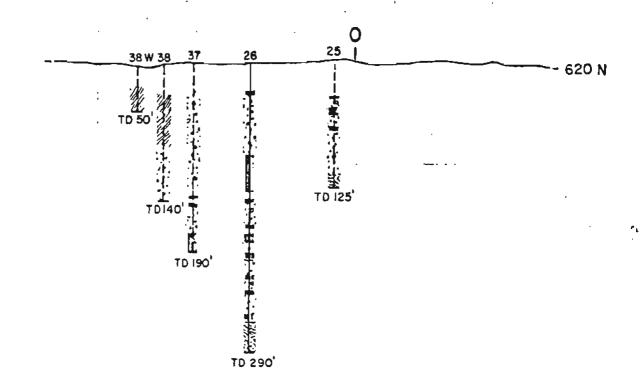


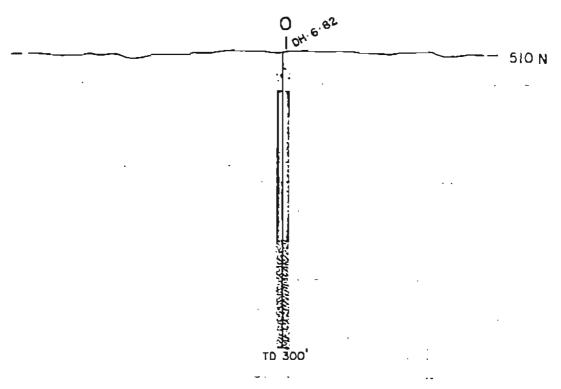


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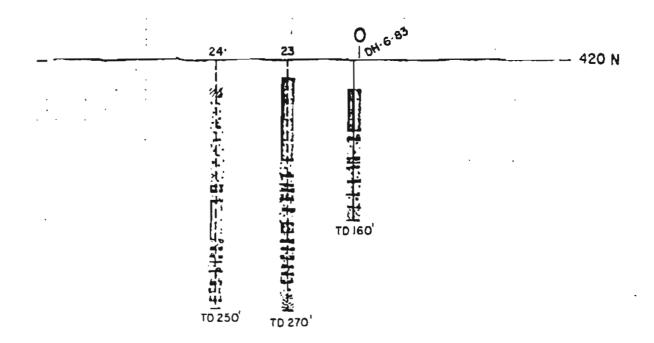


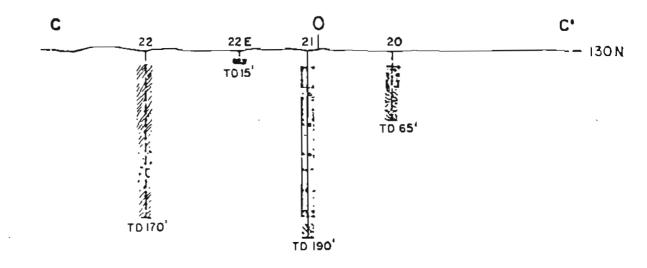


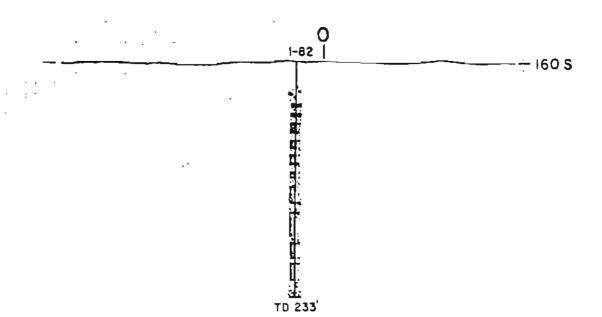


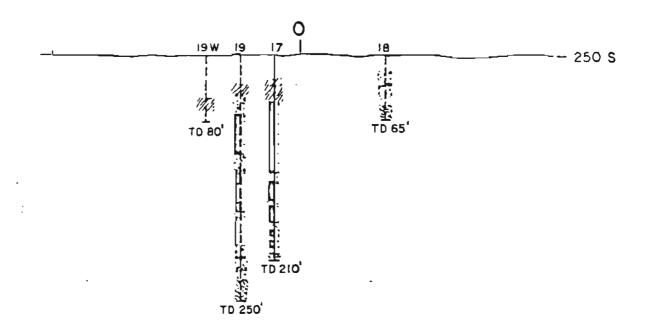


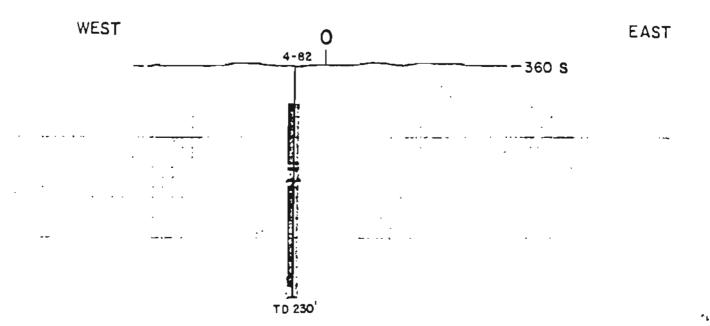
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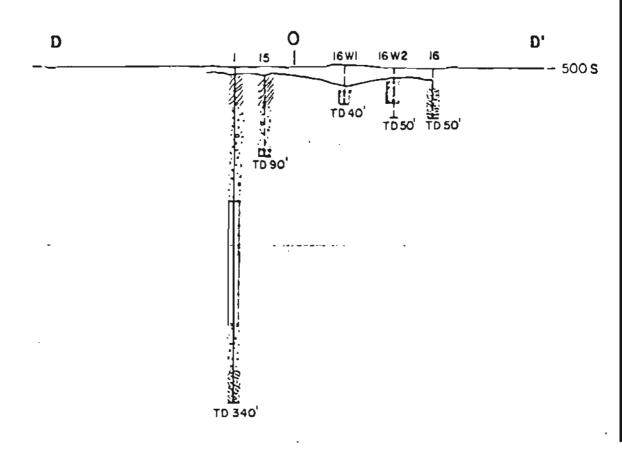


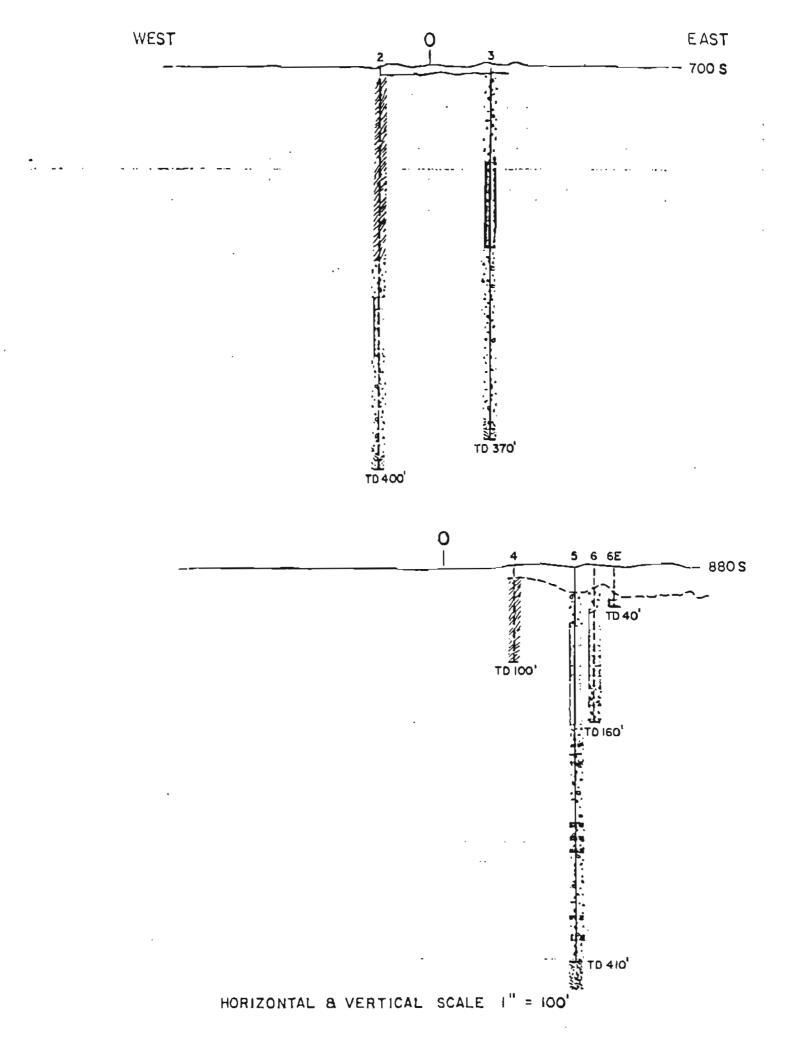


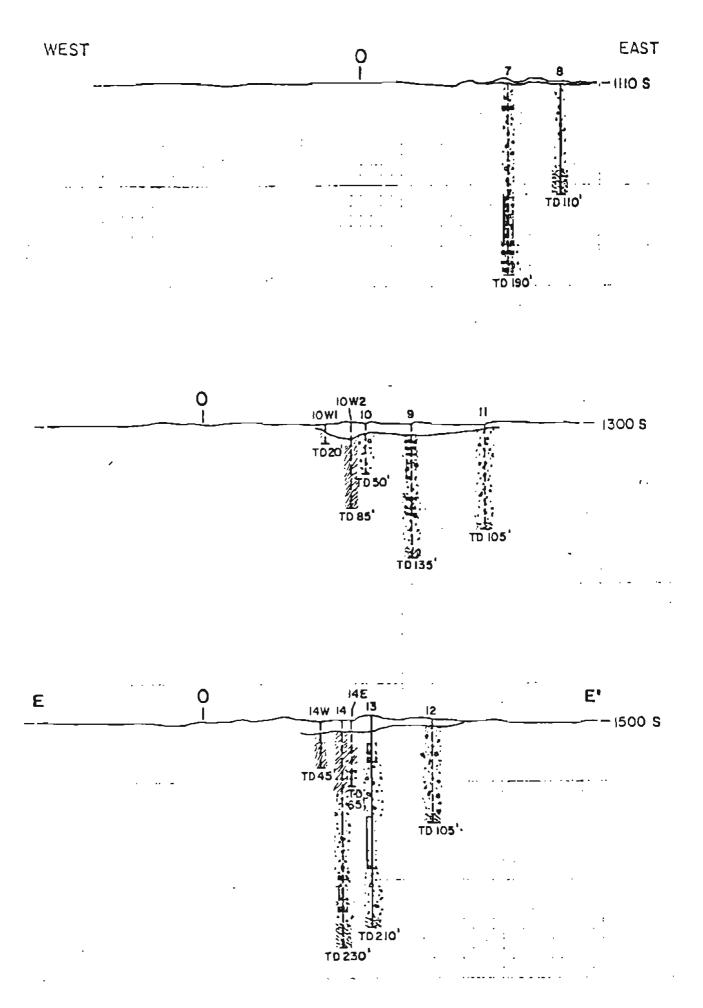












HORIZONTAL & VERTICAL SCALE 1" = 100

APPENDIX C

Core Summary and 1985 Proximate Analyses

		-	1			!	<u> </u>]	APPROX.
	,	•		,		DRILLED		SAMPLED	ADDIN.
	ROTARY	•	RUN		RECOVERY			INTERVAL	ROTARY.
HOLE	# .	DATE	#	FEET	(feet)	l (feet)	SAMPLE	(feet)	(feet)
7.0	15-05	6-12-25	¦	7.0	3,50	81.0- 84.5	1 1- 83	83-5- 84-5	0.03
îč		6-26-85		1 9.0		1 39.0- 43.0			40.0
2C		6-27-85	-	1 4.0	- -	48.0- 52.0			
2C		6-27-85		1 4.5	_	52.0- 56.0			
2C	3-85	6-27-85		1 1.0	_	1 56.5- 57.5		I	
2C	3-85	6-27-85	5	1 4.8		1 57.5- 62.3			
2C		6-28-85		1 3.0		1 63.0- 66.0			
2C		6-28-85		110.0		1 66.0- 76.0			
2C		6-28-85		1 4.0		76.0- 80.0		76.0- 80.01	
3C		7- 3-85		110.0		23.5- 33.5		ļ ļ	23.5
3C		7- 3-85		1 4.5		33.5- 36.0		!	
6C 1		7- 3-85		1 3.0		95.0-98.0			
6C		7- 3-85		1 3.0		1102.0-105.0			
		7- 3-85		110.01		68.0- 78.0			68.0
6C2		7- 3-85		1 7.0		78.0- 85.0			
		7- 3-85		1.0		85.7- 86.5			
6C2	5E-65	7~ 3~85	1 4	6.0	6.00	86.5- 92.5	6- 8/1	89.5- 92.51	
C 00 1	- CD 051		1 -	1 2 0	2.00	1 92.5- 94.5			
6C21		7- 3-851 7- 3-851		1 2.01				94.5- 96.51	
0021	ו כמייתט 1	1-3-65	נז ו	1 4 0	3.30			96.5~ 98.51	
4C	23-851	7- 8-85	1	5.0	5.00			60.0- 65.01	
4C		7- 8-85		1 3.2				65.0- 68.01	
∛C i		7- 9-85		1 4.01		68.0- 72.0			60.0
5C		7- 9-85		1 5.01		1 35.0- 40.0			•
5C		7- 9-85		1 5.01		1 40.0- 45.0	1 5- 401	41.0- 45.01	
5C 1	30-851	7- 9-85	1 3	1 5.01	4.30	45.0- 50.0	5- 461	45.5- 50.01	
5C	30-85	7- 9 - 85	4	1 8.01	7.20	1100.0-108.0	1 5-1001	100.0-106.01	
		7- 9-85	-	1 4.01	_	1108.0-112.0			
		7- 9-85		1 8.01		1130.0-138.0		_	
		7- 9-85		1 7.01		23.0- 30.0			
		7- 9-85		1 6.01		31.0- 37.0			23.0
		7-10-85		1 7.5				80.0-84.01	
		7-10-85		110.01				95.0-102.01	RO.0
		7-10-85		110.0		1 15.0- 25.0			70.0
		7-10-851		1 3.0				70.0- 73.0 73.0- 76.0	
		7-10-85 7-10-85		1 3.01		1 75.0~ 84.5			
				1 9.51				90.0- 92.5	90.0
		7-11 - 85 7-11 - 85		1 8.5		1115.0-123.5		1115.0-121.51	
		7-11-85		110.01	- • -			37.5- 47.51	
		7-11-85		(10.0)		130.0-140.0			130.0
5C				110.01		37.5~ 40.5			37.0
			1			1	i i	1	
10				229.5	157.80				919.0
Roles	J.			Feet	Feet				Feet

SAMPLE NUMBERS	BAS18•	MOISTURE X	VOLATILE MATTER, X	FIXED CARBON, X	ASH %	HEAT ING VALUE BTU/LB	TOTAL SULFUR
1-63	1 2 3	35. 67	29.46 45.79 49.06	30.59 47.55 50.94	4.28 4.66	7499. 11657. 12488.	0.54 0.84 0.92
2-42	1 2 3	37.94	26.36 42.48 44.66	32.67 52.64 55.34	3.03 4.88	7179. 11568. 12161.	0.45 1.04 1.11
2-49	1 2 3	36.62	24.61 38.83 48.93	25.69 40.53 51.07	13.08 20.64	5819. 9182. 11570.	0.55 0.86 1.09
2-52	1 2 3	43.95	24.39 43.52 46.69	27.65 49.68 53.31	3.81 6.79	6385. 11391. 12222.	0.59 1.05 1.12
2-59	1 2 3	3 8.55	27.34 44.49 46.79	31.09 50. 59 53.21	3.02 4.92	7164. 11691. 12297.	0.72 1.18 1.24
2-63	1 2 3	40.05	26.59 44.33 46.16	28.62 47.75 51.84	4.74 7.90	6653. 11098. 12050.	0.66 1.10 1.19
2-67	1 2 3	JB. 53	26.98 43.90 45.74	32.01 52.07 54.26	2.48 4.03	7224. 11752. 12246.	0.53 0.86 0.89
2-76	1 2 3	40.57	25.79 43.39 47.03	29.04 48.87 52.97	4.60 7.74	6877. 11371. 12542.	0. 50 0. 83 0. 90
4-60	1 2 3	40.17	24.55 44.37 47.32	29.56 49.40 52.68	3.73 6.23	6914. 11557. 12325.	0.54 0.91 0.97
4-65	i 2 3	37.97	26.30 42.41 45.40	31.43 50.99 54.40	4.10	7134. 11501. 12315.	0.58 0.94 1.00

^{*1-}AS RECEIVED **

²⁻MOISTURE FREE
3-MOISTURE AND ASH FREE
ALL SAMPLES CONTAIN A SIGNIFICANT AMOUNT OF SURFACE MOISTURE. TRUE BED MOISTURE IS EXPECTED TO BE LESS THAN THIS VALUE, EQUILIBRIUM MOISTURES HAVE REEN DONE FOR A FEW SAMPLES TO INDICATE THE EXTENT OF MOISTURE CONTAMINATION IN THE SAMPLES.

						HEATING	
SAMPLE		MOISTURE	VOLATILE	FIXED	ASH	VALUE	TOTAL
NUMBERS	BASIS.		MATTER, %	CARBON, X	X	BTU/LB	SULFUR
4-68	1	24.70	26.07	21.02	28.21	5462.	1.04
	2		34,62		37.44	7254.	1.39
	3		55 . 35	44.65		11400.	2,20
5-36	1	22.90	17.70	15.76	43.63		0.34
	2		22.96	20.45	54.59	5403.	0.43
	3		52.70	47.10		12447.	1.00
5-40	1	34.68	29.64		16.76	5648.	0.42
	2	·	45.51	28.75	25.74	8673.	0.65
	3		61,29	39.71 		11680.	0, 87
5-46	1	41.63	25.69	. 29.52	3.16	6712.	0.53
	2		44.01	50.58	5.41	11500.	U. 70
	3		46.52	53.49		121 57.	0.95
5-100	1	39.86	24.61	29.15	6.38	6601.	0.44
	2		40.92	48.47	10.60	10976.	1.10
	3		45.78	54.22		12278.	1.23
5-108	1	41.07	24.56	29.93	4.44	6482.	0,40
	2		41.68	50.79	7.53	11339.	1.02
	2		45.07	54.93		12263.	1.10
5-130	1	40.91	24.54	29.86	4.69	6617.	0.49
	2		41.52	50.54	7.94	11198_	0.83
	3		45.10	54.90		12164.	0.90
6-68	1	36.66	28.14	30.50	4.68	7138.	0.58
	2		44.46	48.13	7.40	11270.	0.92
	2		48.01	51.79		12170.	0.99
6-80	1	37.94	26.01	18.99	17.06	5245.	0.68
	2		41.91	30.40	27.49	8451.	1.09
	3		57.80	42.20		11655.	1.51
6-82	1	40.63	26.0 8	2 9. 90	3.39	6972.	0.64
	2		43.93	50.35	5.72	11575.	1.08
	2		46.59	53.41		12277.	1.14

^{+1~}AS RECEIVED ++

⁻¹⁻AS RECEIVED **
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THAN THIS VALUE. EQUILIBRIUM MOISTURES HAVE BEEN DONE
FOR A FEW SAMPLES TO INDICATE THE EXTENT OF MOISTURE
CONTAMINATION IN THE SAMPLES.

SAMPLE NUMBERs	*ABIB*	HOISTURE %	VOLATILE MATTER, 2	FIXED CARBON, X		HEATING VALUE BTU/LB	TOTAL SULFUR
4-87	1 2 3	39.35	25.39 41.86 48.71	24.73 44.07 51.29	8.53 14.04	6269. 10337. 12028.	0.72 1.19 1.38
6-93	1 2 3	40.05	25.81 43.06 48.74	27,15 45,28 51,24	6.99 11.64	6474. 10799. 12224.	0.95 1.58 1.79
6-95	1 2 . 3	37.52	27.57 44.12 47.76	30.15 48.26 52.24	4.76 7.61	7022. 11239. 12165.	1.11 1.77 1.92
6-97	i 2 3	32.96	24.48 36.52 54.49	20.45 30.50 45.51	22.11 32.98	48 63. 72 54. 10 824.	5.28 7.87 11.74
7-23	1 2 3	39.62	26.13 43.28 47.50	28.88 47.83 52.50	5.37 0.89	4577. 10893. 11956.	0.65 1.07 1.18
7-32	1 2 3	42.48	25.60 44.51 46.77	29.14 50.44 53.23	2.78 4.83	6741. 11719. 12315.	0.64 1.12 1.17
7-80	1 2 3	43.26	22.88 40.32 45.73	27.16 47.86 54.27	å.70 11.82	6135. 10812. 12261.	0.79 1.74 1.98
7-95	i 2 3	42.65	20.02 34.91 47.67	21.98 38.33 52.33		4902. 8548. 11672.	1.78 3.10 4.23
7-102	i 2 3	40.52	21.49 36.1 3 48.90	22.46 37.76 51.10		5414. 9102. 12317.	1.25 2.11 2.65
B-15	1 2 3	39.30	24.70 40.70 43.48	32.11 52.90 56.52	3.88 4.40	6905. 1137 6. 12154.	0.52 0.84 0.91

^{*1-}AS RECEIVED **

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⁻⁻ HOISTURE AND ASH FREE

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FOR A FEW SAMPLES TO INDICATE THE EXTENT OF MOISTURE

CONTAMINATION IN THE SAMPLES.

* FRN

SAMPLE NUMBERs	BAS15+	HOISTURE	VOLATILE MAITER, 2		AGH Z	MEATING VALUE BTU/LB	TOTAL SULFUR
B-70	1 2 3	42.19	24.85 42.99 45.93	29.24 50.61 54.07	3.70 4.40	6659. 11519. 12306.	0.85 1.47 1.57
8-75	1 2 3	40.72	20.13 33.96 46.47	23.19 39.11 53.53	15.96 26.93	5175. 8730. 11947.	0.70 1.18 1.41
6-90	1 2 3	41.86	23.50 40.41 45.63	28.00 48.16 54.37	6.64	6414. 11032. 12455.	1.23
9-38	1 2 3	38.54	27.06 . 44.03 46.87	30.67 49.90 53.13	3.73 4.07	6944. 11298. 12029.	0.48 0.79 0.84
9~40	1 2 3	3B.50	27.46 44.64 46.80	31.21 50.74 53.20	2.84 4.61	7066. 11490. 12046.	0.32 0.52 0.55
9-130	i 2 3	40.41	25.16 42.23 43.03	30.71 51.54 54.97	3.71 6.23	6812. 11431. 12190.	0.44 0.74 0.79
DH 17	i 2 3	43.05	23.95 42.06 46.23	27.86 48.92 53.77	5.13 9.02	4372. 11189. 12298.	0.64 1.12 1.23
DH 6	i 2 3	44.24	22.59 40.52 47.88	24.59 44.10 52.12	8.58 15.39	5584. 10018. 11840.	0.49 0.68 1.04
DH 3	i 2 3	37,17	26.37 41.97 45.65	31.40 49.97 54.35	5.04 8.04	7011. 11159. 12138.	0.54 0.85 0.93

^{#1-}AS RECEIVED **

²⁻MOISTURE FREE 3-MOISTURE AND ASH FREE

³⁻MOISTURE AND ASH FREE

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FOR A FEW SAMPLES TO INDICATE THE EXTENT OF MOISTURE
CONTAMINATION IN THE SAMPLES.

SAMPLE NUMBERS	BABIS•	MOISTURE Ž	VOLATILE		ASH %	HEATING VALUE BTU/LB	TOTAL SULFUR
5-40	1 2 3 4	34.88 26.73	29.64 33.33 45.52 61.29	18.72 21.06 28.75 38.71	16.74 18.84 25.74	5448. 6353. 8473. 11679.	0.42 0.47 0.64 0.87
5-46	1 2 3 4	41.43 29.51	25.69 31.02 44.01 46.53	29.52 35.65 50.57 53.47	3.16 3.82 5.41	6712. 8104. 11499. 12157.	0.53 0.64 0.91 0.96
7~32	1 2 3 4	42.49 27.87	25.60 32.10 44.51 46.77	29.14 36.54 50.66 53.23	2.78 3.49 4.83	6741. 8453. 11719. 12315.	0.64 0.80 1.11 1.17
7~B0	1 2 3 4	43.26 30.32	22,88 28,10 40,32 45,72	27,16 33,35 47,87 54,28	4.70 9.23 11.81	6135. 7534. 10812. 12260.	0.99 1.22 1.74 1.98
8-70	i 2 3 4	42.19 29.74	24.83 30.20 42.99 45.92	29-24 35.56 50.41 54.08	3.70 4.50 6.40	6659. 8093. 11519. 12306.	0.85 1.03 1.47 1.57

^{*1-}AS RECEIVED MOISTURE 2-EQUILIBRIUM BED MOISTURE 3-MOISTURE FREE 4-MOISTURE AND ASH FREE

APPENDIX D

Volume Calculations for an Open Pit Mine at Chicago Creek

APPENDIX D

Stripping Calculation Worksheet

TW = True Width
DD = Dip Depth
L = Length

IA

Loess (OB): 560° (W) X 15° (D) X 840 (L) = 7,056,000 FT³ ÷ 27 = 261.333 YD^3

Access Ramp *: 30 YD

Rock: $\frac{(135 \times 260)}{2} + \frac{(260 \times 265)}{2} \times 800^{\circ} = 41,600,000 \text{ FT}^{3}$ $\frac{2}{27} = 1,540,740 \text{ YD}^{3}$

Total Strip: Locas (261,333) + Access (30,000) + Rock (1,540,740 = $1.832,073 \text{ YD}^3$

Ratio: 1,832,073 / 400,000 = 4.6;1

* NOTE: Access, ramp, excavation requirements are all included here although it passes through IB and IIA as well.

IB

Loess (OB): 560 (W) X 15' (D) X 700 (L) = 5,880,000 $\text{FT}^3 \div 27 = 217,778 \text{ YD}^3$

Rock: $\frac{(135 \times 260)}{2} + \frac{(260 \times 265)}{2} \times 700^{\circ} = 36,400,000 \text{ gr}^{3}$ $\div 27 = 1,348,148 \text{ yp}^{3}$

Total Strip: Loess (217,778) + Rock (1,348,148) = 1.565,926 YD³

Ratio: 1,565,926 / 910,364 = 1.72:1

IIA

Loess (OB): $510 \text{ (W) } \text{X } 25^{\circ} \text{ (D) } \text{X } 650 \text{ (L)} = 8,287,500 \text{ FT}^3 \div 27 = 206 \text{ DAA } \text{YD}^3$

306,944 YD3

Rock: $\frac{(190 \times 170)}{2} + \frac{(190 \times 130)}{2} \times 650^{\circ} = 18,525,000 \text{ FT}^3$

 \div 27 = 686,111 YD³

Total Strip: Loess (306,944) + Rock (686,111) =

993,055 YD3

Ratio: 993,055 / 609,700 = 1.6:1

IIB

Loess (OB): 320 (W) X 25' (D) X 730 (L) = 5,840,000 FT³ \div 27 =

216,296 YD³

Rock: $\frac{(185 \times 80)}{2} + \frac{(185 \times 105)}{2} \times 730^{\circ} = 12,492,125 \text{ PT}^{3}$

 $\stackrel{?}{\div} 27 = 462,671 \text{ YD}^3$

Total Strip: Loess (216,296) + Rock (462,671) =

678,967 YD3

Ratio: 678,967 / 193,596 - 3,5:1

III

Loess (OB): 320 (W) X 25' (D) X 840 (L) = 6,720,000 PT³ \div 27 =

248,888 YD3

Rock: $\frac{(185 \times 80)}{2} + \frac{(185 \times 105)}{2} \times 840^{\circ} = 14,374,080 \text{ FT}^{3}$

Total Strip: Loess (248,888) + Rock (532,373) =

781,261 YD3

Ratio: 781,261 / 117,936 = 6.6:1

APPENDIX E

Remanufactured Power Plants (Haemer/Rockware Letter)

ERIC J. HAEMER, P.E. CONSULTING ENGINEERING SERVICES 12800 HUFFMAN CIRCLE ANCHORAGE, ALASKA 99516 (907) 345-6201

December 1, 1985

Hawley Resource Group, Inc. 7011 Old Seward Highway Anchorage, Alaska 99502

Attention: Rob Rutherford

Subject: Kotzebue Power Plant Application

Dear Rob,

Regarding our discussions of November 14, 1985, I transmitted the necessary data to Rockware International and requested that they develop some budject pricing specifically for the above referenced application. Attached is their response which I have reviewed in detail. Based upon my Alaska experience I concur with their estimate of installed costs for the plant. I feel the range is sufficiently broad to cover the wage differential for Alaskan labor at a remote site installation. The estimated costs would also cover all reasonable site development work, but, of course would not cover any extraordinary site conditions which would have to be priced separately.

Also, please find attached a representative equipment inventory which includes a variety of additional equipment sizes. Based upon the final criteria developed for the plant an equipment selection more closely meeting the load requirements may be possible. Rockware International would be pleased to make a formal quotation once the specific criteria is developed for the application, a site is selected and representative fuel samples are available for testing.

I believe that the letter satisfactorily details the advantages of remanufactured equipment. Based upon the cost, delivery and installation schedules, warranty and the variety of selection of components the rate of return on investment and payback periods is almost always superior to new equipment purchases. In addition, the equipment sizing generally required by many Alaskan applications is simply unavailable from today's manufacturers due to the economy of scale which has been generally adopted by the U.S. utility industry.

If you require any additional information or clarification on any of the above material, please contact me.

Very truly yours,

Eric J. Haemer

Professional Engineer

EJH/kcb

Enclosure

cc: William Ware, Jr.

Robert Goldberg



6406 B SOUTH EASTERN AVENUE P.O. BOX 95833 OKLAHOMA CITY, OKLAHOMA 73143 (405) 670-6686

November 21, 1985

Mr. Eric J. Haemer, P.E. 12800 Huffman Circle Anchorage, Alaska 99516

Dear Mr. Haemer:

Rockware International welcomes the opportunity to provide complete turnkey power plants and related equipment on a remanufactured and guaranteed basis to the State of Alaska.

To give you additional background on our organization, Rockware specializes in the remanufacturing and construction of fossil fuel and biomass power plants utilizing existing equipment located throughout the United States, Canada and Europe. As you will see from the enclosed inventory printout, we have a large selection of condensing and non-condensing turbine generators from 300 to 100,000 kW, diesel and dual fuel generators to 6,000 kW, natural gas turbine generators to 30,000 kW, and boilers from 250 HP to 700,000 PPH with steam pressures ranging to 1500 PSIG.

Unlike used equipment dealers, we prefer to deliver our equipment on a remanufactured basis, rather than "as is". All remanufactured items are completely disassembled, each piece inspected, rebuilt or replaced, and upgraded with new technology before the unit is reassembled. All of our work is in full compliance with A.S.M.E. Boiler and Pressure Vessel Code. For your general information, Rockware holds the following A.S.M.E. Certifications:

- S Manufacture of New Steam Boilers
- A Assembly of Field Erect and Package Boilers, No Size Limit
- U Manufacture of Unfired Pressure Vessels
- PP Manufacture of Pressure Piping

We also hold the National Board R Stamp for Repairs.

All of our remanufactured items have new equipment type warranties, comparable to Westinghouse, General Electric and others. The length of the warranty varies with each type of equipment supplied. Major components typically have a one year guarantee for any defects in materials or workmanship.



November 21, 1985 Mr. Eric J. Hasmer Page 2

Whenever possible, Rockware purchases generating plants as a complete system to minimize re-engineering expense, and reduce the overall turnkey price of the power plant to the purchaser. As an example, we recently purchased a 7500 KW municipal power plant in the central United States for relocation. Nearly all of the facility can be reutilized, including the fully insulated metal building, stack and structural steel. Additional major components include:

- 1 G.E. 7500 KW, 3600 RPM, 600 PSI @ 825°F, Condensing Turbine Generator.
- 1 Allis Chalmers 9,000 Sq. Ft. 2 Pass Condenser.
- 1 Babcock Wilcox, 100,000 #/Hr Type FT1-21-15/12LH-48 Boiler. 650 PSIG @ 835°F natural gas with number 2 oil standby. Convertable to pulverized coal.
- 1 Sturtevent 50 HP Forced Draft Fan.
- 1 Sturtevant 100 HP Induced Draft Fan.
- 2 Byron Jackson 200 HP, 8 Stage Boiler Feed Pumps.
- 1 Davis "Paracoil" Evaporator.
- 1 Hoppes 120,000 #/Hr Feedwater Heater.
- 1 Marley Cooling Tower, Model 2024A5, 2 cell double flow.
- 2 Peerless 100 HP Circulative Water Pumps.
- 2 Allis Chalmers Condensate Pumps.

In addition to the equipment itself, the original performance specifications, blueprints, operating manuals and supplier literature are used to re-engineer the plant to meet the specifications of the new application.

A pulverized coal fired, 7500 KW municipal power plant of this type has a replacement value of approximately \$1500 to \$2000 per KW installed in the central United States. Rockware International can provide a comparable facility on a turnkey basis, remanufactured and guaranteed, at an approximate price of \$975 to \$1300 per KW, depending upon local site conditions and labor rates. Suitable pollution control equipment would be included. Rockware has other fossil fuel fired power plants available on a similar basis up to a total plant capacity of 350,000 KW.



November 21, 1985 Mr. Eric J. Haemer Page 3

In effect, Bockware can save the purchaser 30 to 40 percent by utilizing remanufactured components, yet still provide warranties comparable to the original manufacturers. Frequently, we can also have our boilers, generators and related pollution control equipment systems installed and in full operation in less than half the time of new equipment. This provides a highly favorable rate of return on investment and payback period that cannot be matched by new equipment suppliers.

We look forward to taking an active role in the expansion of Alaska's municipal and industrial power generating capacity.

Sincerely,

ROCKWARE INTERNATIONAL CORPORATION

John B. Shelton, Jr.

Sales Manager

JBS/daw

Enclosure

ROCKWARE INTERNATIONAL CORPORATION OKLAHOMA CITY, OKLAHOMA

MAJOR COMPONENTS INVENTORY November, 1985

BOILERS

FIELD ERECTED

630,000	PPH,	1500 PSI/1000 F, RILEY, PULVERIZED COAL	911
450,000	PPH,	775 PSI/775° F, B & W, PULVERIZED COAL	911
400,000	PPH,	1500 PSI/1000° F, RILEY, PULVERIZED COAL 775 PSI/775° F, B & W, PULVERIZED COAL 1500 PSI/955° F, B & W, PULVERIZED COAL (2 AVAIL)	914
350,000	PPH.	920 PSI/905° F, C.E., PULVERIZED COAL/GAS/OIL	906
300,000	PPH,	1000 PSI/900° F, B & W, GAS/OIL	908
300,000	PPH.	750 PSI/650° F, B & W, 2 DRUM DRY BOTTOM TYPE, CO FLU GAS/	913
GAS/OIL			
300,000	PPH,	725 PSI/650° F, VOGT, PULVERIZED COAL/GAS/OIL	913
		650 PSI/835° F, FOSTER WHEELER, PULVER12ED COAL (4 AVAIL)	911
290,000	PPH,	1500 PSI/950° F, B & W, PULVERIZED COAL/GAS	911
250,000	PPH.	477 PSI/575° F, RILEY, STOKER COAL/WOOD	909
210,000	PPH.	1100 PSI/900° F, RILEY, PULVERIZED COAL/OIL	905
207,000	PPH.	1050 PSI/900° F. RILEY, GAS/OIL	100
200.000	PPH.	1500 PSI/950° F, B & W, PULVERIZED COAL/GAS 477 PSI/575° F, RILEY, STOKER COAL/WOOD 1100 PSI/900° F, RILEY, PULVERIZED COAL/OIL 1050 PSI/900° F, RILEY, GAS/OIL 1000 PSI/900° F, B & W, GAS/OIL (3 AVAIL) 850 PSI/900° F, B & W, GAS/OIL 710 PSI/750° F, RILEY, PULVERIZED COAL/OIL 425 PSI, RILEY, STOKER COAL/WOOD	908
200.000	PPH.	850 PSI/900° F. B & W. GAS/OIL	910.
200.000	PPH.	710 PSI/750° F. RILEY, PULVERIZED COAL/OIL	9041
200,000	PPH.	425 PSI. RILEY, STOKER COAL/WOOD	9091
200.000	PPH.	400 PSI SATURATED, RILEY, STOKER COAL/WOOD	909:
		280 PSI SATURATED, RILEY, STOKER COAL/WOOD	9094
		725 PSI/750° F, B & W, STOKER TYPE, MUNICIPAL WASTE/OIL	
165.000	PPH.	865 PSI/835° F, DELTAK, WASTE HEAT/N. GAS	9099
150,000	PPH.	725 PSI/825° F, C.E., PULVERIZED COAL/OIL (4 AVAIL)	1046
150,000	PPH.	675 PSI/825° F, C.E., PULVERIZED COAL/ GAS/OIL	1002
150,000	PPH,	675 PSI SATURATED, SPRINGFIELD, STOKER COAL/WOOD	9081
130.000	PPH.	700 PSI/825° F. RILEY, STOKER COAL/WOOD	9131
		475 PSI/725° F, WICKES, STOKER COAL/WOOD	1003
		475 PSI/725° F, B & W, STOKER COAL/WOOD	1004
120,000	PPH.	1275 PSI/900° F, AMERICAN SCHACK, BLAST FURNACE GAS	9134
(2 AVAI)			,
		705 PSI/700° F, ECONOTHERM, WASTE HEAT	9058
100,000	PPH.	705 PSI/700° F, ECONOTHERM, WASTE HEAT 700 PSI/900° F, B & W, PULVERIZED COAL/ GAS/OIL	1005
100.000	PPH.	700 PSI/750° F, C.E., PULVERIZED COAL	1006
95.000	PPH.	700 PSI/750° F, C.E., PULVERIZED COAL 675 PSI/750° F, B & W, GAS/OIL 600 PSI/820° F, UNION IRON WORKS, GAS 700 PSI/825° F, RILEY, STOKER COAL/WOOD (2 AVAIL)	9052
80.000	PPH.	600 PSI/820° F. UNION IRON WORKS. GAS	9106
70.000	PPH.	700 PSI/825° F, RILEY, STOKER COAL/WOOD (2 AVAIL)	9132
60,000	PPH,	475 PSI/750° F, B & W, PULVERIZED COAL/GAS/OIL	9051
35,000	PPH.	450 PSI, ERIE CITY, STOKER COAL/WOOD (2 AVAIL)	9080
- •	•	• • • • • • • • • • • • • • • • • • • •	

PACKAGE

```
200,000 PPH, 650 PSI/725° F. C.E., GAS/OIL
167,000 PPH, 775 PSI/730° F. RILEY, GAS (5 AVAIL) 9002
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```
150,000 PPH, 900 PSI/825° F, C.E., GAS/OIL
                                                                                 900
125,000 PPB, 750 PSI/750° F, C.E., GAS/OIL (2 AVAIL)
                                                                                 90€
115,000 PPH, 700 PSI/750° F, ERIE CITY, GAS/OIL
                                                                                 900
100,000 PPH, 675 PSI SUPERHEAT, RILEY UNION, GAS/OIL (2 AVAIL)
                                                                                 915
100.000 PPH, 300 PSI/500° F, B & W, GAS/OIL (2 AVAIL)
                                                                                 911
100,000 PPR, 250 PSI SATURATED, RILEY, GAS/OIL (2 AVAIL)
                                                                                 905
75,000 PPH, 350 PSI/500° F, C.E., OIL
                                                                                 905
60,500 PPH, 750 PSI/650° F, WICKES, GAS/OIL
                                                                                 100
60,000 PPH, 680 PSI/700°F, B&W, GAS/OIL (2 AVAIL)
                                                                                 913
60,000 PPH, 250 PSI/D&S, C.E., GAS/OIL
55,000 PPH, 675 PSI/650° F, WICKES, GAS/OIL
                                                                                 900
                                                                                 100
55,000 PPH, 260 PSI SATURATED, CLEAVER BROOKS, OIL
                                                                                 915
40,000 PPH, 690 PSI/750° F, MURRAY, GAS
25,000 PPH, 150 PSI/D&S, MURRAY TRANE, GAS/OIL
                                                                                 906
                                                                                 900
20,000 PPH, 200 PSI SATURATED, ERIE CITY, GAS/OIL
                                                                                 103
12.500 PPH, 200 PSI SATURATED, ERIE CITY, GAS/OIL
                                                                                 104
250 HP, 150 PSI SATURATED, CLEAVER BROOKS, GAS/OIL, NEW 1977
                                                                                 104
```

POLLUTION CONTROL SYSTEMS

87,000 ACFM/420° F, WHEELABRATOR-FRYE, 4 MODULE BAGHOUSE AND SO REMOVAL 914 SYSTEM FOR 2 PERCENT SULPHUR COAL

100

CORLISS ENGINE

1,000 KW CORLISS, 125 PSI/D&S, 5 PSI EXHAUST

GENERATORS, ENGINE DRIVEN

```
5,885 KW ELLIOTT/NORDBERG, DIESEL, 189 RPM, 4160 VOLTS
                                                                             910
3,200 KW ELLIOTT/NORDBERG, DIESEL, 225 RPM, 4160 VOLTS
                                                                             910
2,875 KW ELLIOTT/NORDBERG, DIESEL, 225 RPM, 4160 VOLTS
                                                                            910
2,250 KW ELLIOTT/WORTHINGTON, DIESEL, 450 RPM, 2400/4160 VOLTS
                                                                             909
2,250 KW E.M./WORTHINGTON, DIESEL, 514 RPM, 2400/4160 VOLTS 1,750 KW ELLIOTT/NORDBERG, NATURAL GAS, 277 RPM, 2400 VOLTS
                                                                             907
                                                                             909
1,365 KW FAIRBANKS MORSE, DUAL FUEL, 720 RPM, 2400/4160 VOLTS (2 AVAIL) 912
1.250 KW WESTINGHOUSE/WORTHINGTON, DIESEL, 360 RPM, 2400/4160 VOLTS
                                                                            907
1,245 KW ELLIOTT/WORTHINGTON, DIESEL, 360 RPM, 2400 VOLTS
                                                                             906
1,160 KW ELLIOTT/WORTHINGTON, DIESEL, 360 RPM, 2400/4160 VOLTS
                                                                             906
1,125 KW ELLIOTT/WORTHINGTON, DIESEL, 360 RPM, 2400 VOLTS
                                                                             907
1,125 KW FAIRBANKS MORSE, DIESEL, 300 RPM, 2400 VOLTS
                                                                             104
1.088 KW G.E./WORTHINGTON, DIESEL, 360 RPM, 2400 VOLTS
                                                                             907
900 KW FAIRBANKS MORSE, DUAL FUEL, 720 RPM, 2400/4160 VOLTS
                                                                            912
750 KW WESTINGHOUSE/GM, DIESEL, 720 RPM, 2400/4160 VOLTS
                                                                            906
750 KW M & S/G.E., DIESEL, 240 RPM, 4160 VOLTS
                                                                             910
732 KW G.E./WORTHINGTON, DIESEL, 360 RPM, 2400 VOLTS
                                                                             906
600 KW G.E./WORTHINGTON, DIESEL, 360 RPM, 2400 VOLTS
                                                                             906
400 KW FAIRBANKS MORSE, DIESEL, 400 RPM, 2400 VOLTS
                                                                             104
250 KW FAIRBANKS MORSE, DIESEL, 257 RPM, 2300 VOLTS
                                                                             104
```

GENERATORS, GAS TURBINE DRIVEN

31,000 KW WESTINGHOUSE, W-251-G, GAS/OIL, 3/60/13,800 VOLTS WITH WASTE	904!
HEAT BOILER	
30,000 KW WESTINGHOUSE, W-301-G, GAS/OIL, 3/60/13,800 VOLTS	901(
17,500 KW PRATT & WHITNEY GG4-7, N. GAS, 3/60/13,800 VOLTS (3 AVAIL)	9091
16,500 KW WESTINGHOUSE, 192, GAS/OIL, 3/60/13,800 VOLTS	901:
16,300 KW WESTINGHOUSE, W-191-G, GAS/OIL, 3/60/13,800 VOLTS	911:
16,200 KW G.E., GAS/OIL, 3/60/11500 VOLTS (3 AVAIL)	911
16,000 KW G.E., FRAME 7, 3/60/12,500 VOLTS (2 AVAIL)	9087
15,000 KW WESTINGHOUSE, W-191-G, GAS/OIL, 3/60/13,800 VOLTS	9011
10,000 KW G.E., 5001E, GAS/OIL, 3/60/12,500 VOLTS	9012
8,000 KW G.E., FRAME 3, GAS, 3/60/4160 VOLTS	9141

STEAM TURBINE DRIVEN GENERATORS

CONDENSING

```
85,000 KW C.E., 1500 PSI/1000° F, 13,800 VOLTS
                                                                             9116
50,000 KW G.E., 850 PSI/900° F, 13,000 VOLTS
                                                                             9014
40,000 KW WESTINGHOUSE, 850 PSI/900° F, 13,800 VOLTS
                                                                             9011
35,000 KW G.E., 235 PSI/750° F, 12,500 VOLTS
                                                                             9077
30,000 KW G.E., 850 PSI/900° F, 13,800 VOLTS
                                                                             9017
30,000 KW G.E., 850 PSI/900° F, 13,800 VOLTS
                                                                             906:
28,000 KW G.E., 225 PSI/700° F, 12,470 VOLTS
                                                                             9076
25,000 KW BROWN BOVERI, 650 PSI/835° F, 11,500 VOLTS
                                                                             911:
25,000 KW ALLIS CHALMERS, 650 PSI/825° F, 13,800 VOLTS (2 AVAIL)
                                                                             1045
25,000 KW G.E., 600 PSI/825° F, 13,800 VOLTS
                                                                             9018
20,000 KW G.E., 850 PSI/900° F, 13,800 VOLTS
                                                                             1010
20,000 KW WESTINGHOUSE 850 PSI/900° F, 13,800 VOLTS
                                                                             9055
20,000 KW G.E., 450 PSI/750° F, 13,800 VOLTS
                                                                             9019
15,000 KW G.E., 450 PSI/750° F, 12,470 VOLTS
                                                                             9020
15.000 KW G.E., 225 PSI/700° F, 12,470 VOLTS
                                                                             9075
11,500 KW G.E., 600 PSI/825° F, 13,800 VOLTS
                                                                             9127
10,000 KW G.E., 600 PSI/825° F, 13,800 VOLTS
                                                                             1012
10,000 KW WESTINGHOUSE, 400 PSI/750° F, 14,400 VOLTS
                                                                             1013
10,000 KW WESTINGHOUSE, 400 PSI/750° F, 4160 VOLTS
                                                                             1014
10,000 KW ELLIOT, 375 PSI/725° F, 13,800 VOLTS 7,500 KW G.E. 600 PSI/825° F, 7200/12,470 VOLTS
                                                                             1011
                                                                             9021
7,500 KW G.E., 600 PSI/825° F, 2400/4160 VOLTS
                                                                             1015
7,500 KW ALLIS CHALMERS, 600 PSI, 13,800 VOLTS
                                                                             9049
7,500 KW WESTINGHOUSE, 400/250 PSI, 2400 VOLTS
                                                                             1019
6,000 KW ELLIOT, 375 PSI/725° F, 13,800 VOLTS
                                                                             1016
5,500 KW G.E., 125 PSI/371° F, 2400 VOLTS
                                                                             9084
5,000 KW DELAVAL, 600 PSI/815° F, 6600 VOLTS
                                                                             9128
5.000 KW ALLIS CHALMERS 450 PSI, 2400/4160 VOLTS
                                                                             9050
5,000 KW G.E. 150/200 PSI/D&S, 13,800 VOLTS
                                                                             9022
4,000 KW G.E., 600 PSI/825° F, 13,800 VOLTS (2 AVAIL)
                                                                             9123
3,500 KW BROWN BOVERI, 150 PSI/D&S, 2 PHASE, 2300 VOLTS
                                                                             1017
2.500 KW ALLIS CHALMERS, 125 PSI/371° F. 2300 VOLTS
                                                                             9085
1.500 KW G.E., 400 PSI/700° F. 4160 VOLTS
                                                                             9136
1,500 KW WESTINGHOUSE, 300 PSI/725° F, 2400/4160 VOLTS
                                                                             9078
1,000 KW ALLIS CHALMERS, 150 PSI/370° F. 2300 VOLTS
                                                                             9086
```

CONDENSING DOUBLE AUTO EXTRACTION

```
7500 KW G.E., 600 PSI/750° F, 170/60 PSI EXTRACTION, 2400/4160 VOLTS 91 5000 KW G.E., 600 PSI/825° F, 205/55 PSI EXTRACTION, 2400/4160 VOLTS 91 1,000 KW WESTINGHOUSE, 150 PSI, 50/5 PSI EXTRACTION, 2400 VOLTS (2 AVAIL) 10
```

CONDENSING MIXED PRESSURE

```
1,000 KW WESTINGHOUSE, 150/10 PSI, 5 PSI EXTRACTION, 2400 VOLTS 10
```

CONDENSING SINGLE EXTRACTION

```
25,000 KW G.E., 850 PSI/825° F. 60 PSI EXTRACTION, 13,800 VOLTS
                                                                          90
17,500 KW WORTHINGTON, 850 PSI/825° F, 11-25 PSI UNCONTROLLED EXT,
                                                                          90
13,800 VOLTS (2 AVAIL)
15,000 KW WESTINGHOUSE, 850 PSI/750° F. 140 PSI EXTRACTION, 13,800 VOLTS 91
7,500 KW G.E., 410 PSI/650° F, 60 PSI EXTRACTION, 2400 VOLTS
                                                                          90
5,000 KW G.E., 400 PSI/650° F, 90 PSI EXTRACTION, 2400/4160 VOLTS
                                                                          91
2,500 KW G.E., 450 PSI/700° F, 50 PSI EXTRACTION, 480 VOLTS
                                                                          90
2,500 KW G.E., 400 PSI/700° F, 130 PSI EXTRACTION, 2400/4160 VOLTS
                                                                          90
2,500 KW WESTINGHOUSE, 300 PSI/750° F, 15 PSI EXTRACTION, 2400/4160
                                                                          90
VOLIS
1.500 KW G.E., 400 PSI/700° F, 90 PSI EXTRACTION, 2300/4160 VOLTS
                                                                          91
1,000 KW WORTHINGTON, 200 PSI/528° F, 5 PSI EXTRACTION
                                                                          10
```

NON-CONDENSING

```
20,000 RW WESTINGHOUSE, 480 PSI/850° F, 160/185 PSI EXHAUST, 13,800
                                                                           90
VOLTS
15,000 KW WESTINGHOUSE, 1250 PSI/900° F, 400 PSI EXHAUST, 13,800 VOLTS
                                                                           91
12,500 KW WESTINGHOUSE, 170 PSI/375° F (WET STEAM), 20/34 PSI EXHAUST
                                                                           91
13,800 VOLTS (UNUSED)
10,000 KW G.E., 1250 PSI/950° P, 285 PSI EXHAUST, 13,800 VOLTS
                                                                           91
10,000 KW G.E., 1250 PSI/750° F, 235 PSI EXHAUST, 11,000 VOLTS
                                                                           91.
10,000 KW G.E., 1250 PSI/750° F, 180 PSI EXHAUST, 11,000 VOLTS
                                                                          · 91.
10,000 KW WESTINGHOUSE, 840 PSI/825° F, 150/185 PSI EXHAUST, 13,800
                                                                           90.
VOLTS
7.500 KW G.E., 850 PSI/850° F, 110 PSI EXHAUST, 2400/4160 VOLTS (3 AVAIL)91.
6,000 KW ALLIS CHALMERS, 900 PSI/820° F, 210 PSI EXHAUST, 4160 VOLTS
                                                                           901
6,000 KW WESTINGHOUSE, 650 PSI/750° F, 15-25 PSI EXHAUST, 11,000 VOLTS
                                                                           90:
3,000 KW TERRY/G.E., 700 PSI/700° F, 60 PSI EXHAUST, 4160 VOLTS
                                                                           901
2,500 KW G.E., 450 PSI/750° F, 50 PSI EXHAUST, 480 VOLTS
                                                                           901
1.500 RW G.E., 400 PSI/625° F, 40 PSI EXHAUST, 2400/4160 VOLTS
                                                                           91:
1.500 KW WESTINGHOUSE, 225 PSI/580° F, 18 PSI EXHAUST, 2400 VOLTS
                                                                           90:
1,500 KW G.E., 200 PSI/D&S, 10 PSI EXHAUST, 480 VOLTS
                                                                           900
1,500 KW G.E., 150 PSI, 15 PSI EXHAUST, 480 VOLTS
                                                                           904
1,250 KW ALLIS CHALMERS, 175 PSI/D&S, 18 PSI EXHAUST, 480 VOLTS
                                                                           901
750 KW G.E., 410 PSI/600° F, 150 PSI EXHAUST, 480 VOLTS
                                                                           101
750 KW TERRY, 150 PSI, 5 PSI EXHAUST, 2300 VOLTS
                                                                           914
```

101

300 KW TERRY, 200 PSI/500° F, 20 PSI EXHAUST, 480 VOLTS

NON-CONDENSING SINGLE EXTRACTION

40,000 KW G.E., 1250 PSI/925° F, 475 PSI EXTRACTION, 13,800 VOLTS 40,000 KW G.E., 1250 PSI/900° F, 165 PSI EXTRACTION, 20 PSI EXHAUST,	908 910
13,800 VOLTS	310
25,000 KW WESTINGHOUSE, 1250 PSI/950° F, 350 PSI EXTRACTION, 180 PSI	914
EXHAUST, 11,000 VOLTS 10,000 KW G.E., 400 PSI/600° F, 140 PSI EXTRACTION, 60 PSI	003
EXHAUST, 13,800 VOLTS	903
7.500 KW G.E., 435 PSI/750° F, 100 PSI EXTRACTION, 15 PSI EXHAUST, 2300	102
VOLTS	102
7,500 kW G.E., 410 PSI/650° F, 250 PSI EXTRACTION, 45/60 PSI EXHAUST,	903
2400 VOLTS	
5,000 KW WESTINGHOUSE, 825 PSI/750° F, 400 PSI EXTRACTION, 140 PSI	915
EXHAUST, 2300 VOLTS	
5,000 KW WESTINGHOUSE, 725 PSI/750° F, 225 PSI EXTRACTION, 15 PSI	9 0 3
EXHAUST, 13,800 VOLTS	
5,000 KW G.E., 400 PSI/650° F, 150 PSI EXTRACTION, 60 PSI EXHAUST,	903
2400 VOLTS	003
3,500 RW G.E., 400 PSI/545° F, 50 PSI EXTRACTION, 5 PSI EXHAUST,	903
2400/4160 VOLTS 2.500 KW WESTINGHOUSE, 550 PSI/750° F, 210 PSI EXTRACTION, 10 PSI	903
EXHAUST, 2400 VOLTS	703
LAMBOUL ATOU TOULO	

NON-CONDENSING DOUBLE EXTRACTION

5,000 KW G.E., 650 PSI/750° F, 150/50 PSI EXTRACTION, 5 PSI EXHAUST, 2300/4000 VOLTS	102
4,000 KW WESTINGHOUSE, 215 PSI/525° F, 60/10 PSI EXTRACTION	904
3,500 KW G.E., 650 PSI/750° F, 150/50 PSI EXTRACTION, 5-10 PSI EXHAUST,	, , ,
2300/4000 VOLTS (2 AVAIL) .	

PUMPS, BOILER PEED

225,000 PPH, 1021 PSI, PACIFIC, 500 HP MOTOR DRIVE (2 AVAIL)	1027
840 GPM, INGERSOL RAND, 46 HP TURBINE DRIVE (2 AVAIL)	103
710 GPM/330 FT. HEAD, INGERSOL RAND, 65 HP TURBINE DRIVE	103
290 GPM/900 FT. HEAD, WORTHINGTON	103
285 GPM/1900 FT. HEAD, WORTHINGTON, 6 STAGE, TURBINE DRIVE	103
250 GPM/2000 FT. HEAD, WORTHINGTON, 6 STAGE	103

PUMPS, CENTRIPUGAL

1,500 GPM/310 FT. HEAD,	INGERSOL RA	ND, 80 HP TURBINE DRIVE	103
1,150 GPM/4220 FT HEAD,	INGERSOL RA	AND, 8 STAGE, 1750 HP MOTOR DRIVE	914
(3 AVAIL)			
1,078 GPM/278 FT. HEAD,	BINGHAM, 60	HP TURBINE DRIVE	103

REPRICERATION

2,000 TON YORK OM-2060 LIQUID CHILLER, 2075 HP MURRAY TURBINE (2 AVAIL) 103

SPEED REDUCERS

2,250 HP FALK, 4.4 RATIO, 1.5 S.F., INPUT 720 RPM, OUTPUT 163 RPM	903
1,700 HP PACIFIC WESTERN, 10.946 RATIO, INPUT 3600 RPM, OUTPUT 329 RPM	904
1,375 HP FARRELL, 13.01 RATIO, 1.5 S.F., INPUT 3600 RPM, OUTPUT 277 RPM	904
1,000 HP LUFKIN, 13.36 RATIO, 2.47 S.F., INPUT 3600 RPM, OUTPUT 270 RPM	904
1,000 HP WESTINGHOUSE, 3.364 RATIO, 2.54 S.F., INPUT 300 RPM, OUTPUT	904
89 RPM	
600 HP WESTERN, 7.091 RATIO, 2.0 S.F., INPUT 7091 RPM, OUTPUT 1000 RPM	915
(2 AVAIL)	" 4
300 HP FALK, 110.06 RATIO, 3.75 S.F., INPUT 1200 RPM, OUTPUT 11 RPM	904

TURBINES

1,300 HP TERRY, 850 PSI/850° F, 110 PSI EXHAUST, 3570 RPM, SOLID WHEEL	912
TYPE	
1,000 KW G.E., 410 PSI/600° F, 3600 RPM	102
750 HP WESTINGHOUSE, 850 PSI/950° F, 110 PSI EXHAUST, 3550 RPM (2 AVAIL)	912
510 HP COPPUS, 140 PSI SAT, 15 PSI EXHAUST, 4000 RPM, UNUSED	915
300 HP TERRY, 150 PSI/450° F, 20 PSI EXHAUST, 3500 RPM	91C
264 HP WESTINGHOUSE, 850 PSI/950° F, 110 PSI EXHAUST, 3500 RPM (3 AVAIL)	912

APPENDIX F

Fluidized Bed Combustion (Signal Energy Systems Letter/ Power Magazine Reprint)



Signal Energy Systems, Inc.

CORPORATE OFFICE
Liberty Lane
Hampton, New Hampshire 03842

Telephone 603-926-5911

Salt Lake International Center Lakeside Plaze 2—Suite 275 P.O. Box 535206 Salt Lake City, Utah 84116-6206 Telephone 801-531-6193

April 23, 1985

Chuck Hawley HAWLEY RESOURCE GROUP 7011 Old Seward Highway Anchorage, AK 99502

SUBJECT: Fluidized Bed Combustion

Dear Chuck:

In response to your questions concerning the potential use of fluidized bed combustors (FBC's) as steam generators to produce electrical power and steam for district heating and/or process use in Alaska, I am enclosing the attachments listed below. Kindly excuse my delay in responding, but from some attachments you will see current dates for information that might shed more light on some of your concerns.

Attachment A: Your letter of March 1, 1984 accompanied by Ralph Stefano's

letter of opinion.

Attachment 8: A brochure and some bulletins from one FBC supplier

(Keeler/Dorr-Oliver, a SOHIO Company).

Attachment C: An "Experience Summary of FBC by USA Vendors Only."

Attachment D: A special report from Power magazine re: "Fluidized-Bed

Boilers Achieve Commercial Status Worldwide, Feb. 1985.

Attachment E: "Preliminary AFBC Boiler Vendor Comparison"

Attachment F: "AFBC Boiler Design Variable (Cause) vs. Effect Matrix."

The five (5) general advantages of FBC versus conventional coal-fired boilers cited by Mr. Stefano are essentially correct and could be expanded upon as given below:

- Greater Fuel Flexibility (High or Low Grade)
 - Propane
 - Natural Gas
 - Alcohol
 - -011 (#2 #6)
 - Wood (Bark, Sawdust or Chips)
 - Peat
 - Lignite
 - Coal (Coarse or Pulverized)
 - Coal Refuse (Gob and Culm)
 - Petroleum Coke
 - Hazardous Wastes



- Improved Operating Characteristics
 - Industrial Size Scale (Up to 100 MWe)
 - Small Rather than Pulverized Feedstock (Less Preparation and Crushing)
 - Smaller Size Combustion Chamber
 - Better Turndown Load Response/Control
 - High Heat Transfer Rate
 - Higher Carbon Burnout (90%)
 - Increased Boiler Efficiency (by 2% to 4%)
- Reduced Maintenance Requirements
 - No Refractories in the Combustion Chamber (for waterwall types)
 - No Flue Gas Desulfurization (FGD) Equipment
- Improved Emissions Control
 - SO, Reduction 90% During Combustion
 - Low NO Emissions (0.6 Lb./MMBtu)
 - No Limê Slaking and Scrubbing Required
- Easier Disposal of Solid Wastes
 - No Fouling or Slagging
 - No Sludge
 - Waste Disposal Entirely Dry
- Reduced Capital and Operating & Maintenance Costs (from a combined effect of the above)

Of the three (3) general disadvantages of FBC in comparison to conventional units outlined by Mr. Stefano, we respectfully submit the following comments:

- Fuel and sorbent feed systems vary considerably by FBC manufacturer/design. Overall, there is relatively minor difference up to the point
 of placement of these materials into the boiler day bins. Following
 that point it appears that FBC is less complex because:
 - a. Pulverizing is not required (FBC's accept coarse particle size distributions).
 - b. Pneumatic feed systems (using eductors) have few moving parts and have exhibited over 8,000 hours of continuous operation without pluggage or appreciable wear.
 - c. The mechanical feed systems usually employ helical screw conveyors to meter input and are of long standing design and reliability.



The number of feed points varies by vendor design.

- "Chemistry in the fuel bed is critical" is a statement of fact, but not a disadvantage. Rather, it is an advantage because today's FBC instruments and controls use varying feed rates to sense, monitor and maintain emissions to a more stringent level than conventional combustors.
- 3. "[Tube] Erosion in the bed can [could] be serious" is a statement of fact, but not necessarily a disadvantage for all FBC designs. On a comparative basis, the wear and tear experienced on conventional stoker-fed boilers (grate mechanisms) can be equally serious.

Probably the single most concerning disadvantage to FBC's is the limited number of operating installations fueled with coal and the data related to operations and maintenance in the USA (Refer to Attachment C). However, the firms who have accepted the orders to provide the FBC's are of considerable substance and obviously have the confidence of their clients.

As far as environmental compliance goes, the FBC's have been declared to be the Best Available Control Technology (BACT) in California which has the most stringent regulations. Compliance to federal requirements that govern Alaska would be assured using FBC.

Signal Energy Systems has become very knowledgeable in FBC technology and is currently in the development stage for several projects fueled by coal and coal wastes (refuse coal material or RCM to energy). In full commitment to this method of combustion, on April 1, 1985, The Signal Companies acquired Combustion Power Company, Inc., an engineering firm specializing in FBC's. Within a few weeks, we shall be proposing a coal-fired FBC system to provide power, steam and high temperature hot water to support Cominco's Red Dog project. This proposal is being tendered as an alternative to diesel generation; and, as you know the site is about 100 miles inside the Arctic Circle. That would pretty much state our opinion and we would encourage you to consider FBC. If your specific project requires someone to design, finance, build, own and operate it, Signal Energy Systems would be most willing to become involved. Please do not hesitate to contact us if we can be of assistance.

Warm regards.

Sincerely

Robert S. Pringle Project Manager

RSP/mas

enclosures

cc: Chris Sauer/File

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EXPERIENCE SUMMARY ATMOSPHERIC FLUIDIZED BED COMBUSTORS (FBC)

FUELED BY COAL OR COAL WASTE

(U.S.A. YENDORS ONLY)

April. 1985

, L

Vendor	(All Fue	ls) Overall	Caal .	or Coal-Waste * 4	0,000 pph	Notes
	Sold	Operating	Total/wSO2	Operating/wSO2	Op. Hrs./wSa	nuces
Babcock & Wilcox	2	1	1/1	1/1	6000/6000	
Combustion Engineering Lurgi	3	1	3/3(?) 3/ND	1(?)/1 1/ND	ND ND	MD=Mo Data
Combustion Power Co.	5	1	1/1	٥	0	
Dedert	5	2	٥	Ď	0	
Deltak	٥	0	0	0	0	
Energy Products of Idaho	21	20	1/0	1/0	RD	
Fluidyne Engineering Corp.	1	1	1/0(?)	1/0(?)	ND	
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Keeler-Dorr Oliver	7	2	5/4	1/0	3000/0	
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Pyropower Ahlstrom	6 11	1 9	6/S+(?) 7/ND	1/? 5/ND	КО Фи	
Riley Stoker Corp.	1	0	1/1	0	0	
Solids Circulation Systems	1	٥	٥	٥	0	
Stone Johnston Corp.	14	14	5/0+(?)	5/0+(?)	25,000/0+	
Struthers Wells Corp.	2	2	1/1	1/1	ND	
Wormser Engineering, Inc.	3	1	3/3	1/1	8300/8300	
York-Shipley Inc.	17	17	0	0	0	
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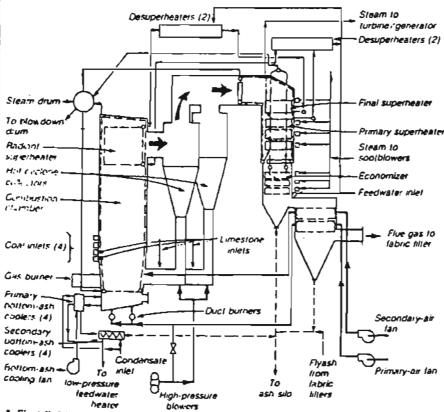
- 1. This tabulation includes AFBC boiler vendors based in the U.S. or who have sold boilers in the U.S. Also included are companies affiliated with the above, indicated by single spacing.
- 2. Tabulation includes boiler demonstration plants, but not pilot plants.
- 3. The unit count excludes duplicate boilers at the same site.
- 4. Operating units include those which have discontinued operation.
- 5. Operation cutoff 1s 9/30/84.
- Tabulation has no intentional exclusions, but may not be completely correct. Data has been gathered from trade journals, not vendors.

Special Report

Fluidized-bed boilers achieve commercial status worldwide

US electric utilities give atmospheric fluidized-bed technology their blessing by investing in three demonstration projects employing the world's largest such boilers. Confident industrials are ordering units for process-steam and cogeneration service, several with ratings above 200,000 lb/hr on difficult fuels

By Bob Schwieger, Editor-in-Chief



 First fluidized-bed boiler built for central-station service, rated 925,000 lb/hr at 1510 psig. 1005F, will be installed by Colorado-Ute Electric Assn Inc.

Imospheric fluidized-bed (AFB) technology for steam and electric generation got a big boost last year when three electric utilities-Colorado-Ute Electric Assn Inc. Northern States Power Co, and Tennessee Valley Authority-and their partners committed more than \$300-million to the construction of three demonstration plants, ranging in size from 100 to 160 MW. The vote of confidence by US utilities, traditionally among the most demanding companies when it comes to adopting new technology, means to many industry observers that AFB boilers are truly commercial.

Perhaps the most surprising aspect of the rapid commercialization of the fluidized-bed boiler—the first successful coal-fired watertube unit, a bubbling-bed steam generator, began operation at Georgetown University only six years ago—is industry's fascination with circulating fluidized-bed (CFB) systems.

Though only two CFBs are now operational in this country-at Gulf Oil Exploration & Production Co. Bakersfield, Calif. and Conoco Inc. Uvalde. Tex, each rated 50,000 lb/hr-and their service time is somewhat lacking because of cutbacks in oil-field production, US companies recently have ordered at least eight such boilers rated more than 400,000 lb/hr each and several others capable of producing more than 100,000 lb/hr (see tables, pp S-6, S-10, and S-14). When one considers that CFBs operating overseas (the largest is 270,000 lb/hr) have relatively little experience burning coal, the primary fuel here, the investment in them appears even more surprising to some industrial sources.

However, the general consensus among knowledgeable engineers is that CFBs certainly are worthy of the attention they're getting. These boilers typically operate at higher combustion efficiencies and at lower excess-air levels than the more familiar bubbling-bed steam generators (POWER special report, Fluidized-bed builers, August 1982). CFBs also have more forgiving sucl-seed systems, typically require less timestone for SO, capture, and usually are more easily adaptable to staged-combustion techniques for NO, control than bubbling beds.

US interest in the CFB, nurtured primarily by Pyropower Corp, probably was not anticipated by the traditional boiler manufacturers. Babcock & Wilcox Co. Combustion Engineering Inc. and Riley Stoker Corp each now offer CFB boilers under license or in cooperation with overseas manufacturers (see table, pp S-2 and S-4). And even though Keel-

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er/Dorr-Oliver Boiler Co sells CFBs of its own design, the company was not actively publicizing this aspect of its business before selling six units to Archer Daniels Midland Co for plants in Iowa and Illinois. Foster Wheeler Energy Corp also recently announced plans to offer CFBs of its design.

First utility CFB boiler

Colorado-Ute is installing the nation's first utility CFB steam generator (Fig 1) at its Nucla generating station, located in the western part of Montrose County, as part of a major life-extension project

which will (1) increase plant capacity from its present to MW to 110 MW, for an investment of \$2407kW. 2) improve net station heat rate by 15%. 31 allow a reduction in fuel cost of about 30%, and (4) reduce emissions.

Participants in the \$86-ms. Son project that are sharing unite of the financial risks with the utility include hollermaker Pyropower, architect/engineer Steams Catalytic World Corp, fuel sumplier Peabody Coal Corp, and turbine generater manufacturer. Westinghouse Electric Corp. The Electric Power Research Institute (EPRI) and National Runs

Electric Cooperative Assn also are contributing to the project.

The upgrading effort, scheduled for completion in 1986, essentially consists of replacing three stoker-fired steam generators with one 925,000-lb/hr (at 1510 psig/1005F) CFB boiler and adding a new turbine to produce 75 MW and extraction steam to power the three existing 12-MW turbine/generators 1600-psig/825F inlet conditions), which will be retained.

The utility evaluated several types of steam generators for the Nucla project, selecting the CFB unit on the basis of

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cont. efficiency, and its ability to fire low-grade local fuels while satisfying stringent emissions criteria. A high-ash cual will be burned.

Nucla's new boiler will be the largest CIB steam generator in the world when it goes into service, as well as the world's largest fluidized-bed boiler of any type built new from the ground up. It works this way: High-velocity air fluidizes coul-and limestone bed material for 50, capture—in the combustion chamber, transporting the solids with high turbulence up the full height of the Saler-vooled structure. After releasing

heat to the membrane waterwalls and radiant superheater, the particulate-laden combustion gases flow into the hot cyclones, as shown in the figure.

Solids, including unused limestone and unburned fue), are returned to the combustion chamber via a nonmechanical loop seal to mix with fresh fuel and sorbent; flue gas flows through the convective heat-transfer sections, air heater. fabric filters, and out the stack. The long furnace retention time for the fuel and limestone, and the continuous circulation of them, ensure high combustion and SO,-removal efficiencies.

The lower section of the combustion chamber includes an air-distribution grid and bottom-ash removal system. Approximately half of the heat released in the furnace at full load is transferred to the waterwalls and radiant superheater, remainder to the convective superheater, economizer, and air heater. The convective pass, typical of those in most solidfuel-fired boilers, includes ash-removal equipment and provision for sootblowers, if required. Finally, note that primary air is supplied to the windbox below the air-distribution grid and provides the initial fluidization; addition of secondary

Major	US	firms	extend	their	capabilities
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air in the furnace gives a staged-combustion effect, maximizing carbon burnout and minimizing NO, production.

Fuel-feed system provides for eight hours of raw coal storage; storage capacity of crushed (1000-micron) limestone is 24 hours.

Expected stack emissions from the upgraded plant are these; 117 tons/yr of particulates, 1948 tons/yr of NO, and 1559 tons/yr of SO1. The original plant emitted greater quantities of pollutants while delivering only one-third the power of the new system. Those numbers: 204 tons/yr of particulates, 911 tons/yr of

NOs and 2826 tons/yr of SOs emissions. Confidence in the CFB boiler's ability to remove SO, while operating efficiently comes from a wealth of test data. To illustrate: When burning 1/4 in. × 0 Ohio

No. 6 coal (5.14% sulfur, 13.4% ash. 12,520 Btu/lb), using 100-300-micron Lowellville limestone (93% calcium carbonate, 1.6% magnesium carbonate) as the sorbent, and operating with a 1525F combustion temperature and 8.5% excess air, 50, retention was 92% at a calciumto-sulfur ratio of 1.4; combustion efficiency, 99.2%. For a low-grade Braziliun coal (1.4% sulfur, 46.9% ash), a 1580F

combustion temperature, and a CaiS ratio of 0.6, sulfur retention was 79.6% (some SO, being captured by the ash); combustion efficiency, 98,9%.

Largest AFB project

The fluidized-bed retrofit of the nonreheat Unit 2 boiler at Northern States Power Co's Black Dog generating plant, located only 15 miles south of downtown Minneapolis, differs from the Nucla project in several respects. The most important: An AFB combustor of the bubbling-bed type will be installed in an existing pulverized-coal-fired boiler after

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demolition of part of that unit's lurnace and convection pass. Through the conversion effort, the utility expects to find a technical and cost-effective basis for responding to the acid-rain issue in the upper Midwest. In addition, NSP hopes to satisfactorily demonstrate its ability to achieve a higher unit capability and availability and to extend the life of an existing unit.

EPRI, which partially funded economic seasibility studies, has considerable interest in the project. It claims that more than 200 units, built between 1945 and 1965, with a total capacity in excess of 20,000 MW, are potential candidates for conversion to AFB combustion.

Foster Wheeler Energy Corp, supplier of the fluidized-bed system, began demolition work on Unit 2 last September under the direction of the utility and its architect/engineer, Stone & Webster Engineering Corp. When the refurbished boiler produces steam in the spring of 1986, it will be the largest AFB unit in the world. More important, Black Dog 2 will (1) be able to generate 40 MW more than it can now, (2) operate for 25 more years, (3) emit less pollutants, and (4) burn a wider range of fuels than currently possible. NSP's confidence in the \$50million project - or about \$400/kW. one-third the price of new capacitystems from the success of its fluidizedbed retrofit of the stoker-fired French Island plant, described in POWER's 1982 report referenced earlier.

Like other utilities, NSP has suffered from generating capability lost as a result of environmental regulations. The AFB retrofit will allow the 1954-vintage. 100-MW Unit 2, detated to 85 MW because of a mandated shift to a mixture of Illinois and low-sulfur western coals. to produce 125 MW while reducing SO,

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emissions by up to 80%, cutting NO, emissions by up to 50%, and decreasing particulate discharges to 0.03 lb/million Btu—the last a provision of the current new-source performance standards. The turbine/generator and auxiliary systems must, of course, also be upgraded to achieve the higher unit rating.

The original boiler for Unit 2 was designed to produce 860,000 lb/hr of 1770-psig/1000F steam; the re-equipped steam generator will deliver 1.04-million lb/hr at 1525 psig/1000F when firing the difficult Sarpy Creek (Mont) coal. This low-sulfur (0.9-1.2%), high-alkalifuel, noted for the fouling and slagging problems it causes, has been test-fired at French Island with favorable results. Tests to select the most cost-effective sorbent continue.

Design limitations of the existing boiler and NSP's desire to increase the unit rating created some job-specific requirements necessary to facilitate the conversion (Fig 2). These should be expected on any retrofit project of this type. At Black Dog they included:

A maximum 10-ft/sec bed superficial velocity to minimize carryover of unburned coal and unreacted limestone. The limit essentially reduces the recycle rate to levels approaching those used on stoker-fired boilers. It was necessary to do this at Black Dog because of a 50-ft/sec maximum allowable gas velocity in the convection section at the maximum continuous rating (MCR) of the unit, and because of the need to restrict flue-gas particulate loadings to levels acceptable to existing precipitators with minimal upgrading.

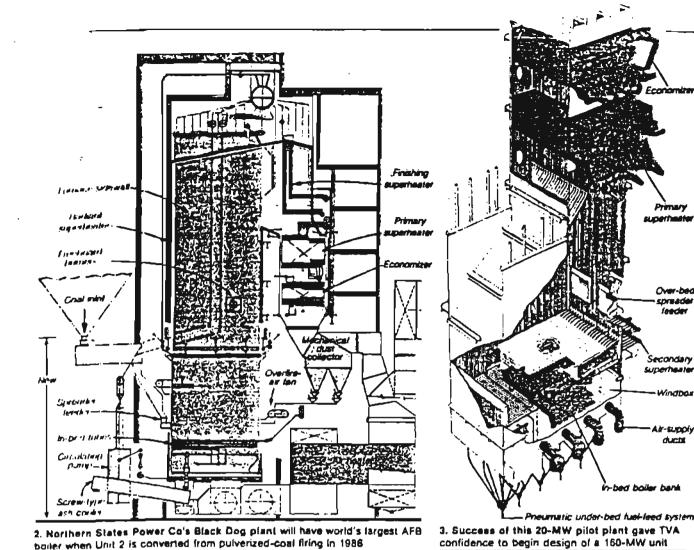
Addition of a multi-cyclone dust collector between the boiler outlet and air-heater inlet to allow recycle of highcarbon-content flyash and to reduce the dust loading at the precipitator inlet. Use of an over-bed (spreader stoker) coal and limestone feed system. Overfire-air ports will be located above coal-feeder inlets to the furnace to disperse the incoming coal fines from the feeder discharge area.

Replacement of the two existing air heaters with a single, low-leakage regenerative unit capable of handling the higher pressure drops, flows, and particulate-loading requirements of the retro-

Installation of new forced-draft fans and modifications to the existing induced-draft fans to satisfy the higher static-head and flow requirements of the

AFB system.

Use of a circumferential seal around the furnace to accommodate the differential thermal expansion where the existing furnace and the new fluidized-bed system are joined. The seal is a combination water/mechanical and slip-joint



extracerment, with the furnace-gas-side

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Provision for the injection of a flucgas conditioning agent in case one is required later to facilitate dust collection by the precipitator.

Reinforcement of existing boiler. and precipitator gas-xide pressure casmy and of flue-gas and air ducts.

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The Tennessee Valley Authority took its first step toward a utility-scale demanstration of fluidized-bed technology by constructing a \$68-million, 20-MW pilot plant at the utility's Shawnee steam plant in Paducah, Ky (Fig 3). The unit has operated for well over 8500 hours since the first coul fire in May 1982.

I nomaped by progress in the developinion of the AFB process over the last few years. IVA, in cooperation with I PRI, the state of Kentucky, Duke Power Co Combustion Engineering Inc. and others, is designing a bubbling-bed boiler for Shawner capable of providing sufficient cleam to the existing Unit 10 turhighe principles to produce 160 MW. Completion of the \$220-million project (a follow-on test and evaluation program are included in the cost) is expected in

Pilot-plant results indicate that 90% SO₂ retention is possible using under-bed fuel and limestone feed with a Ca:S ratio of 2.0 to 2.5 and a recycle ratio of 2.0 to 2.5 (1b solids recycled to 1b new fuel added to the combustion chamber). Only eight years ago, the predicted Ca:S ratio was about 5 to achieve 90% SO, removal (without recycle). Results with over-bed feed—the TVA pilot plant has both under-bed and over-bed feed systemsshow the same positive trends; however, overall boiler performance is not as good as when the under-bed feed system is used. When fuel is fed from over the bed, fines content must be tightly controlled to achieve the 97% combustion efficiency typically possible with under-bed injection.

Similar improvements in the control of NO, emissions also have been observed. To illustrate: Data from Monongahela Power Co's 300,000-1b/hr Rivesville (WVa) demonstration unit (no longer operating) produced 0.6 lb NO,/million

Btu. The TVA pilot plant has operated at NO, levels below environmental limits for all conditions tested and, at the expected 3% excess-O₂ operating level. emissions are less than 0.25 lb/million

ducts

Regarding equipment and component performance, the 20-MW-unit tests revealed the following:

- The relatively simple over-bed feed system operated at a high availability in approximately 1000 hours of testing, However, consistent fuel sizing was not possible and a special feed-preparation and -handling system would be necessary to control fines.
- Reliability of the original under-bod feed system was not satisfactory. Plugging caused by high moisture and large particles, and erosion of the feed pump and supply lines, were among the problems. Redesign of the system, use of wear-resistant materials, lower transport velocities, and other changes have since improved reliability considerably.
- Corrosion and crosion of in-bed tubes and tube supports have been within acceptable limits. Wear associated with the SA-210-A1 in-bed evaporator bun-

Small boilers-watertube, firetube, and c

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 10 Serboux pariety use u 6 m. 12 16 mest. burcton min.

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- 21 Congress for future appropriate at 625 page 22 Per cell 23 -50% of last loss than % at
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- 27 Ignified firsten, which is, not it from consisting bod prison but at his many than all embers of consisting for the payment privace in the manufacturers. 28 High recycle rates of so in 1.1 (b salely recycle obsess
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 18 This records med. It displayed to the lens, began consequently and to the lens, began consequently appearance or October 1982. Indeeth Sept. 30, 1984, it had 10,000 hores of operation and an enablasting of 965.

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- 19 And preference (ed.) and to the master, and grait
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- 37 the to 70 m.
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die, SA-213 superheater tubes, and TR-304H tube supports are monitored at 500-hr intervals.

Plans for the 160-MW unit call for a balanced-draft, drum-type, bubbling-bed boiler to supply 1800-psig/1000F main steam to the existing high-pressure turbine and 450-psig/1000F reheat steam to the low-pressure turbine from the combustion of high-sulfur bituminous coal. An expansion joint in the freeboard section will allow a combination top- and bottom-supported unit, like Black Dog Unit 2. Fuel and sorbent feed will be from under the bed.

Bear in mind that an under-bed feed system is a virtual necessity for utility-size boilers designed with a single bubbling bed (an alternative could be the use of multiple stacked beds). Here's why: Over-bed feeders require a long, narrow furnace to ensure good fuel distribution from spreader stokers, which are limited

in their throwing distance. Thus, the furnace for a 160-MW, single-bed unit would have to be about 70 × 36 ft in plan. A 500-MW unit would be half a football field in length or longer. Use of an under-bed feed system, by contrast, allows an evenly distributed flow of coal and limestone to a furnace of any dimension, so a more economical shape can be used.

The feed system being considered by TVA, jointly designed by Combustion Engineering and Power Recovery Systems Inc. is a modified version of what the now-defunct Energy Resources Co installed in Texas Tar Sands Ltd's bubbling-bed boiler. PRS purchased the fluidized-bed division of ERCO when it went bankrupt. The system, illustrated in Fig 4, uses a crusher/dryer to prepare the coal to these key specifications: 1/2 in. × 0, less than 6% surface moisture. The second condition can be achieved com-

fortably as long as the surface moisture in the raw coal is 16% or less.

Prepared coal and limestone, stored separately, are fed from their respective silos through a system of pressure and gravimetric feeders and charging hoppers - where they are mixed - to 12 fuel distributors, so-called bottles. The enlarged view of a bottle in the illustration shows that it is a fluidized feeder with a central inlet and 10 21/2-in.-diameter outlet fuel lines arranged concentrically around the inlet. The fuel-transport blowers pressurize the bottles to between 3.5 and 4 psig, enough to transport the coal/sorbent mixture to the furnace. The fluidizing velocity is 10 ft/sec. Designers say a bottle is analogous to a burner and that turndown of a fluidized-bed boiler using such a system is accomplished in the same way as load reduction on a pulverized-coat-fired unit.

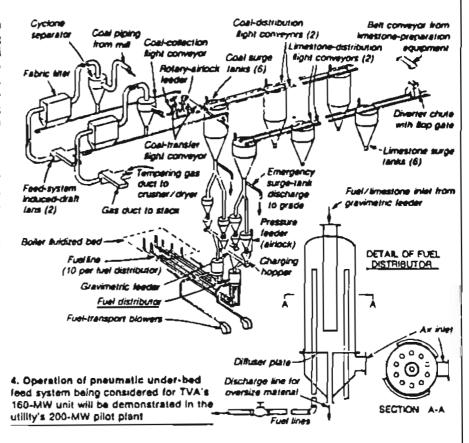
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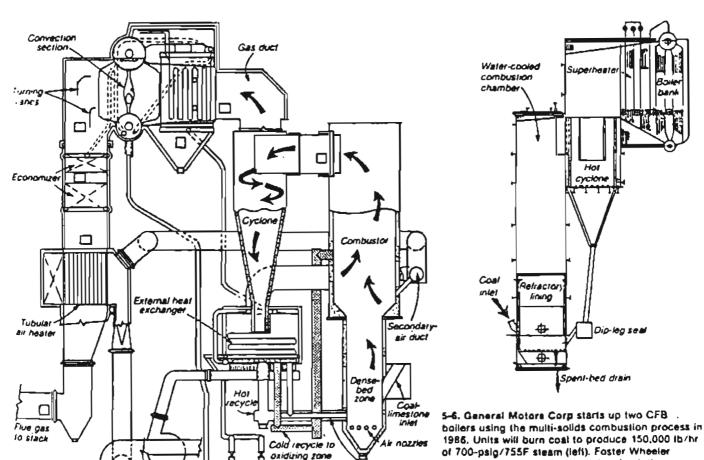
its bed divided into six firing zones each with two bottles, or 20 fuel lines, serving an area of about 400 ft². Plugging of feed lines caused by excessive surface moisture is not expected to be a problem. A rule of thumb that comes from pilot-plant experience says that you won't plug the feed system if coal flows freely from storage silos.

Overseas developments

The largest fluidized-bed boiler under construction outside the US reportedly is the CFB Lurgi GmbH is building for the West German city of Duisburg. When operation begins late this year, it will have the capability to produce up to 140 MW of district heat together with 70 MW of electric power and have the flexibility to generate up to 100 MW when no district heat is needed. In the optimum cogeneration mode, designers say, plant efficiency will exceed 90%.

Boiler for the reheat unit is sized to produce \$95,000 lb/hr of 2100psig/995F main steam. The water-cooled combustion chamber feeds hot solids via cyclone separators (arrangement of combustor and cyclones is similar to that at Nucla station) to two fluidized-bed heat





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recently announced plans to offer circulating

fluidized-bed boilers of its design (above)

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exchangers arranged in parallel. These external heat exchangers (EHX) allow independent control of superheat and reheat temperatures. The dust collector is a hot electrostatic precipitator.

One advantage of having an external heat exchanger in a CFB is that it can easily compensate for variations in combustor heat absorption caused by changes in fuel properties and load conditions - that is, heat absorption in the EHX is increased when combustor absorption drops and vice versa. Thus, it is possible to maintain the optimum level of combustor performance at all times.

An EHX essentially is a refractorylined box containing an air-distribution grid and an immersed tube bundle designed to cool hot solids delivered by the cyclone and then return them to the combustor. Fluidizing velocity is low (less than 3 st/sec), solids density and heat-transfer coefficients very high. There is virtually no combustion in the EHX because the solids being recycled

contain little carbon. Erosion/corrosion in the immersed tube bundle is not a consideration because of the low fluidizing velocity and the low level of combuslion

To compete against CFB systems, Deutsche Babcock AG (DB), West Germany's largest boiler manufacturer, is offering high-recycle-rate bubbling-bed systems in sizes up to 250 MW (electric rating), designed to meet the stringent new federal standards for SO, and NO, control while economizing surbent and achieving combustion efficiencies comparable to those offered by pulverizedcoal firing. External recirculation rates range from 10 to 15 lb of solids recycle per 16 of fuel added. DB engineers say the bubbling bed is less expensive to build and operate than CFBs for utility boilers of comparable size.

Such high recirculation rates, while improving SO, capture and carbon burnout, also cool the bed, reducing the amount of in-bed surface required to

maintain the optimum temperature for SO, and NO, control. Decreasing the amount of heat absorption in the bed was a DB design objective. The company has had its share of crosion problems, primarily in the Atlas Consolidated Mining & Development Corp units, located in the Philippines. Erosion there was corrected by replacing the original in-bed bundle with expensive square tubes (production tubes that in cross section resemble square bar stock with a hole drilled in the middle). These tubes are welded together, one over the other, in stacks of four.

Recent studies conducted by the manufacturer indicate that the most economical way to avoid erosion is to use refractory-covered waterwall sections as the in-bed heat-transfer surface. This way, the bubbling solids essentially impinge on only the refractory covering the lowest tube in the stack. Most of the heat released in the DB bubbling-bed steam. generator is captured in the convective

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Impact on cogeneration

Except for annoying erosion problems in a few AFB boilers with in-bed heattransfer surface, industrial fluidized-bed operating experience has been good, as indicated by the large number of new systems being installed. Predictions are that fluidized-bed steam generators will continue to capture a significant part of the industrial large-boiler market in the years ahead for two reasons:

First, the changing economics of cogeneration dictate increased use of low-grade fuels and industrial waste products for such projects to remain viable. AFB combustion systems are inherently capable of burning these low-cost sources of energy, as the tables show. Second, acid rain and other environmental issues mean even tighter controls on stack emissions in the future. The low combustion temperatures used in fluidized-bed boilers, and their ability to capture SO, during combustion, provides perhaps the most cost-effective control of NO, and SO, discharges for industrialsize units.

Industrial CFBs

Circulating fluidized-bed boilers generally are considered more economical than bubbling-bed units for industrial applications requiring more than 150,000-200,000 lb/hr of steam. For large units, the taller furnace characteristic of the CFB boiler offers better space utilization, greater fuel-particle and sorbent residence time for efficient combustion and SO, capture, and easier application of staged-combustion techniques for NO, control than bubbling-bed steam generators.

The most popular CFB designs among industrial users are the two described earlier: systems like Pyropower's at Nucla station that do not have an external heat exchanger and those like Lurgi's

at Duisburg that do. To date, the largest CFB unit ordered by industry is the 650,000-lb/hr boiler bought by Scott Paper Co for its Chester (Pa) plant. A joint effort of Combustion Engineering and Lurgi, it will have an EHX.

Another manufacturer offering CFBs with external heat exchangers is Riley Stoker Corp, which operates under a license from Battelle Development Corp. The two boilers incorporating Buttelle's multi-solid fluidized-bed combustion system recently sold to General Motors Corp differ from the CFB systems discussed thus far in that the lower part of the combustion chamber contains a dense bed of large particles of river rock which do not leave the combustor (Fig 5). Its role is to increase the residence time of the entrained bed of ash particles, fuel, and limestone in the combustor and to promote proper mixing of these constituents.

In the GM unit illustrated, note that the combustor has no heat-transfer surface. Combustion temperature is controlled under normal conditions to 1650F ±50 deg F by the reinjection of relatively evol ash, fuel, and limestone via ports in both the oxidizing and reducing zones of the combustor. Recycle of hot solids is used to increase the rexidence time of difficult-to-burn fuels—such as petroleum coke—and to allow fast startup of the system.

Foster Wheeler's new CFB (Fig 6) incorporates design features that have worked well in the company's bubbling-bed units. These include:

- A water-cooled plenum and grid plate to eliminate problems resulting from grid-plate leakage and to allow quick startup by in-plenum burners.
- A hot-recycle cyclone specially engineered for rapid startup and minimum refractory maintenance.
- Membrane waterwall surface extending the full length of the combustor.

Unit shown, with a two-drum boiler bank, is for pressures up to about 900 psig; a single-drum design would be used for higher pressures. Unit sizes extend up to 700,000 lb/hr.

Bubbling-bed boilers

Bubbling-bed steam generators come in a variety of designs—including water-tube, firetube, and combination water-tube/firetube types; units with single or dual beds, both shallow and deep, etc. Sizes runge from the smallest AFB boilers offered to the largest, as evidenced by TVA's commitment.

For capacities less than about 50,000 lb/hr, horizontal firetube designs generally are most economical, though vertical firetubes are appropriate for outputs below 10,000 lb/hr. Hybrid boilers, consisting of a watertube combustion chamber and firetube convection section, can extend the range of relatively low-cost construction up to about 90,000 lb/hr and increase the nominal 300-psig pressure limit on firetube boilers to 500 psig. Watertube AFB boilers generally are specified for outputs above about 50,000 lb/hr and for high pressures.

The price of bubbling-bed steam systems is dropping as experience builds and manufacturers can better predict performance and the cost of construction. In fact, you no longer have to pay a premium for the fuel flexibility and pollution control offered by AFB-boiler plants rated less than about 200,000 lb/hr. They can be had, from at least some manufacturers, for about the same price as an unscrubbed stoker-fired facility. Combustion-efficiency guarantees of 97-98% can be obtained when quality coals are burned.

Regarding absorption of SO₂, experience with good coals and practical limestones in bubbling-bed boilers indicates that about 80% retention is required to meet the commonly specified emissions standard of 1.2 lb SO₂/million Biu heat input. A rule of thumb is that a Ca:S ratio of 2 can achieve this level when operating in a steady-state condition with the bod temperature close to 1550F.

Limestone consumption at a Ca:S ratio of 2 is 6¼ lb/lb of sulfur in the coal. But, remember that because bed temperature and load are variable in most cases, the actual limestone supply must incorporate a moderate safety factor. Recycle, of course, improves sorbent utilization. The tabular material on pages S-8 and S-12 gives actual Ca:S ratios for key units. When reviewing this information, bear in mind that it was provided by the boiler manufacturer, not the user.

Availability data given on pages S-6 and S-10 indicate how fluidized-bed boilers are performing under actual industrial conditions. Unfortunately, most manufacturers completing Power's questionnaires did not have access to the necessary plant data or the plants were not keeping this information.

The first seven months of operating experience for the 120,000-lb/hr singlecell bubbling-bed boiler installed at Midwest Solvents Co. Pekin, Ill, illustrate just how far the technology has come in a few short years. The first coal fire in the unit was ignited last May, only 16 months after contract award. Through the end of November, availability of the unit was 93.3% with no forced outages. Operators consistently have been able to turn down the boiler to 25% of rated load and regularly have increased steam output by as much as 20,000 lb/hr over a 30-sec period without more than a 15-20-psi drop in outlet pressure. These load changes have been accomplished with the unit in automatic control.

Erosion of In-bed tubes is an area of concern in the design and operation of bubbling-bed boilers. Though the literature (Refs 13, 14, 15) reveals wear problems, many boilers operate with negligible erosion. Encouraging news on industry's ability to deal with crosion comes from Central Soya Co. Marion, Ohio, where a 40,000-bb/hr firetube unit went into service in April 1980.

By the end of 1981, after 6300 hours of operation, sidewall wear of up to 0,080 in, was noticed; weld-buildup and a metal-spray treatment were prescribed. After 10,400 hours, 12 in-bed tubes had to be replaced with Schedule 80 pipe. Only 4000 hours later, operators found

the original metal-spray coating worn away; a new coating was applied and wear fins made popular by the Chinese (Power, March 1983, p.59) were welded to the tubes. After another 10,000 hours, the tubes and fins have exhibited only some ninor metal loss.

References, suggested reading

- A M Manaker and P 8 West (TVA), Status of utility fluidized-bed commercial development, Coal Technology '64, Houston, November 1984
- 2 F.A. Heacock Jr., M.B. Devereux, and X.J. Heinachel (Goldrado-Ute Electric Assn. Inc), CF8 technology applied to life extension of Nuclagenerating station, John Power Generation Conference, Toronto, October 1984.
- 3 F Engström (A Ahlström Oy), Pyroflow Multifuel CFBC boiler with movement impact on the environment, Puidized Combustion Conference London, October 1984
- 4 J R Zyrkowski (Northern States Power Co), B C Krippene (Stone & Webster Engineering Corp), and R L Camble (Foster Wheeler Energy Corp), Emission reduction, capacity increase, and life extension through AFBC retroft, Joint Power Generation Conference, Toronto, October 1984
- 5 JW Bass III and M D High (TVA), Operating and performance summary for TVA's 20-MW AFBC priot plant, Fuldized Combustion Conference, London, October 1984
- 5 S Darling (Combustion Engineering Inc) and others, Advantages of the Lurgi/C-E CFB boxe in handling multiple tuels and varying load conditions, Coal Technology '84, Houston, November 1984.
- 7 L Capuano and K Atabay (Combustion Engineering Inc) and S A Fox (Lung Corp), CFB steam generation, Meeting of the Pacific Coast Electric Assn., San Francisco, March 1984
- The multi-solid fluidized-bed combustion process, Riley Stoker Corp. Worcester, Mass. October 1982
- 9 J.L. Cano (Instituto Mexicano del Petroleo) and t. S. Cohen (Solida Circulation Systems Inc), Solida circulation botter commercial plant, Coal Yachnology '84, Houston, November 1984
- 10 P Coast (Fives-Call Babcock), Latest operating experience with fluidized-bed combustion in Ignifiuld boilers, First International Pulidized-Bed-Combustion and Applied-Technology Symposium, Belling August 1983.
- Symposium, Beijing, August 1983
 11 J Highley (National Coal Board), Development of fluidized-bed combustion for industry, First International Fluidized-Bed-Combustion and Applied-Technology Symposium, Beijing, August 1983

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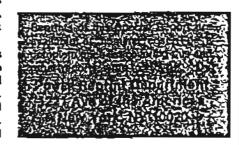
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- 12 M J Virr (Stone Johnston Corp), Operating experience with industrial packaged firetube FBC boilers, Fluidized Combustion Conference, London, October 1984.
- 13 J Stringer (EPRI) and A J Minchener (National Coal Board), Materials issues in the development of fluidized-bed combustion, Fuldized Combustion Conference, London, October 1984
- 14 H Kobro (Studsvik Energiteknik AB), A discussion of the operation and performance of a 2.5-MWt fast fluidized-bed combustor and a 16-MWt bubbling-bed combustor, Fluidized Combustion Conference, London, October 1984
- 15 B Lectner, B Anderson, and J Vijii (Chalmers University), Operational results from the 18-MWt FBB at the Chalmers University, Fluidized Combustion Conference, London, October 1984



				PREL ININARY	AFBC BOILE	R YENDOR C	OMPARISON .					April, 1985 Grant Brown	
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Sorbent Size	1/8 x 0	ND	ND	5/16X16a	1/8x16m	NAp	MD	ND	ND	MD	MD	NO	110, 1/810
Fuel Injection Method	018, 0v8, Un8	НΩ	KD	018*, Dv8, Un8	DvB	0v8	0v8	018	MD	OvB	018	013	D18
Circulation thru tubes	For	MD	ND	For	Nat	For	Nat	MAp	KAp	For	Hat	For	For

Pt - Peat

Sat - Saturated

Un8 - Under bed

Wt - Water tube

W - Wood, wood waste

Wst - Miscellaneous wastes

- Affiliated companies
- Typical

SYMBOLS: BN - Babcock & Wilcox Co.

CE - Combustion Engineering

LUR - Lurgi

CPC - Combustion Power Co.

FWC - Foster Wheeler Corp.
FML - Foster Wheeler Power Products Ltd.

KOO - Keeler/Dorr-Oliver

PYR - Pyropower

AHL - A. Ahlstrom Co.

RS - Riley Stoker Corp. SJC - Stone Johnston Corp.

SWC - Struthers Wells Corp.

WOR - Wormser Engineering, Inc.

8b - Bubbling bed

C - Coal, Coal waste Cb - Circulating bed 018 - Directly (nto bed

For - Forced circulation

Ft - Fire-tube

m - mesh

Nat - Natural circulation

MAp - Not applicable

ND - No data

NG - Natural Gas

0 - 011

Ov8 - Overbed

Pet. Ck. - Petroleum coke

PrN - Process wastes

NOTE:

1. Also municipal wastes, municipal sludges, tires, petroleum coke.

1.2

AFBC BOILER DESIGN VARIABLE (CAUSE) VS. EFFECT MATRIX

April, 1985 Grant Brown

DESIGN VARIABLE (CAUSE)	A. Combustion Efficiency	B. Heat Transfer	C. 50, Emissions	D. NO. Emissions	E. Particulate Loading	F. Bed Statering	6. Pluggage	H. Pipe Eroston	I. Tube Eroston	J. Fube Wastage	K. Tube Overheating	L. Warpage, Cracking	M. Turndown	N. Fluidizing Ability	0. Startup Time	P. Poor Air Distribution	Q. Scale-up Problems	R. Refractory Cracking	S. Heat Release Split	T. I In-bed Surface	U. Miscellaneous Mechanical	Problems
1. Soiler Pressure/Temperature		X	İ																	X		
2. Type Combustion System	X	X	X		X														X			
3. Bed Size																	X					
4. 8ed Arrangement													X				_					
5. Distribution Plate Type	X					X						X				X						
6. Air Introduction Method	X					X										X						
7. Fluidizing Velocity	X	X	X	X					X				X	X							\Box	
8. Excess Air	X		X.	X						X												
9. Bed Temp. Range	X	X	X	X		X							X	X								
10. Bed Depth	X		X																			\Box
11. Bed Differential Pressure																X					\Box	
12. Heat Release Split	X	X																		X		
13. Combustion Staging				X						X												
14. Freeboard Height	X		X	X	X																	
15. Load Control Method													X									
16. Fuel	X		X	X			X	X	X										X			
17. Fuel Size	X		X	X												,			X			
18. Fuel Introduction Method	X		X	X															X			
19. Recycle Amount	X		X		X				X													
20. Ash Introduction Method	X		X		X				X													
21. Sorbent			X																			
22. Sarbent Size			X																			
23. Sorbent Introduction Method			X																			
24. Ca:S Ratio			X																			
25. Startup Method																		X				
26. Bed Tube Design									X	X	X											
27. Material Handling Design								X													X	

APPENDIX G

Contents of Supplementary Volume*

- 1. Rotary Drill Hole Logs 1985 Field Program
- 2. Core Logs 1985 Field Program
- 3. Downhole Geophysics Logs 1985 Field Program
- 4. Surface Magnetic Survey Data
- 5. Plate G-1 -- Interpreted Magnetic Data of the Chicago Creek Area
- 6. Plate G-2 -- Overlay of G-1 -- 1983 and 1984 Magnetic Profiles
- 7. Plate G-3 -- Geologic Map of the Chicago Creek Area (1" = 1,320')

^{*}Supplementary material on file with the Alaska Division of Geological and Geophysical Surveys, Fairbanks.

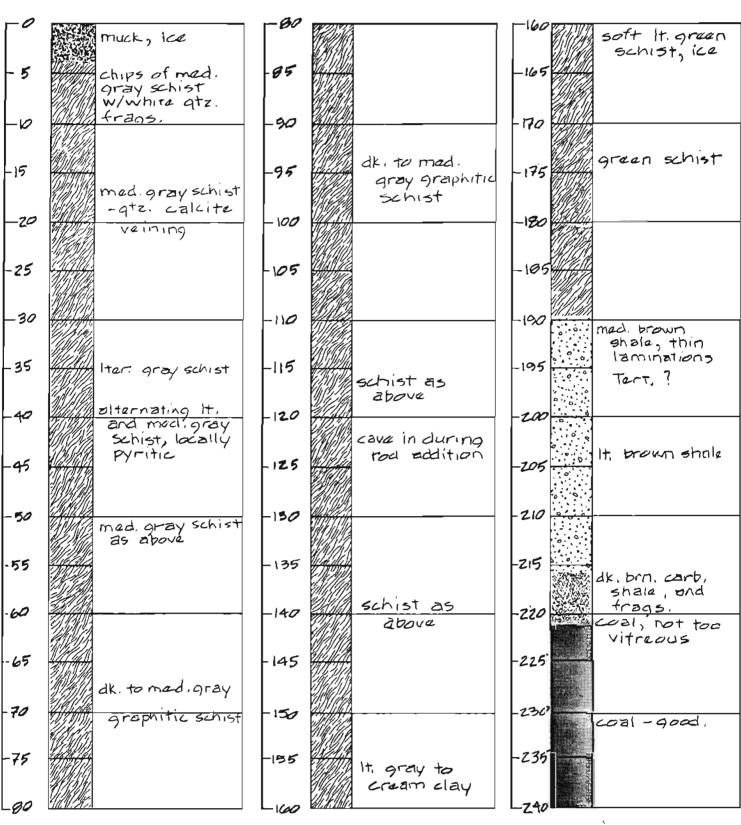
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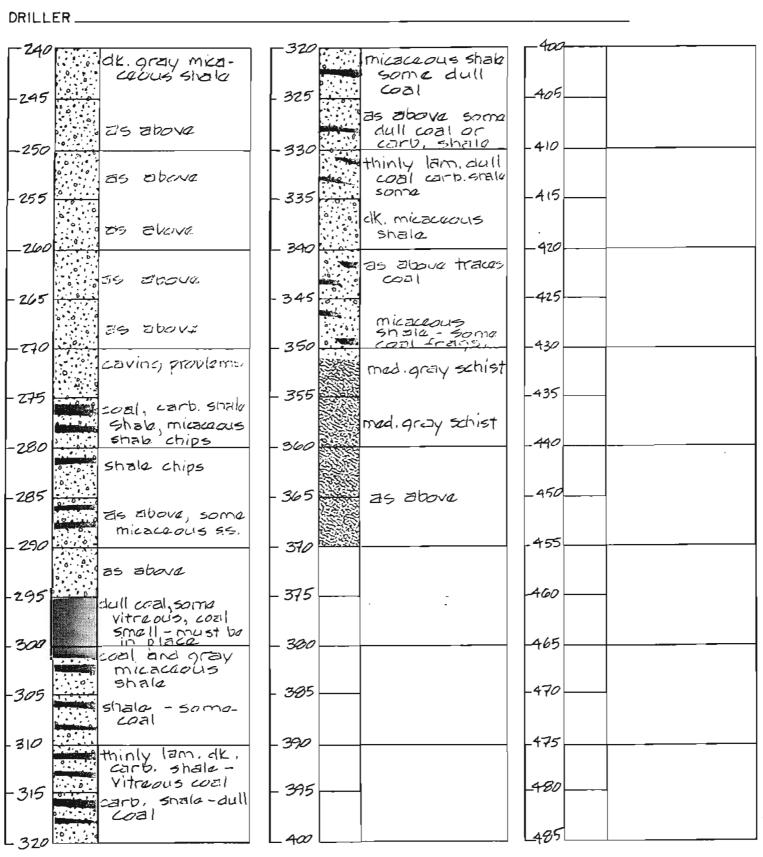
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-15 Interpretated and brown shale strains -16 Interpretated and brown shale strains -17 Interpretated and brown shale some measures some measures some measures some measures some measures some coal some coal some shale some coal shale shale shale shale shale some coal shale sha		lt. to med. brn.		مرد الرياد	as above
hole steems -40 -120 -120 -120 -120 -120 -120 -120 -121 -122 -123 -124 -125 -125 -126 -127 -128 -128 -129 -120	- 35		115		195
-40 -45 -45 -46 -47 -48 -48 -48 -49 -49 -49 -49 -49					ark brown shale
dull and vit. CODI mad. brn. shale 130 130 130 130 130 130 130 13					
-30 -30 -30 -30 -30 -30 -30 -30	-40		-120		ak. brn. shale
hard drilling mad. brn. shale some coal coal - easier drilling mad. br. mica- caous shale -135 moist zones coal coal zero shale some coal coal					water
-50 med. brn. shalo -130 Coal - Rasier Cral somo Shale -55 mad. br. micz - Caous shale Coal -60 mad. br. micz - Caous shale Coal -60 mad. br. micz - Coal Coal -140 as abova Caous shale -140 as abova Caous -140 as abova -140 as a	-45	0.4	-125	2021	
-50 med br. shale -130 coal - easier drilling -55 moist zones -60 med br. micz60 coal - easier -60 coal some -60 coal some -60 coal some -60 coal -140 coal -140 coal -215 shale some -616 coal -140 coal -220 dk. brn. shale -617 (encountered a little vapor from hole -140 linterbedded -140 parting 1-2' -150 shale -150 coal somo -215 shale -225 coal -230 coal somo -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal some -230 coal				hard drilling	
-55 -60 -60 -65 -65 -65 -66 -65 -66 -67 -68 -68 -68 -68 -68 -68	-50	mad brn. shalo	-130		-210
med. br. micz- caous shale -140 -140 -140 -140 -140 -145 -146 -146 -147 -147 -148 -1		7/1.71		200	
med. br. micz- caous shale -140 -1			136		
-140 -140 -140 -140 -140 -140 -140 -140 -140 -140 -145 -145 -145 -145 -145 -145 -145 -146 -146 -146 -147 -148	-22		- 199	moist zonos	shale some
as above (ancountered a little vapor from hole (40-1701) better coal 230 interbedded mod brn and micacaous shale (a lot of carb shale soft gray brn. shale mixed in this section.)		med, br. MICZ-			1 1 2 3 3 60
-145 -145	-60		-140		
a little vapor from hole (40 - 1701) better coal -230 soft gray shale shale (a lot of carb shale shale shale shale shale shale					
better coal -75 -75 -75 -75 -75 -75 -75 -7	-65		-145	a little vapor	-225
better coal -75 better coal -75 better coal -75 better coal -75 better coal -75 better coal -75 better coal -75 -75 better coal -75 -75 -75 -75 -75 -75 -75 -7				from hole	as above
mad. brn. and micacaous shale (a lot of carb. shale shale shale shale shale shale shale	31		-1-50	PRINCE SERVICE	
and micaceous shale (a lot of carb soft gray brn. shale this section.)	'			Partim 1-2'	soft gray
shale (a lot of carb) soft gray browship shale this section.)	7-	and micaceous		7	736 Soma LOZ
this section.)	17	shale	- 105 E		soft gray brn
L90 1-0-1-1 - C00		1.7.03.4	v.		shale
	L80	[]	-100		

COMPANY HAWLEY RESOURCE GROUP ADD	DRESS 7011 OLD SEWARD HWY. ANCH., AK 99502
	STARTED COMPLETED
CONTRACTOR	GEOPHYSICAL LOGS LOGGED BY
SAMPLES DESCRIBED BY: TK. H	
LOCATION: SEC. ZZ T. 6 N.	R. 18W. MERIDIAN KATEEL RIVER MER.

DRILLER _



		IAWLEY KESOURCE						
PROJECT CHICAGO CREEK CONTRACTOR			_ STARTED COMPLETED _ GEOPHYSICAL LOGS LOGGED BY					
							SAMP	LES D
LOCA	TION:	SEC. 22	T. 6	N.	R IBW.	MERIDIAN	KATEEL	RIVER MER.
			- "		,,			
							•	
DRILL	.ER							
			-80					
10		muck						
		*			as above			
- 5	600		85			-165		
	}	ica, rad-yellow	ľ		It. gray to It	.		
		rock chips			green soft	z.		
-W			-90		-	—— ⊢(<i>to</i> ⊢		
		raddish yallow			gray greendl w/green wh	δY		
	Will Control of the C	V. SILICEOUS			frags, gumo			
-15		some chips	-95	1181.000	up hola	175 -		
		have green			hola obanduna	zcl	'	
~ZO		areas on tresn	-100		年 一個 年井村	-130		
		breaks					-	
	129W/							
-25		as above - all	-105		_	105		
		hard doiling						
-30			-110			<u> </u>		
		as above - slow						
- 35		drilling	-115			195		
		3(1(1)(4)	(1)					
-40			-120	-		-200-		
		as above						
-45			-125			-205		
		as about - good						
-50		weathering	-130					
		schist	120					
		8						
-55		Ht, yellow weathering	-135			-215 -		
		It, green sullist			,			
		slightly fister drilling						
-60		7	-140					
	0000	raddish yellow						
-65		Vult faicher	145			-225		
	WWW.	drilling						
-70		Itar yellow weeth.	-150			-230		
		atz., chlorita schist						
ر بر		w/tr. Pu or Ry	ر ا			-235-		
-75		soft v. It. green	-195			[-233]		

LITHOLOGIC LOG OF CUTTINGS	HOLE NO. DH-5-85	PAGE 1 OF 2
COMPANY HAWLEY RESOURCE GROUP ADD		•
PROJECT CHICAGO CREEK		
CONTRACTOR		
SAMPLES DESCRIBED BY: T.K. HINDERHAN	T.D. 410 FT.	DIAM
LOCATION: SEC. 22 T. 6N.	R. 18 W. MERIDIAN K	ATEEL RIVER MER.

	ER				
, 		muck	-80	as above	carb. shale
		162	-85		-165 mad, gray sha
,		124	-90	as above	-170
	11.81.	med. brn.	-95	as above	coal bed 175 med gray shall
	B. 0	micaceous Shale - Tert.		as spava	G. A. A. A. A. A. A. A. A. A. A. A. A. A.
2	6	gray and brn.	-100	as above	-180 coal bad
	0 0	medito Itionni	-105		gray shale
2		SIVALE	-110	as above	-190 Some cool
	á	micecamus shalo	-115	as allova - harder layers	Shalls gray brown tha
	0	It brn. shaw,		as above	coal chips w/d
,		lt, to dk, brn.	-120		-200 coal chips w/dk.
			-125	3 MA	gray shele -205 coal chips, some
	0	as above	-130		dk.dry mica- caous shab
	0.0	as above		med cyray shall parting	dk. gray shale
		medigray micacous	-135		-215 dk. gray micaced
		Shala	-140	brownish dull coal - some vitraous	-ZZO dk. gray shala
		It. to med. brn. shale	- 145	madi brn. shake	-225 fine coal seams
	4	dk. brn, carb. shale dull to vit. coal	-150	shale brn.	230
,		good drilling		shale and coal	prounish gray Shale tine cool seams
		coal	-195	dk. brn. carb.	as above

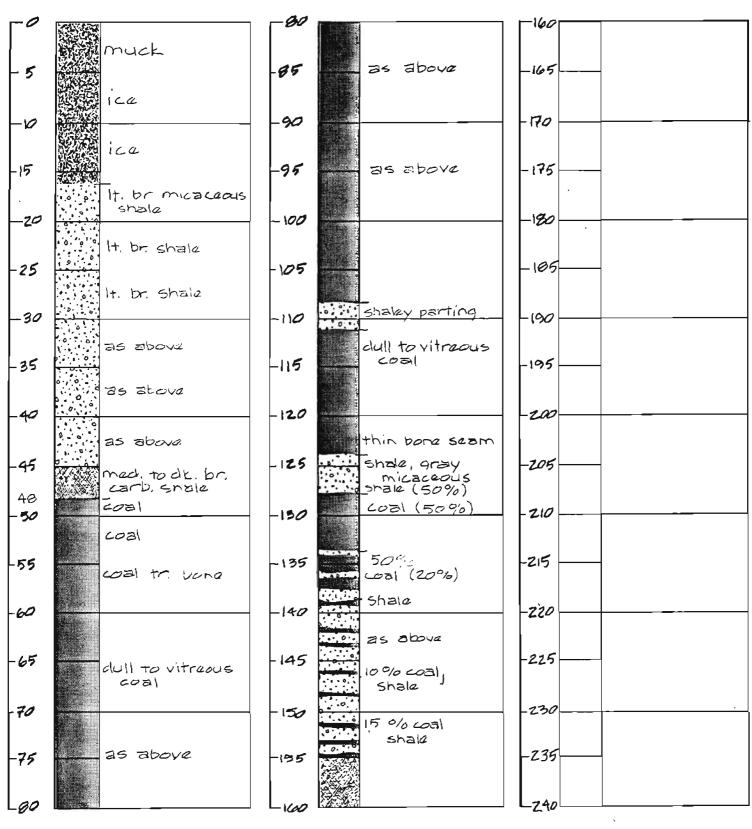
MER.

DRILLER _________

-240 carbonaceous	gray br. shale	gray schist
shale	325	hard drilling
-245 gray brown	as above	gray schist hard drilling
Shak	- 330	-410
gray brown shale	CROUS SHALE W/	
- 255	335 (5%)	415
as abar	35 abiva (5%)	
-200 gray br. shale	340	420
5% coal chips	as above	
-265 50% shale	345 as above	-425
50% 600	coal (tr.)	420
-270 90% caal	- 350	-430
-275	- 355	-435
cray br mica- crous shale	gray brishak	
-280	- 360 ay or shalo - sm,	440
COBI		
-285	- 365 coal seams (5%)	- 450
as above	Shale - Small	1
- 290 gray br. shale-	310	-455
laminations	- 375 (00) (35%) bone?	460
-295 aray brown micaceous	-375 (00), bone?	
-300 shale	300 Shale, coal (5%)	465
as above	bcm (5%)	
-305 above - small	gray br. to gray	-470
(5%)	shale	
-310 as above, small	390	-475
-315 again (5%)	- 395	480
gray br shall	gray shala	
320	400	485
		•

COMPANY HAWLEY RESOURCE GROUP ADD	RESS 7011 OLD SEWARD L	WY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR	GEOPHYSICAL LOGS	LOGGED BY
SAMPLES DESCRIBED BY:	T.D. <u>155</u>	DIAM
LOCATION: SEC. 22 T. 6 N.	R. 18 W. MERIDIA	AN KATEEL RIVER MER.

DRILLER.



160

LITHOLOGIC LOG OF CUTTINGS	HOLE NO. PH - 7 - 65	PAGE OF
COMPANY HAWLEY RESOURCE GROUP ADD PROJECT CHICAGO CREEK	STARTED CO	MPLETED
CONTRACTOR	T.D. 190 FT.	DIAM

DRILLER

DRILL	.E.R						
r0		-BO	10.1	_	T160		cool 5% snale
	muck - ica		25	stove		į	
-5	dk carb shale	85	la~	ninated gray	-165		coal, shole
	ned gray shale		in an	icaceals /			50%-50%
-b	th, br. to med.	-90	dk.		-170		gray micaceous shale, 5% coal
-15	Shale	-95	9'	ray shale	-175]
	carb, shale			1. br. and Tay shale			gray micaceous shale - trace coal
-zo	dull coal	100	10:1:11 10:10:11	br. shala	-130	, i	gray micaceous
	gray shale			sy shale			shola
-25	gray micachous	-105		,	-105	0,1,0	gray micacaous
-30	shale	-110	dk	br. shale	-190	, ,	ishala
	oray to It, br.		A ALLI	to vit. coal			
- 35		-115		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	-195		
ļ	med br shale						
1-40	mad to It. br.	-120			-200		
-45	shale	-125	25	zbove	-205		
'	med. on shale						
-50	dk br. shale	-130			-210		
	It. br. shale						
-55	dk. brown shale	-135	35	a bove	-215		
-60	medigray shale	-140			-ZZO		
	med gray shale						
-65		-145			-225		
	brown shale		- CAN	e parting 11-dull to			
-70	med gray mica-	150	Vi-		-230		
-75	Leous shale	-195	1. 2	,	-235		
'	med gray and brown shale		50	gray shale			
L80	2002	L160	5 //	7,9,27	L240		,

PROJE	CT CHICAGO CREEK		DRESS 7011 OLD SEWARD HWY. ANCH., AK. 99502 STARTED COMPLETED		
	RACTOR		_ GEOPHYSICAL LOG	S LOGGED BY	
SAMP	LES DESCRIBED BY: T.K. Hi	UDERMAN	T.D. 110	DIAM.	
LOCA	TION: SEC. 2Z	T. 6 N.	R. 18 W.	MERIDIAN KATEEL RIVER MER.	
DRILL	.ER				
-0	muck ice gray shale	-80	dk. br. shale	160	
- 5	Signal Control of the	85	dust - weathered gray schist	165	
- W	gray br. shala	-90	frægs.	-170	
	ica		gray schist	-175	
-15	gray to med br	-95	gray schist		
-z0	ak to med	-100	<u> </u>	- 180	
-25	br. shale	-105	gray schist hard drilling	105	
_3 <i>0</i>	grava 1 - schist and az pubbles	-110	gray schist	- 190	
_ 50	to 3/4 m.				
- 35	as above	-115	-	195	
-40		-120		-200	
-45	mad br. gravel	-125		-205	
	as abova				
- 50	grayish gravel	-150		-210	
-55	grayish graval	-135	_	-215	
-60	weathered schist peoples	-140	_	-zzo	
-65	as above	145		-225	
- 67	gravel-brown micaceaus shale				
-70	a above - tr. coal	150		-230	
-75	frags. in shale	~195		-235	

COMPANY HAWLEY RESOURCE GROUP ADDRESS 7011 OLD SEWARD HWY. ANCH., AK. 99502 PROJECT CHICAGO CREEK STARTED COMPLETED ____ CONTRACTOR _____ GEOPHYSICAL LOGS ____ LOGGED BY_____

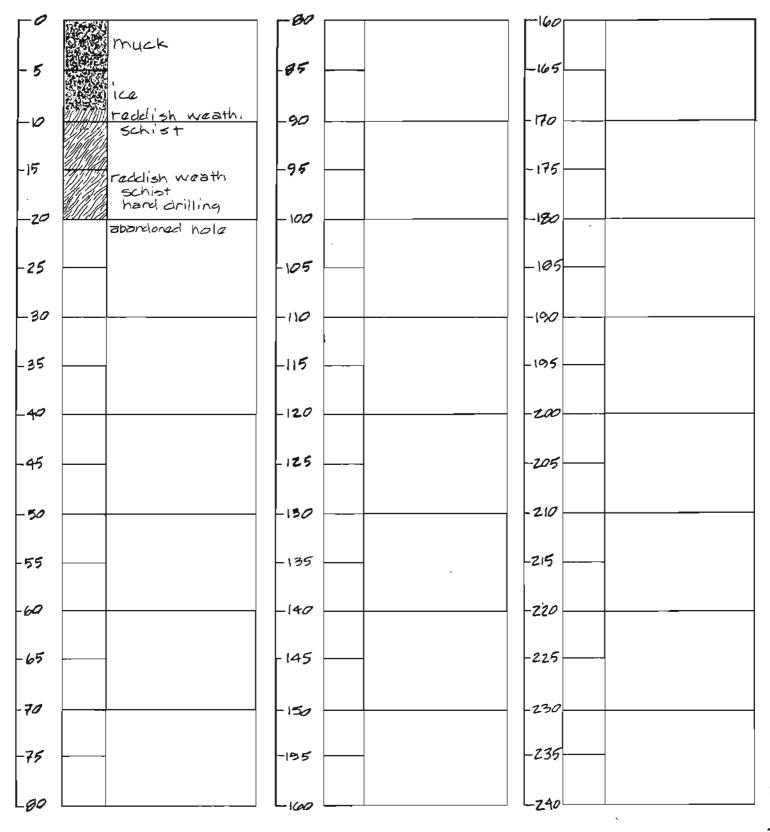
SAMF	LES DESCRIBED BY: T.K. 1	HINDERF	IAN	T.D. 135	5 FT.	DIAM.	Divier.	MED
LOCA	TION: SEC. 22	T	N.	. R. <u>18 w.</u>	MERIDIA	N'VAI EE	RIVER	191660
			\$1 B	1 1 2 2 2				
2011	F.D.							
ORILL	-cn							
-0		-00		br. shale	7 160			
			. 6	6 in, coal scam				
- 5		85	8.00	gray snok	-165			
•	10055 ?			arou brown				
				micoccous shale				
-10		-90	0	८०३।	-170			
			0	gray shale				
-15		-95		groy micacuous	175			
	coal			shale				
-zo	shale	-100	, , , ,		-180			
	coal			gray micaceous				
-25	gray-br, shale	-105	.0.		-105			
27	gray and brown		0	gray to brown				
	shale		. 0	micaceous shole				
-30	cool Shale	-110		gray - br. mica-	- 190			
	coal			coous snok				
- 35		-115	10.00	gray br. shale	-195			
	spod coal			gray schiat				
-40		-120			-200			
·	1 11 1 11			med, gray schist	7			
-45	dull to vit,	-125		some weathered	-205			
47				dk. to med.				
				groy schist- dusty				
-50		-150			-210			
	tr. bona			as above				
-55	寄	-135		_	-215			
	iorio ica lansus							
60	shale	-140			-220			
_	orovel							
.=	gray shale tr. coal	-145			-225			
-65	15.5534	[145						
	gray shale							
70		-150			-230			
	gray shake]			
-75		-195			-Z35			
	H, coal							
-80		Lico	L		J L _{z40}			
-								

-Z90

00

COMPANY HAWLEY RESOURCE GROUP ADD	RESS 7011 OLD SEWARD F	WY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR	GEOPHYSICAL LOGS	LOGGED BY
SAMPLES DESCRIBED BY: T.K. H.	T.D. ZO FT.	DIAM
LOCATION: SEC. 22 T. 6 N.	R. 18 W. MERIDIA	AN KATEEL RIVER MER.

DRILLER _____



- 145

-150

195

-1600

65

70

75

as obora

as above

-225

230

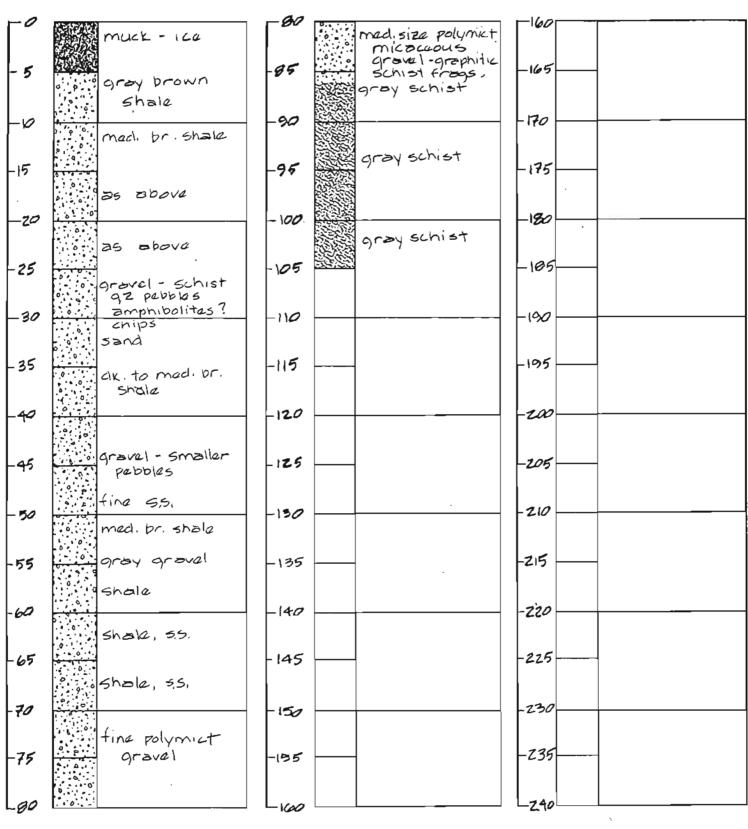
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-240

				WARD HWY. ANCH., AK. 99502
				COMPLETED
	RACTOR	· Inchia	_ GEOPHYSICAL LO	SS LOGGED BY
SAMP	LES DESCRIBED BY: T.K. HI	NUERMAN	T.D. 10	5 FT. DIAM.
LOCAT	TION: SEC. 22	T. 6 N.	_ R. <u>18 W.</u>	MERIDIAN KATEEL RIVER MER.
				-
DRILL	ER			
		-80		
_	muck and ica			
			igray grovel	
- 5	gray to brown	85		-165
	shale -		es above.	
	(+ar+?)	90		-170
10	soma ica	100		
l	gray to brown		<u>}:</u>	
-15	tart	95	: gravel	-175
	shale (soft)		weath schist	
·	6	100	<u></u>	-180
-z <i>o</i>	ogray to brown	-100	35Ch15+	
	shale		(weathered)	
-25	0.00	-105	<u> </u>	- 105
	25 abova			
	5.17.23	,,		
-30		-110		-190
1	OS above			
-35		-115	_	-195
	soft gray tart.			
100	smale smale	120		- 200
-40	F-7/10)			
	35 BOOVA			
-45		125	_	-205
	is a gravel layer			
	Shake Shake			210
-50	snow	-130		
	graval			
-55	polymict gravel	-135	_	-215
	o pounded az schist		-	
١,,	Dabbles	(4.0)		720
-60	shale - some grave	-140		zżo
-65		145	_	-225
	as above			
	20002			
-70	oray gravel w/	150		- 230
	fairly fresh wood, coal frags.			
-75	Frags.	195	4	- 235

COMPANY HAWLEY RESOURCE GROUP ADD	DRESS 7011 OLD SEWARD HWY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED COMPLETED
	GEOPHYSICAL LOGS LOGGED BY
	T.D. 105 FT. DIAM.
LOCATION: SEC. 22 T. 6 N.	R. 18 W. MERIDIAN KATEEL RIVER MER.
	<u> </u>

DRILLER -



_			EWARD HWY. ANCH., AK. 99502	
PROJECT CHICAGO CREEK		_ STARTED COMPLETED		
CONTRACTOR		GEOPHYSICAL LOGS LOGGED BY T.D. ZIO FT. DIAM.		
			MERIDIAN KATEEL RIVER MER.	
LOCATION: SEC.	- I. <u>• 157</u>	N	WILKIDIAN 1.7.35 TELEVISION 1.1.1	
			_	
DRILLER				
DRILLER				
	TEO ETT	inectional shak	160 cray schist	
muck	(in the second	ار در از از از از از از از از از از از از از	chips	
-5 and	85		-165	
160	1 1 2 1. 8.	idull br. coal	as abova	
isinala	63.444	adil Dr. Wal	[[[[[[[[[[[[[[[[[[[
	90	vit, cool-drill	170	
shab	, l	rattles-15%		
-15 polymict pas gra	-95 -	clay seams, 20% of ull-broom	-175 CAK APPLANTED	
graval		dull brown coal	dk gray mica- ceous snake	
		10% vit.		
-20 brown carb, shab	-100		- 120	
18 120 It. brown to gray			as abova	
-25 yellow snak	-105	dull brown 25%	-105 dk. gray brown	
		vitcosi tr. bone	micacaous Shela	
-30 COAL	-110		- 190	
coal 50%, car shale 25%,	b- - (1 b	mostly vit coal	dk gray br.	
snale 25%		AFAI CAILLES	Shist chips hard arilling	
-35 gray to brown	-115		195 Mara arilling	
shak		äs above	(2.16)	
40	-120		-200	
gray shake		ayado es	dusty, hard	
(0, 1, 1, 1)	125		1 33388 de Nino	
-45	- 129	vit to dull coal	-205	
oray shake		not quite as	bedrack gray schist	
50	-150		-210	
med. to alk. Dow		as whove, tr. bond	.	
-55 Shale	-135	4 1)	-215	
		dull coal, some		
gray shale				
-60	-140	vit. coal some	- -ZŽO	
		aull boodly wet	.	
-65 medi br. shale	-145		-225	
[1.16 to 2.1 [1.16 to 2.16]		as above		
gray shab			230	
70	- 150	med gray		
brown and gray	,	micoceous Shala		
75 shale	195	<u>্</u> ব	-235	
		as above		
max [[1]] [1] [1] [1]		/네	4 -	

LITHOLOGIC LOG	OF CUTTINGS	HOLE NO DH - 14 - 62	PAGE OF I
COMPANY HAWLEY	RESOURCE GROUP	ADDRESS 7011 OLD SEWARD HWY	ANCH., AK. 99502

PROJECT CHICAGO CREEK STARTED COMPLETED CONTRACTOR_____ GEOPHYSICAL LOGS____ LOGGED BY_____

SAMPLES DESCRIBED BY: T.K. HINDERMAN T.D. Z30 FT. DIAM.

LOCATION: SEC. 22 T. 6N. R. 18 W. MERIDIAN KATEEL RIVER MER.

DRILLER _____

Pille			· ·
[°	muck ice	-00	med arzy br. Gull to vit.
- 5		-85	-165
<u>ا</u>		-90	shale shale
			Z Ft., 600 0/1 COS
-15	hard, yallow	-95	175 40 % Shale coal 5% shale 5%
-20	weathering schist	-100	-180 LOBI 5 %
-25	green schist solter	-105	mad. br. shale shale shale,
_30	yallow to green schist	-110	25 above 10% CO21
	yallow waathering schist		gray shale shale
- 35	med, hard yellow weath	-115	gray micaceous -195 as above schist chips
-40	SCHIET	-120	- [
-45	as sbove	-125	as above -205
	yellow green		brown shale schist chips
-50	green yellow schist	-130	gray micaceous graphitic schist
-55	mad graun	-135	10 1 2 10 1 1 2 10 1 1 1 2 10 1 1 1 1
-60	schist	-140	-ZZO
-65	tr. grean schist	-145	-225 as above
7.4	gray schist	. س	230
-70	gray schist coal, vitraous	-150	
-75	to dull	-195	
60	shale	L160	shale

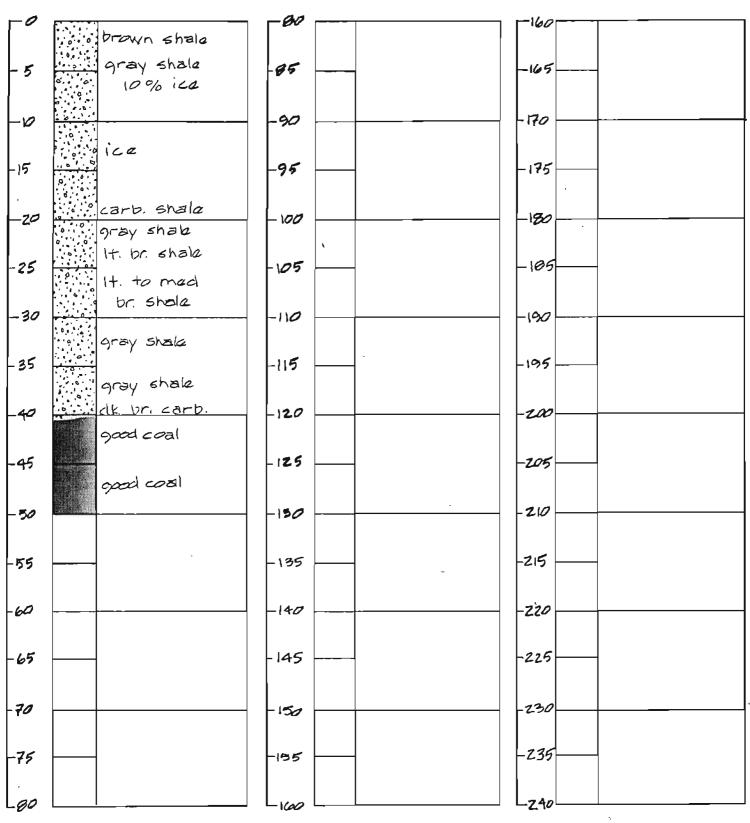
-Z40

-75

.00

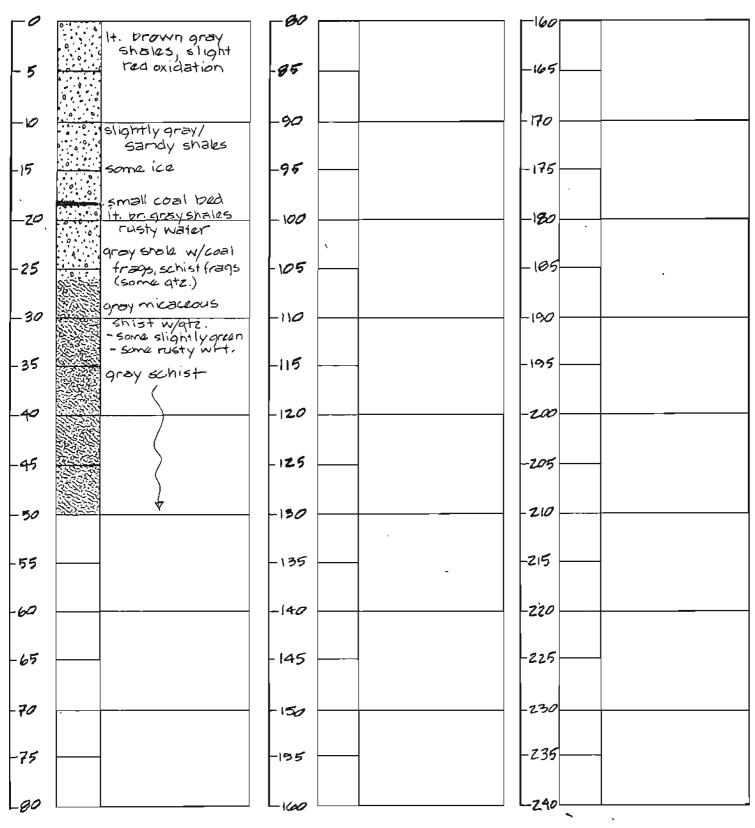
COMPANY HAWLEY RESOURCE GROUP ADD	DRESS 7011 OLD SEWARD	HWY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR	_ GEOPHYSICAL LOGS	LOGGED BY
SAMPLES DESCRIBED BY: T.K. HINDERMAN	T.D. 50 FT.	DIAM
LOCATION: SEC. 22 T. 6 N.	R 18 W. MERID	IAN KATEEL RIVER MER.

DRILLER.



COMPANY HAWLEY RESOURCE GROUP ADI	DRESS 7011 OLD SEWARD	HWY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
	_ GEOPHYSICAL LOGS	LOGGED BY
SAMPLES DESCRIBED BY: R.M. RETHERFORD	T.D. <u>50 FT.</u>	DIAM
LOCATION: SEC. 22 T. 6 N.	R. 18 W MERIC	IAN KATEEL RIVER MER.

DRILLER.



JECT CHICAGO CREEK		_ STARTED	COMPLETED
NTRACTOR		GEOPHYSICAL	LOGS LOGGED BY
IPLES DESCRIBED BY: TK H		T.D	35 FT. DIAM. MERIDIAN KATEEL RIVER ME
ATION: SEC. 22	_ T. <u>6 N.</u>	_ R. 18 W.	MERIDIAN KATEEL RIVER ME
			
LER			
GSE-SEA	-80 -		
2000 S			
muck			
	85		-165
ice			
	-90 -		-170
ica			
	-95		175
ica coal frags.			
	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	100		180
coal			
	105	_	 105
coal, ica			
	110		190
coal	-115		195
	-120		-200
-	-125	\dashv	-205
	-130		-210
	,25		-215
	-135	7 -	-213
	140		
	- 145	-	-225
			-230
	150		
	195	7	-235
i i			

290

COMPANY HAWLEY RESOURCE GROUP ADD	RESS 7011 OLD SEWARD	HWY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR	GEOPHYSICAL LOGS	LOGGED BY
SAMPLES DESCRIBED BY: T.K. HINDERMAN	T.D. ZIO PT.	DIAM
LOCATION: SEC. 22 T. 6N.	R. 18 W. MERIO	IAN KATEEL RIVER MER.

DRILLER ______

			an		Y 100 100 100 100 100 100 100 100 100 10	-14.5	
	m	uck, br. shale	-80			T160	Total Control
- 5			85	-	sm. parting-shale	-165	
	gr	-ay shale			parting-gray shale		
1-10	ic	a	-90		dull to vit. coal	-170	
-15		-) -	-95	SHI		-175	br. shala
	5 r	rale			as above	100	nard dusty shala
-z <i>o</i>	. 11/11/11		-100		as above thinly	-180	coal
-25		avel - 92, schist	105		Idminated	-105	
						100	gray shale
30	gr.	avel az, graan schist, red-	-110		small arxy shale	-190	10% coal
-35		yellow schist frags, - near	-115		small græy shale parting coal	-195	(, (,) (,)
-40		upper plate?	-120			-200	brown shale
			,				gray shale
-45	ده	781	-125	- 4 - 7 - 0	parting	-205	
-50			-130		dull to vit, coal	-210	gray schist
	60	alydull br,			dull med. br. coal		
-55	200200-00000000000000000000000000000000	al, dull to	-135			-215	
-60		vitreous	-140		as abova	-270	
	35	s above			more silicates and coal?		
-65	be	bwnish coal	- 145		good black layer	-225	
70			-150			-230	
		constitution (.7)		. 0	parting		
-75		n. partings (bone?)	195		thin partings	-235	
L80			LKO		(10%)	Lz40	` .
							· ·

COMPANY HAWLEY RESOURCE GROUP ADI	DRESS 7011 OLD SEWARD	WY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR		LOGGED BY_TKH
SAMPLES DESCRIBED BY: T.K. HINDERMAN	T.D. 250 FT	DIAM
LOCATION: SEC. ZZ T. 6N.	R. 18 W. MERIDI	AN KATEEL RIVER MER.

DRILLER______

4			20			17 -		
		muck			coal 90%, 10% sm. ohale partings	-160		coal
- 5		Ice	85		50% shale parts	163		shale
		med. br. to gray sads.		17. W. 17.	50% coal			75 % coal
J-10			-90	X. () ()	shale	-170		dull to vit.
-15		as obove	-95	#10-	Loal	-175		COD(.
		ica		10	good dull to			as above
_zo		gray br. shale	-100	1/1/4	vit. coal	-180		
		gray br. sand			gray shale			
-25	_	lacal gravel	105	0.8	lost circ.	-105		oray shale
_30	31 <i>20</i> 0	rad yellow shist	-110		gray shale and br. shale	-190		br. to black coal
		graen and red yellow shist			gray shak	.~	0.	5% shale
- 35	21/1/16		-115		5% (0)	-195		coal, tr. shale
		br. to gray shale			85% cool 15% shale	in the second se		
-40	9	med, gray shale	-120	10 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	lost return	-200		os abova
-45	0,		-125		mostly coal	205		
	0.	as above			cool-nat	La Ca		coal, 25% shale
-50	. 0 . 0		-150			-210		10% shak
	ø. o	as abova			coal			,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
-55	0.00	darkening br.	-135		dull to vit.	-215		10 % shale
-60		shale to coal	-140		2001	-ZZO		
	.0	mudy dk. br. carb shale or coal			as abova	No.		coal, 10% shale
-65		v. dk. dull to	-145		,	-225	100	as above, 30%
7.4		vit, LODI			as abova	220	一块	corb. shale gray shale
-70		as above - net	-150		as above	-230		gray shale
-75		9000 co21	-135			-Z35	0	shist
		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			as abovo		204.50	gray shale shist
L80	i catto		L160			LZ40E	<u> </u>	>r1>1

-320

160

75

00

-Z35

PROJECT CHICAGO CREEK			STARTED	COMPLETED
ONT	RACTOR		GEOPHYSICAL	LOGS LOGGED BY DIAM.
AMF	LES DESCRIBED BY: T.K. HI	NDERMAN	T.D.	65 FT. DIAM.
OCA	TION: SEC. 22	T. 6 N.	R. 18 W.	MERIDIAN KATEEL RIVER MER
				· · · · · · · · · · · · · · · · · · ·
D., (
KILL	ER			
0	,	- <i>60</i>	<u> </u>	<u> </u>
	brown to gray			
5	seds,	85		165
9				
			,	
0	gravel (rounded)	-90 -		
	coal chips			
15	grey shale	95		175
19	coal	L 2.2		
20		100		
	gray shale			
25	brown muddy cool	105		105
	AA 5% shale	1,00		
		}		
30	part Make 1	-110		-190
	AA			
35		-115		-195
	parting gray shab			
	0			
40	gray shale - qz -	-120		-200
	schist pebbles			
15		125		-205
	gray schist, shale			
50		150	_	
	gray schist			
55		135	4	-z15
	gray schist		-	
_		14.0		
0		-140		-zżo
	gray schist			
,5	<u>>>>5</u>	145	\dashv	-225
11				730
0		150		-230
15		195	\dashv	-Z35
30		L160 L	<u> </u>	L _{Z40}

COMPANY HAWLEY RESOURCE GROUP ADD	DRESS 7011 OLD SEW	ARD HWY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR	_ GEOPHYSICAL LOGS_	LOGGED BY
SAMPLES DESCRIBED BY: T.K. HINDERMAN	T.D. 190	FT DIAM
LOCATION: SEC. 22 T. 6 N.	R ISW. M	IERIDIAN KATEEL RIVER MER.

DRILLER_____

DRILL	ER			
r0	It. br. sads -	T80	A,A,	C031
	some Fa stain			:: " shala,
5		-85	brownish bone coal	-165 bone coal
- W	polymict aravel	-90	brownish bone	br, gray shale
	coal chips (broke blade moved		dk. br. to bl. coal	gray shale
-15	Zftcont, from 15)	-95	sm. parting	-175
	coal - black, dull to vit,		caal	gray shale,
-zo	14.00 C	-100	small parting	-180
	as above	ا	(021,5% shale	gray schist
-25	v.dk. br. to black	-105	parting	gray schiot
-30	coal	-110	coal,5% shale	-190
]	as above		dk. br. to bl. coal	
-35	dk. br. to black	-115		-195
	coal shale	,,,,,	as above sm. parting	
-40	(dk.grsy)	-120	coal - tr. shale	-200
-45	coal	-125		-205
	dk.br. muddy coal		shale	
-50		-130	shale 50%	-210
	dk. br. to bl. coal		coal 50%	
-55	as above	-135	dk. br. to bl. coal	-215
-60		-140		-270
	as above		good shale	
-65		- 145	CONTROL OF THE PROPERTY OF THE	-225
7.4	as above		coal	420
-70	parting	-150	shola	-230
-75	Coal, 5% shale	-195	medibri to	-235
	dk, br, to bl. coal		black coal	
L80		Lico		Z40

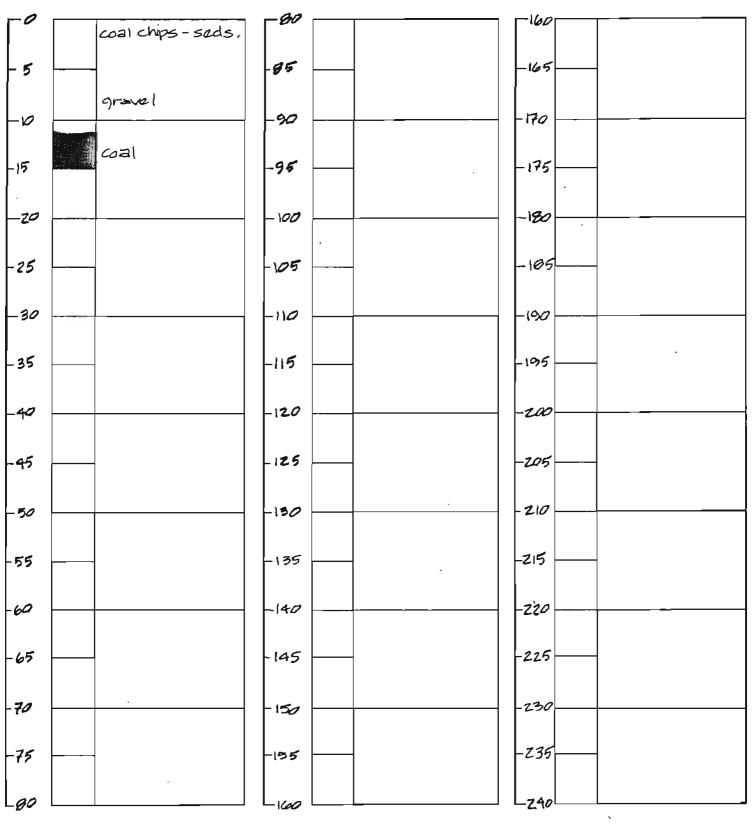
COMPANY HAWLEY RESOURCE GROUP ADD	RESS 7011 OLD SEWARD	HWY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR	GEOPHYSICAL LOGS	LOGGED BY
SAMPLES DESCRIBED BY: T.K. HINDERMAN	T.D. 170 FT.	DIAM
LOCATION: SEC. ZZ T. 6 N.	R. 18 W. MERIC	DIAN KATEEL RIVER MER.

DRILLER_____

DIVILL			
r		Teo Walle	-160
	sado - muck	green schist	grean schist
- 5		-85	-165
	1	gray day rich schir	green schist
-\o	graval	⊣	-170 2/16/14
1		grean and gray	
-15	graan schist	95	175
	It, green to white		
-z0	May easy drilling	- 100 Manacl pr. shale	-120
	as above	med, br. shale	
-25	A A laally	105	-105
	horder drilling	tt. to med br	
-30		I I I I I I I I I I I I I I I I I I I	190
	A.A.		
- 35	GANDA	-115	195
		trouble with hole no return	
-40		120	-200
	gray graan schist		
-45	harder drilling	It tan to med	-205
	AA hard drilling	br fine ss shale	
-50	A.A.	mad todk br.	-210
	Margan schist	shale	
-55	faster drilling	med to dk . br.	-215
-60		- 140	-zzo
	AA.		
-65		-145 main green shale	-225
	AA.	Greek Stole	
-70		150	-230
'	//////////////////////////////////////	gray and green clay rich shale	
-75	gray green schist		-z35
'		A series shale -	
Loo	dk. gray graph.schist	grean shale-	L _{Z40}
-			•

COMPANY HAWLEY RESOURCE GROUP ADDRESS 7011 OLD SEWARD HWY. ANCH., AK. 99502 PROJECT CHICAGO CREEK STARTED COMPLETED _____ GEOPHYSICAL LOGS_____ LOGGED BY_____ CONTRACTOR____ SAMPLES DESCRIBED BY: T.K.H., T.D. 15 FT. DIAM. LOCATION: SEC. 22 T. 6N. R. 18 W. MERIDIAN KATEEL RIVER MER.

DRILLER _____



COMPANY HAWLEY RESOURCE GROUP ADD	RESS 7011 OLD SEWARD	WY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR	GEOPHYSICAL LOGS	LOGGED BY
SAMPLES DESCRIBED BY: T.K. HINDERMAN	T.D. 270 FT.	DIAM
LOCATION: SEC. 22 T. 6N.	R. 18 W. MERIDI	AN KATEEL RIVER MER.

DRILLER_ 160 80 coal - dull br. grey to br. seds. to 101., 15% shale A_1A . 85 165 5 A.A. A.A Д,Д, 90 170 0 shale, zo% coal mud A,A, -still graval lots of Ica 95 175 -15 coal, 15% shale coal, 5% shala -Z0 100 180 shale, 20% coal dull to vit, black wal 14 parting 105 105 -25 coal, dull to vit br. dull br. coal and bl. coal 15 % shala tr. vitraous -30 -110 190 shala dull br. coal A,A. wal -35 -115 195 coal, 10% shale A.A.A,A, brown shale -40 120 parting snak, 10% coal Coal, tr. shale A.A. 125 -45 coal, 25% shale wal, 5% shak A.A. (tiny partings) 210 130 - 50 gray br. shale coal, 15 % shale 10% 2001 A.A. -215 55 135 coal, 15% shale coal, 5% shale **A**, **A**, ·Z20 -60 -140 30% coal A.A. wet -ica A.A. 70% Shale 65 -145 225 araphitic br. to bl. coal MILALADUS tr. bone parting Shele wet, ice 230 gray shale 70 150 dull to vit. coal A.A. abund, ica schist ica 235 -75 -195 A.A. shale, 10% coal A.A. 160

-320

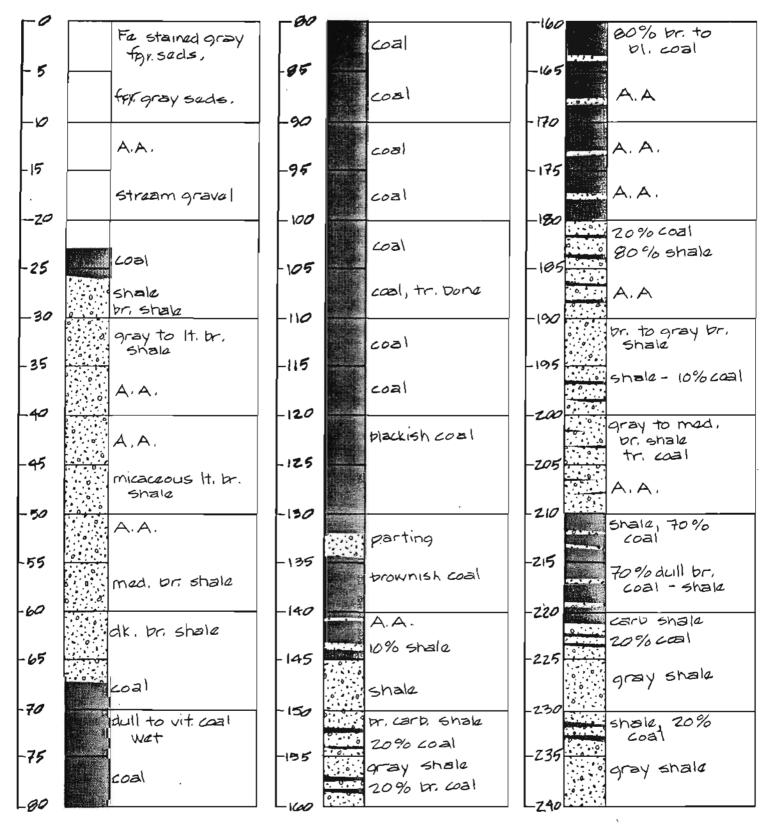
COMPANY HAWLEY RESOURCE GROUP ADD	RESS 7011 OLD SEWARD H	WY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
SAMPLES DESCRIBED BY: TK HINDERMAN	T.D. 250 FT.	DIAM
LOCATION: SEC. 22 T. 6N.		

A.A. wood chips Polymict pounded stream grave) Polymict poun	105 dull to vit. Coal
tine grained seds, A.A. wood chips A.A. wood chips A.A. Polymict purched stream grave A.A. Igo partir (organic rich shale - claystone A.A. Igo partir (organic rich shale - claystone A.A. Igo partir (organic rich shale - coal - coal - carb, shale - carb, s	dull to vit. (02) 175 CO21 180 Parting 185 Shale, 20% CO21 190 CO21 190 Shale 50% CO21 50% Shale
A.A. wood chips: Polymict pounded stream grave 100 Vary dk. br. (organiz rich shale -claystone 110 Gray and br. shale Gr	175 Coal 180 Parting 185 Shale, 20% Coal 190 Coal - 10% Shale Shale, 10% Coal 50% Coal 50% Shale
polymict purched stream gravel 100	180 Parting Shale, 20% COAL 190 COAL - 10% Shale Shale, 10% Coal 50% COAL 50% Shale
polymict pounded stream grave -100 -120	parting shale, 20% coal coal - 10% shale shale, 10% coal 50% coal 50% shale
gravel ice gravel ice gravel ice (organiz rich shale) -105 A.A. -106 -106 -106 -106 -106 -106 -106 -106 -106 -107 -107 -108 -	parting shale, 20% coal coal - 10% shale shale, 10% coal 50% coal 50% shale
coal shale are shale are shale are coal are shale are coal are shale are coal are coal are shale are coal are coal are shale are coal are	190 COAL 10% Shale 10% COAL 195 Shale 10% COAL 10%
oray and br. shale vary dk. br. carb. shale- vartical bl. aganic rich shale oraan clay rich rack as above schist cantars to chips -120 tr. Dony lans vary dk. br. carb. shale- vartical A.A. -205 50% 50% 50% 50% 50% 50% 50%	195 coal - 10% shale 50% coal 50% shale
bl. arganic rich shale organic rich shale organic by rich rack as above schiet centers to chips -125 A.A. -126 -127 -195 -195 -195 -195 -120 -12	50% coal
oreancley rich rack as above schist centers to chips -126 A.A. -205	50% coal 50% shale
as above schist canters to chips -125 A.A.	50% coal 50% shale
to chips -125	705 - 100 PM
and an order	
20	210 10% COEL
A.A. coal	med. gray br snale, 10% a
75%	75% coal 25% shale
-140	高ないのは間間受
	.0

DRILLER_ 00 shale-carb soft sads. Shak 10 % coal 85 5 A.A. - ica 5% 600 wood snale 170 -10 gray shale A.A. -175 -15 95 soft gray seds, aray to araybrown shale ica 120 -20 100 gray to br. graval hard drilling 105 105 -25 dk. carb. shale gray schist tr. Loal 110 190 -30 gray schist A.A. - 35 -115 -195 u, dk. carb shale gray and graphitic traces coal 120 200 40 gray shald med. br. to bl. A.A. coal, locally vit. 125 -45 -205 brown coal locally vit. 210 -130 - 50 parting 215 .55 -135 shale. 30% coal Shale -220 .60 -140 Shala 4021 -65 -145 -225 shale, 10% coal 230 70 -150 Shala, 10% coal -235 -75 -195 shak Shala 160

COMPANY HAWLEY RESOURCE GROUP ADD		
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR		
SAMPLES DESCRIBED BY: T.K. HINDERMAN		
LOCATION: SEC. 22 T. 6 N.	R. 18 W. MERIDI	AN KATEEL RIVER MER.

DRILLER_



COMPANY HAWLEY RESOURCE GROUP ADD	DRESS 7011 OLD SEWARD	WY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR		LOGGED BY
SAMPLES DESCRIBED BY: TK. HINDERMAN	T.D. 330 FT	DIAM
LOCATION: SEC. 2Z T. 6 N.	R. 18 W. MERIDI	AN KATEEL RIVER MER.

DRILLER_____

-				
	br. and gray t.gr. sads.	-00	mad gray br,	
-5	ica	-95	A.A.	A.A. coal ? frag. in seds
-15.	med. br. f.gr. seds.	-95 -95	micacaous gray	-170 -175
_zo	A.A.	-100	A.A.	AA.
-25	gravel, wood chips	105	AA	A.A. regular seds.
-30	polymict gravel, some rounding	-110	A.A.	A.A.
- 35	ica, gray f.g. seds.	-115	A.A	harder drilling schist- chips shale, schist
-40	seds - ica	-120	A. A.	-zab med br. shale
-45	oray to med.	-125	A.A	Schist chips
-50	br. seds	-150	[U + ja + 14]	210 mad, br, sads
-55		-135	A.A. +r. ICA	Z15
-60	A.A. trica	-140	schist chips	-zzo
-65	tr, ica	- 145	narder drilling	-225 med, br. seds
70	Slightly darker	- 150	schiet frags,	-230 55, in schist
-75	or, seds.	-195	softer, lacks like	-236 +rags
-80	tr. ica	160	sads again.	Z40

COMPANY HAWLEY RESOURCE GROUP ADD	DRESS 7011 OLD SEWARD 1	HWY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR	GEOPHYSICAL LOGS	LOGGED BY
SAMPLES DESCRIBED BY: T.K. HINDERMAN	T.D. 210 FT.	DIAM
LOCATION: SEC. 22 T. 6N.	R. 18 W. MERIDI	AN KATEEL RIVER MER.

DRILLER _____

	ı			
10	br. seds, Fe	-BO	shale	160 ,]
1	stain		coal	
		1	6101C	ا
- 5		-85	7 D B	-165 gray or, shale
1	tan seds		(1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	10 % coal
1			coar	
-6		-90		gray br shale
	A.A.		gray br.	100
-15		-95	shala	-175
Γ''				gray br. shale
- ∤ .	A.A.		coal	
_zo		-100	3	180
-	,	""	shale	gray be shale
	gravel		181911	5% coal
-25		105	br shale	-105
				gray br. shale
	ice, coal chips		It. gray ss. schist frags.	tr. coal
-30	caal	-110	br. shale	190
			coal - v. light	A.A.
	shale	پر. ا	snale (bone?)	195
- 35	Kills coal 50%,	-115	20% coal, also	- 1 - 1 22 % 1xl
	shale 50%		gray br. shale,	AA
40		-120	11 11 11 11 11 11 11 11 11 11 11 11 11	200
	dull br. coal 75%		micaceous br,	lighter gray
	shale 25%		Shale	Shale
-45		-125		205
	dull to vit.		A, A, also dk.	mea, to ar.
	- bone		br. shale - coal frags.	br. ohala
- 50	VOI 12	-130		-210
			coal bad	
	A.A,			
-55		-135	1,177,0,1	-215
	A.A.		Shale, 5% coal	
-60		-140		-220
	1.		gray br shale	260
	and the second			
-65	parting	-145	77.3.6	-225
	gray brishale		A. A. wat	
	tr. coal frags,			
70	8	-150		-230
	A.A.		A.A. coal	
77	100.5	L.~_	trags in sads	-235
75		195		
	coal	1	A.A.	
L00		Lico	((3), 9	L _{Z40}
<i>U</i> -				 -

COMPANY HAWLEY RESOURCE GROUP ADD	DRESS 7011 OLD SEWARD	HWY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR		
SAMPLES DESCRIBED BY: T.K. HINDERMAN	T.D. <u>Z90 FT</u>	DIAM
LOCATION: SEC. 22 T. 6 N.	R. 18 W. MERID	IAN KATEEL RIVER MER.

DRILL	_ER			
r-0	gray f gr. seds.	Г <i>во</i>	mea. br. mica.	160
- 5	wood trags.	85	Shale	-165
	gray figr. seds.		t to med, br.	A. A. wet
<i>ا</i> ط	ica	-90	gray, gray-br,	-170 aull coal locally vit.
-15		-95	br. Shale	-175
ZO	ica	_100	tr. bone	-180
_	groval-rounded polymict		shale-goody drilling	A, A,
,	2012	-105	gray to It. br	-105 v. small parting wat
	bone, med br shale	-110	snola A.A.	-190 dull to vit.
- 35	layerers	-115	dk. br. shale	-195 black coal
10	med br shale- 15%, bone (thin lams.)		dull to black	emall parting trown coal
-40	AA	-120	consistent black coal	dull to vit, black coal
-45	A, A,	-125	v.dk. br. tobl.	-205 A.A.
- 50		-130	coal locally vit.	-210
-55	A A Zo% Dona	~135	Α. Α.	A, A,
-99	A. A	7,99	A, A, -	A, A,
-60	brown shale	-140	dull br. to dull bl. coal	-zzo A.A.
-65	gray layers med brown	- 145	bi. dull coal	-225 still good coal maybe slightly
70	Shale 10% pond	-150	Some viti wet	brown -230
	mad brown snale 15% bone		bi. dull to vit. coal	small partings
-75	it to med br	-195	Α, Α.	-235 snale, 10% coal
-80	grayien tint	L160		240

COMPANY HAWLEY RESOURCE GROUP ADD	RESS 7011 OLD SEWARD HWY. ANCH., AK. 9950
PROJECT CHICAGO CREEK	STARTED COMPLETED
CONTRACTOR	GEOPHYSICAL LOGS LOGGED BY
SAMPLES DESCRIBED BY: TK. HINDERMAN	T.D. 250 FT. DIAM.
LOCATION: SEC. 22 T. 6 N.	R. 18 W. MERIDIAN KATEEL RIVER MER.

DRILLER ______

ווווב			
	frozen f.gr.	A.A.	1 ft parting
5	same thing gray	A.A.	dk. br. to bl.
-15		-90 A.A.	A,A.
-20	grave	A.A.	A.A.
-25	med br shale	more dull br.	dull br. coal some bl.
_30	mad to dk	coal, tr. frag. bone - wet	A.A. -190 dk br. to bk.
-35	tan lams bonalika	-115 A. A. more dull br.	-195 COAL
-40	dk. Dr. Silts lam. dk. br.,	coal, some ica dull br. to bl.	-zao hairlina
-45	med br. silts- loc. carb	v. thin parting Some frag. boney layers	-zos dk. br. to bl.
-50	coal dull br. local vit layers	-130 A.A.	-210 COAT 5hale-dk.br.
-55	coal and bone?	-135 A.A	-215 coal frags
-60	w/carbonate séams soft again dull br. coal	-140 A.A.	-zzo A. A.
-65	vit, lams.	- 145 A.A.	-225 A, A.
-70	br. to bl. coal - increas. vit.	-150 dull to vit b1,	-230 A.A.
-75	dull bl. to vit.	A.A.	gray to br. shale coal
L80		L160	- Z40

LITHOLOGIC LOG OF CUTT	INGS	HOLE NO. PH - 3	30-85 PAGE Z OF Z
COMPANY HAWLEY RESOURCE PROJECT CHICAGO CREEK	GROUP ADDI	RESS 7011 OLD SEU	DARD HWY, ANCH. AK 99502 COMPLETED
CONTRACTOR		GEOPHYSICAL LOGS	DET. DIAM.
SAMPLES DESCRIBED BY: TIKIH		T.D. <u>45</u>	DELL DIAM.
LOCATION: SEC.	Т	R	MERIDIAN KATEEL RIVER HER
DRILLER			
ZAO DIENE			
A.A.			
- 245			-
shale			
-Z50 COAL			
	1		
]	1		
-			
<u> </u>			
<u> </u>	<u> </u>		
[
	1		
		-	
	 		- -
]		
<u> </u>	F		-

COMPANY HAWLEY RESOURCE GROUP ADDRESS 7011 OLD SEWARD HWY. ANCH., AK. 99502

				COMPLETED
CONTRACTOR			_ GEOPHYSICAL LO	S LOGGED BY
SAMPLES DESCRIBED BY: T.K. HINDERMAN LOCATION: SEC. 22 T. 6 N.		T.D. 45	FT, DIAM.	
LOCA	TION: SEC	T. <u>6 N.</u>	R. 18 W	MERIDIAN KAI EEL RIVER I-IER.
				-
DRILL	_ER			
-0		00	1	- -160
-0	t.gr. br. seds.			
- 5		85		165
	1111/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1			
-w	green schist	90		-170
-15	bl. schist	-95		-175
L12	W. W. W. W. W. W. W. W. W. W. W. W. W. W	79]	
·	A.A.			
-z <i>o</i>		100		- 180
	A. A.			
-25		- 105	1	-105
	bl. and green scrist			
-30	\U.G.G.G.G.	-110		- 190
ر ا	A. A.			
- 35		-115	_	-195
	black schist			
-40	silic. bl. schis	+ -120		-200
	marci drilling			
-45		-125	1	-205
- 50		- 150		-210
-55		-135	-	-215
-60		-140		zzo
-65		- 145	-	-225
-70		- 150		-230
-75		195	_	-235
	1 1	1 1 1	1	

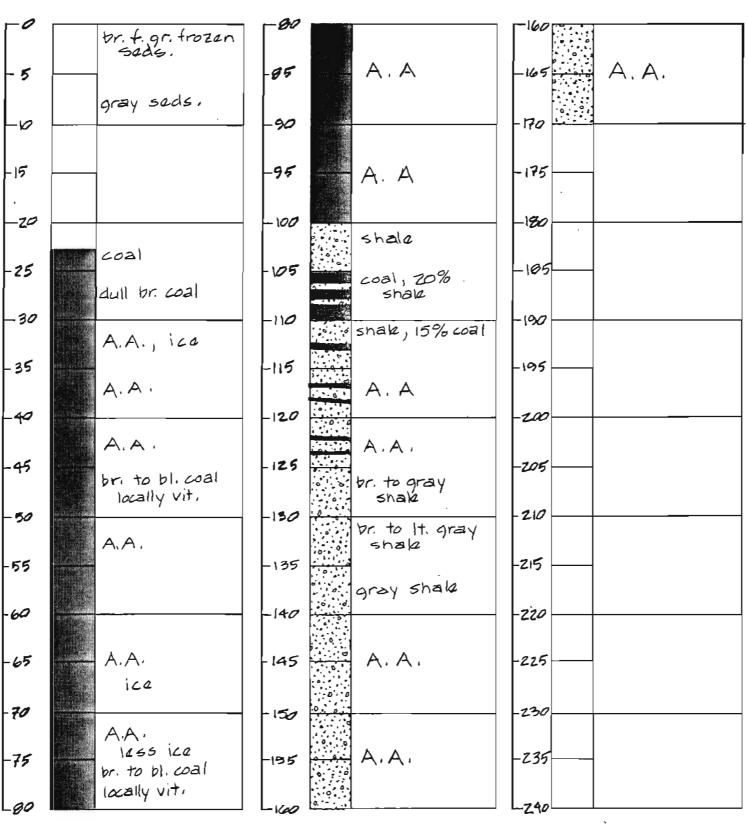
COMPANY HAWLEY RESOURCE GROUP ADD	RESS 7011 OLD SEWARD L	WY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR		
SAMPLES DESCRIBED BY: TK. HINDERMAN		DIAM
LOCATION: SEC. 22 T. 6 N.	R 18 W MERIDI	AN KATEEL RIVER MER.

DRILLER_____

-0		-80	[60[11]]
	fgr. Frozen seds.		shale, coal
- 5		bl. dull to vit.	-165 50% ea.
L0	br siltatone -	-90 CO3.1	-170
	(tart?)	dull dk br.	A. A
-15	A. A.	-95 A.A.	gray to br, ss,
-zo		-100	-1 2 0
-25	A . A .	-105 A.A.	-105
-30	A. A	-110 A.A.	A. A.
- 35	gray to br silt-	A, A. tr. bone	A, A,
- 23	A.A.	dull br. to bl.	A A
-40	tan to med br.	A,A,	50% coal
-45		- i Z 5	-205
-50	gray to br.	A, A,	-210 -210
	AA	A.A.	gray to pr. siltstone
-55	A.A.	-135 dull to vit bli coal.	A.A.
-60	dk, br. siltstona	-140 A.A.	-Z20
-65	coal	-145 A.A. trilica	-225
-70		A. A.	-230 SIN SIN SIN SIN SIN SIN SIN SIN SIN SIN
	300	-195 A, A,	A.A
-75			A A
60		-100	_Z40

COMPANY HAWLEY RESOURCE GROUP ADDRESS 7011 OLD SEWARD HWY. ANCH., AK. 99502 PROJECT CHICAGO CREEK STARTED COMPLETED CONTRACTOR_____ _____ GEOPHYSICAL LOGS_____ LOGGED BY____ SAMPLES DESCRIBED BY: TK HINDERMAN T.D. 170 FT DIAM. LOCATION: SEC. 2Z T. 6N. R. 18W. MERIDIAN KATEEL RIVER MER.

DRILLER ____



COMPANY HAWLEY RESOURCE GROUP ADDRESS 7011 OLD SEWARD HWY. ANCH., AK. 99502 PROJECT CHICAGO CREEK STARTED COMPLETED CONTRACTOR _____ _____ GEOPHYSICAL LOGS_____ LOGGED BY_____ SAMPLES DESCRIBED BY: T.K. HINDERMAN T.D. 150 FT. DIAM. LOCATION: SEC. 22 T. 6N. R. 18 W. MERIDIAN KATEEL RIVER MER. DRILLER _____ -00 trozen f.gr. sads. Loal 85 -165 - 5 A,A, coal -170 90 -10 gravel?, br. br. to bl coal siltstona, coal frags. -15 95 -175 A.A. green - bl -20 100 180 schist A, A-105 -25 105 or siltstone -30 -190 -110 A. A. A.A. shala - 35 -115 -195 tan to br. shale, 50% coal siltstone -120 40 200 It. tan (bone?) shale, 10% coal to be siltstone -125 45 -205 gray to br. med, to alk , br. siltstone shale -210 -130 50 gray shale med. br. 35. -215 -135 55 tan to med br. A.A. 55, 60 -140 -ZZO A. A. C00 65 145 -225 A.A. COB1 230 70 150 ८०५। Z35 75 195 Loal

COMPANY HAWLEY RESOURCE GROUP ADDRESS 7011 OLD SEWARD HWY. ANCH., AK. 99502 PROJECT CHICAGO CREEK STARTED COMPLETED CONTRACTOR _____ GEOPHYSICAL LOGS ___ LOGGED BY_____ SAMPLES DESCRIBED BY: T.K. HINDERMAN T.D. 155 FT. DIAM. LOCATION: SEC. 22 T. 6N. R. 18W. MERIDIAN KATEEL RIVER MER.

DRILLER_____

- <i>0</i>		-80 	
	br. f. gr. seds frozen		
- 5		-95 Coal	-165
<u>ا</u>	gravel	_90	170
	gravel		
-15		-95 coal	175
_zo	bl. schist	-100 boney parting	-130
-25	A.A.	shale, 25% coal	-105
	A. A.	A.A.	
-30		poor return br. siltstona	-190
-35	Hall A. A.	-115 br. siltstona	-195
		A. A.	
40		br, siltstone	-200
-45	(1) A. A.	125	-205
-50		130 A.A.	-210
	Managraen day	A.A.	
-55	or siltstone	135 lost return	-215
-60	br. silt stone	140	-270
~65	siltstone	hole booting	-225
	A. A.	what little came up was	
-70	A. A. A. an stuff	bri shake	-230
-75	(bone?)	-195	-Z35
60	coal	1/40	_z40
-80		-160	

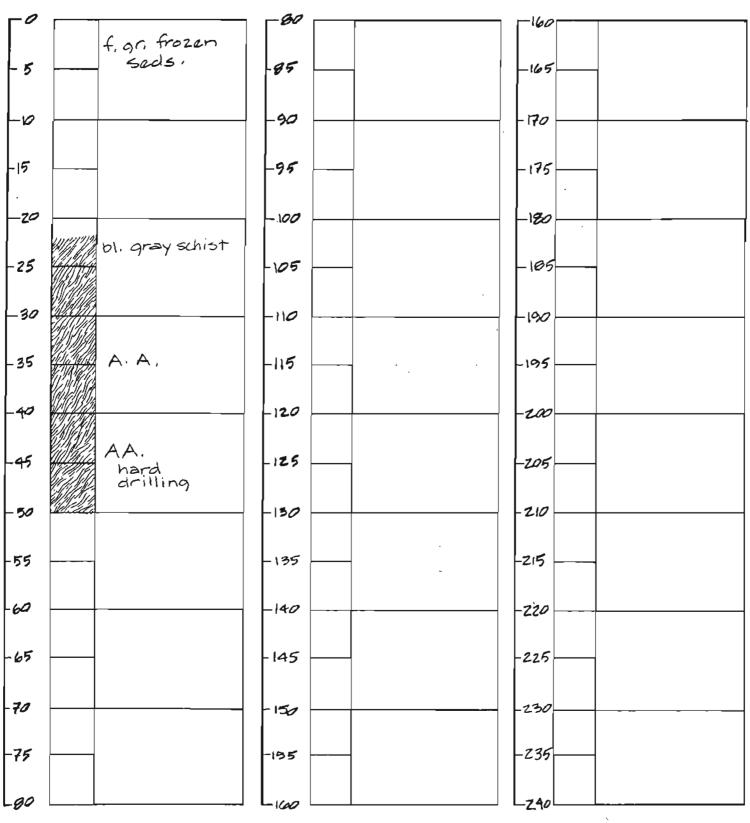
COMPANY HAWLEY RESOURCE GROUP ADDRESS 7011 OLD SEWARD HWY. ANCH., AK. 99502

PROJE	CT CHICAGO CREEK		STARTED COMPLETED GEOPHYSICAL LOGS LOGGED BY				
CONT	RACTOR						
SAMP	LES DESCRIBED BY: R.M.	RETHERFORD	T.D. 190	O FT. DIAM.			
LOCAT	TION: SECZZ	T. 6 N.	_ R. <u>18 W.</u>	MERIDIAN KATEEL RIVER MER.			
DRILL	ER		_				
L 0		60	brown shala	-160			
- 5	10255	-85		-165			
-w		- 90	gray shale	-170			
-15	gravel layer coal trag in gravel	-95		-175 -021			
_zo	graval.	-100	gray shale	-180 good coal			
-25	brown shalk	105	carb. shak	-105 Coal			
_30	20,000 DIDANI DIDANI	- 110	gray shala				
	tan/cresm laminated br shale			-195			
- 35	gray brown	-115	gray brown Shales				
-40	shale	-120	carb. shale,				
-45	no carb yat	-125	rattles	205			
-50	as above	-150	A				
-55	as above	-135	gray br. shales	-z15			
-60	35 Blove	-140	coal bad, vithin				
-65	brown shale	- 145	coal bed gray shale	-225			
-70		- 150					
-75		-195	bown shales	-z35			
an			0	740			

PROJE	CT C	HICAGO CREEK			DRESS 7011 OLD SEWARD HWY. ANCH., AK. 99501 STARTED COMPLETED				
	RACTO		.		GEOPHYSICAL LO	GS	LOGGED E	BY	
SAMP	LES D	ESCRIBED BY: T.K.	TINDER	エタエ	T.D. <u>\</u>	+0 FT.	DIAM		
LOCA	TION:	SEC. 22	<u> </u>	N	R. 18 W.	_ MERIDIA	N KATEEL	RIVER MER.	
		· · · · · ·				-	•		
DRILL	ER								
-0		Y), .	-80	7277-17-T		160 r			
		f. gr. gray to brown			bl. schist				
- 5		- 52ds	-85	25/1/19(1) 11/11/11/1	dk. br. and	-165			
-10		A. A. wood	-90	0	tan siltotone	. 1 - 170			
		A. A.		0					
-15		abundant wood grave	-95	, , ,	med br silts	-175			
-20		,	-100			-180			
		br. sads.					,		
-25		br. sads	-105		dk. to med. br. silts.	-105			
-30		bl. schist	-110	0	med to ak	-190			
-35		A, A,	-115	0	•	-195			
- 52		~.~.			A, A.				
-40		A. A.	-120	0 0 0	۸ ۸	-200			
-45			-125		A. A.	-205			
		green and It,		6	A, A.				
-50		raddish schist	-130	0	A. A.	210 -			
-55		bl. schist	-135		-	-215			
20			-140		A.A.	zzo			
60		red and It. gray schist	-140						
-65	19664 1866)	v. It. gray clay-	-145			-225			
70		rich schist	-150					•	
•-		red and gray schist			•				
-75		b1. schist	-155			-235			
ap			,, ,			1 740			

COMPANY HAWLEY RESOURCE GROUP ADD	RESS 7011 OLD SEWARD	LWY. ANCH., AK. 99502
PROJECT CHICAGO CREEK	STARTED	COMPLETED
CONTRACTOR		
SAMPLES DESCRIBED BY: T.K.H.	T.D. 50 FT	DIAM
LOCATION: SEC. 22 T. 6 N.	R. 18 W. MERIDI	AN KATEEL RIVER MER.
<u> </u>		

DRILLER _____



 10-85	
Hole No.	

Proje	ct:	CH	ICAG	o cre	TK.		Date: <u>6/18/85</u>
Geolo;	gist:	T.K	Hinc	terman		D1	Oriller: A. Throsher
Drill	Туре	May	how	1000	A /R	<u>t.</u> Sa	Sample Type: _SS / 10' DIA: 25/8"
DEPTH	 RUN	RECOV-	BAG/	TYPE ANALY- SIS	FROZEN	 LITHIC	1
 	 		i !				
lotes:	-						
							10-85
							Hole No.

Proje	ct:		- CA-C	-0 (1¢	<u>-</u>			Date:	6/26/95	
Geolog	gist:	_Re	THERE	ord		D:	Driller: THRASHER, A.			
Drill	Type		ng how!	1000	- Air /F	ot s	ample Typ	e: 55/10	' DIA: 23/8"	
DEPTH (FT)	RUN	ERY		ANALY-	FROZEN / THAWED	LITHIC	 	DESCRIPT	LON	
39 40- 41- 42- 43- 44- 45- 46- 41- 49-			BX	\$P.	GROGEN	MANAMAN AND AND AND AND AND AND AND AND AND A	upon with Contract of francis appear con 1 41-431 =	indurated is well of thering is provided as a standard three points at 21/2 11 throck notrix w/ coal ice veins & staye. Think =	black coal with ringers to 1" thick	
Notes: (vay 1 Flace	Cor Crys pic	e descrip co 426	otions!	≤olid Eagments	Messiv d llegge	price 1"	-3") Chip	ken 25 (1/8"-3/4")		
									2 C - 85 Hole No.	
								•	TOTE HO!	

2C-85
Hole No.

Proje	ct:	CH1	CAGO	OCR.				Date	: <u> </u>	6/27/85
Geolo	gist:	RIN	1. R.	ther to-	لم-	D:	riller:	A. Threshor		
Drill	Type:	Ma	hour	1000	Air-F	ટ ન ક	ample Typ	e: <u>\$5/</u>	10'	DIA: <u>23/8"</u>
DEPTH (FT)		RECOV- ERY (FT)		TYPE ANALY-	FROZEN / THAWED	LITHIC	[DESCRIP		
48 49 - 50 -	1		2C-85	 		MINING!	MESSIVE	dull black	coal	black coal
51 - 52 -				 		onvinos Virvinos Virvinos	 	e co.		thous; probably of
53 -	 			 	.] - -	 	<u>Note</u> : 1 2114 s	next lough	run contrins
-	 		1]] 	 	 			
			1	 	 	i i ! !				
Notes										
										C-85
									HA.	1 a Na

Proje	ct:	CHIC	CAGO	CĘ.			Date: 6/27/85
Geolo;	gist:	RIN	1. Re	ther for	J.	Dr	iller: A. Thrisher
							imple Type: 55/10' DIA: 23/8"
	RUN	ERY	BOX	ANALY-	FROZEN / THAWED	LITHIC	DESCRIPTION
52	<u> </u>		3 X 2C-85	¦) F .		nessive dull black and
53 –	<u>-</u>			<u> </u>	į) .	mann	11 31 34 34 34 34 34 34 34 34 34 34 34 34 34
		>	f 	[]		30 126	Frestured in place and
5 4 —	<u> </u>		·	ļ		2000	"chippoil" or highly broken coal
	;	{	 	 		Maria	missive coul
55-					<u> </u>		chipped and (90%-100% coal)
56 -	<u> </u>		<u> </u>	! 	¦	000	-freduced coel
		五	 	 	¦ \$		missive coal.
5 7 —	<u> </u>		. <u>i</u>		į .	Ĺ	
				 	! [
-			¦——	 	}]	L I	
	i]]	1	
_			-		<u> </u>	<u> </u>	
			 		 	<u> </u>	
_	 		[1		<u> </u>	
_	ļļ		<u>.</u>		[_	<u>֡</u> ֡֓֡֝֡֝	
			1		[]	 	
				<u> </u>	<u> </u>	 	
	' '·	_	'	'	'	'	
Notes:							
							2C-85
							Hole No.

2 C-85	
Hole No.	

Proje	ct:	CH	ICAG	OCE	FEK		Date: <u>C/27/85</u>			
Geolo	gist:	R.M	. Ret	her ford		D ₁				
Drill	Type:	Mayh	<u>mr 100</u>	70 - A	ir/Rot	Sa	mple Type: <u>\$5/10'</u> DIA: <u>23/8</u> "			
DEPTH (FT)		ERY		ANALY-	FROZEN / THAWED	LITHIC	DESCRIPTION			
56 57 –	#4 <u>-</u> <u>5</u>	<u> </u>	BX. 2C-85	 	! ! ! !	1	Corect 1 test, plugged off, retrieved small sample; which was coal (added to top of run \$5) Returned to bettom of hole, plugged off on 2.4 rounded colobic of quartz in grownschist.			
58 —	 	-{-	! !	 	\$ F .	Jan Jan	Freduced block coal. Freduced and chipped coal (11 and)			
59 -		423"	 	 			black messive coal			
61-	 	1	 	 		A Sales	black massive coul			
62-	<u>-</u>		<u> </u>	 	♥ 					
_			 	 	 	<u> </u> -	, 			
_			 	 	 	 				
						l				
Notes:	hops	- 57,5'	swite reiding	had fro	m recie	nuch.	to tresh weter			
		_		_		_	2C-85 Hole No.			
							TOTE RO.			

Proje	ct:	CHIC	A60	CREEK			Date: 6/28/85
Geolog	gist:	R .M	1. R	ether fo	d	D1	iller: A. Throsher
Drill	Type:	Mayl	ميد ا	000	tir/Rot.	Sa	mple Type:
DEPTH (FT)		RECOV- ERY (FT)	_	ANALY-	FROZEN / THAWED	LITHIC	DESCRIPTION
62	 		BX. 2C-85	1	' 	 ·	lost core because of rearning
63 -	<u>#6</u>	}	i 	i I	F . 		dull black massive tragments of wal
64	<u> </u>	32"	i 	 			fragmental (up to 3" pieco) and chapped (1/2") and is homogenes; no indication
45 –	<u> </u>		!	 	!	16 125	ico Imae in fracture dipping @ 2500
<i>(6 -</i>	 	-₩	<u> </u>	i !	i ∳ _	6 6 9	lie completed and fragments.
-	 		 	 	 	! <u> </u> 	
_	 		 	 	i -	<u> </u> 	
_	i i 		<u></u>	!	! _	i L	
	 		<u> </u>	 	<u> </u> -	! !	
]] 	} } 	 	 	
_	— 		1	i !	! !	<u> </u> 	
	<u> </u>					i	
Notes	: Ré	pamed a	out hold	trom	39'-63'		
					-	-	20-85
							Hole No.

	2C-85	
•	Hole No.	

Proje	ct:	CHIC	460	CREE	κ,			_	Date:	6/28/85
Geolo;	gist:	R.M.	Reth	erford		D:	riller:	A. 7h.	vehe	
Drill	Type:	Mayba	<u> (850</u>	Air	/Rut.	S	ample Ty	pe: <u>s</u> s	/10'	DIA: 23/8"
DEPTH (FT)	RUN 1	ERY	_	ANALY-	FROZEN / THAWED	LITHIC	[[DES	CRIPTIO	NO.
26 67- 68- 69- 71- 72-		\\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\	2C-85 8d.		F		Frad Sh Wall Frad A 14" w	coal -	black	to core - gray/brown spots - concretion - lile
73- 74- 75- Notes:		filled A		L'-76'	 	 	- most	run.	opining.	nort interval during ethre), 71-76' lost not picked up on
									Ħ	lole No.

2 C-	- 85
Hole	No.

Proje	ct:		41640	-o C1	e	_		Date:	6/28/85		
Geolo,	gist:	RW) Ret	hartore		Driller: A. Thasher					
Drill	Type	· Mayb	Mayhan 1000 Ai			S &	Sample Type: <u>\(\S \) 10'</u> DIA: <u>\(\Z \) 3/\(\B \)</u>				
DEPTH (FT)	RUN	RECOV-		TYPE ANALY- SIS	FROZEN / THAWED	LITHIC] 	DESCRIPTI	ON		
77-	#8 }	{	2C-85	 			Frymonte	d dull black could	/ bown parder w/ knite blade.		
78 —	}		1	[[[MANAGE TO STATE OF THE PARTY OF	frz,	tures.	gs; some vertical		
7 9 —	(f I I	! .	DASA	سمها زي	d, some chipperd as ppti (pyritis) matid coul	on fracture surfices.		
æ−	i_ ♦ _	}		i ! !	i ∳ . !	PEB					
81-	 	<u> </u>	 	i] 	 	<u> </u>					
_	 			 	! !	1 1					
	! ! !			 	 .	<u> </u>					
_	 	 	 	 	 	 <u> </u>					
	l			 	 	 					
Notes		ioul to		o rrown		st run.	(71-76')-	encountered.			
					,				26-85		
-									Hole No.		

3 C-85 Hole No. BOOF MATERIAL

Proje	ct:	<u> </u>	CAGO	CR.			Date: <u>7/3/85</u>
Geolo	gist:	R, M	1. Re	ther for	d	D1	iller: A. Thresher
Drill	Туре	: May	how 1	00 0	Rot/Ai	r Sa	mple Type: _55/ 10' DIA: _23/3*
DEPTH (FT)	(FT)	RECOV-	BOX	ANALY-	FROZEN / THAWED	LITHIC	DESCRIPTION
24—	£ {	1 7	&x 3C 	 	F 		gray claysiltstone, banded (1-2 mm) dip @ 2 55-60°
25 – 26 –			; ————————————————————————————————————				grades downward to homogenous nearly unconsolidated gray silt sclay
Z7 —]		! ! !		higher yercentage of muscovite fragments here
28 - 29 -			 			L !	core is soft, so bagged to protect.
30 —			 		 	 	
31 — 32 —					 	L 1 	
33	3316	,,			 		
HEL IN	tended s plan on tativ	to be oned. This	nses, n bole section	1 of 6E-8 231; is 312 ft h 6-85 on of co	estollow enthored and so ore hours 1-1.	ole); Rote shife, we did wor will	red hole to 23.5' regenics 13ft, massive ice Note: this hole rot get into 6c a good Hole No. ard Highway, Anchorage, AK 99518 673

3C-85
Hole No.
POOF MATL,

Proje	ct:		IC AG	O (Rt	EK			Date	7/3/85	
Geologist:		P.N	1. Re	ther fa	الم	α	Driller: A. Thrusher			
Drill	Type:	_Magba	<u>au 1500</u>	<u>ه A</u> ن	/Rd.	s	ample Typ	DIA: <u>Z 3/8 "</u>		
DEPTH (FT)		ERY	1	TYPE ANALY- SIS		LITHIC	1	DESCRIPT	LION	
33	 #2 ĭ		8× 3C	1	F	 	. -			
34_	ii		<u> </u>		i	<u> </u>	ا وحداء م	ensolidated gran	silt a mudistones.	
35_		-	 		! ! !	<u> </u> _ 	"rolled 1	traguanteed " w	silt a mudistones. j material is jith a four proportions not possible. Once	
<u>3</u> L –		}		 		1 []	50°,		gest dips of about	
34—					-	<u> </u> 	1			
3B-		<u> </u>			¦ ¦	1	T.O. 6.3	B' estimato below.	coal is still 25'	
-				 	 	<u> </u> 	next m	over chord a state of the down to	art dishers to 6E	
	 			 	! - ! ! ! _	<u> </u> 	 			
_			<u>}</u>	 	 	! <u> </u>	 			
				! ! !	! 	 	[
Notes:			·			l	1	-		
									3C-85	
									Hole No.	

4C-85	
 Hole No.	

Proje	ct:	_ C #	1(AG	o cr	FEK		Date: <u>7/8/85</u>
Geolog	gist:	T.K	<u>. 44 1</u> 2	dorma.		D ₁	iller: A. Threshor
Drill	Туре	: Mayb	eur 10	on A	-/Rot	S &	mple Type: <u>55 / 10'</u> DIA: 23/8"
DEPTH (FT)	RUN		BAG/ BOX NO.	TYPE ANALY- SIS	FROZEN / THAWED	LITHIC	DESCRIPTION
60 61- 62- 63- 63- 63- 63- 63- 63-	321	(1006) / / / / / / / / / / /					broken scation Coal A.A. (arebare), local traces of boncy blebs sourceted in sounds to 1/411 or so
							4C-85

4C- 85	
Hole No.	

Proje	ct:	CHI	CAGO	cr.				_ Date	: <u>7/9/85</u>		
Geolog	gist:	R.M	Re-1	ner for	λ	Dr	Driller: A. Thresher				
Drill	Type	Mujh	en 100	O A	ir/Rd	Sa	mple Typ	e: <u>35 / 10</u>	DIA: <u>25/a"</u>		
DEPTH (FT)	RUN	ERY		TYPE ANALY- SIS		LITHIC		DESCRIP	TION		
<u>48</u>	\\ \{\pm\}	{	#2	 	 F 	0°000	Coxl for	agments (1"-	2") dull black		
70 –				 		money money money money	bee	dull black . ding (?) 0 %	دىدا 45°		
71-	 			l 	! ! ! .	000	Cod from				
72 - -			\	 	¦	0000	Cool of	•	wn stranks in coal		
73 —	 			 	 						
74-	i 			i !	i - 	i i L !					
-				 	! ! !	 _ 					
-	 !			[[[
_				 	 	! 					
				l	 	 					
Notes:	<u> </u>	ation	nar	rotary h	ole# 2	3-85			:		
									4C-85 Hole No.		

	40-85
_	Hole No.

Proje	ct:	CHIC	A60	(RFE)				Date:	7/10/85
Geolo	gist:	T.K	(, H)	nderm	2r	Dr	iller: _	A. Throsher	
Drill	Type	· May	hour	1000	Air/Ra	<u>st.</u> Sa	mple Type	: 55/10'	DIA: 23/8"
DEPTH (FT)	RUN	RECOV- ERY (FT)		TYPE ANALY- SIS	· .	LITHIC		DESCRIPTI	ON
%- %- %- %-	10/41	7					Grayish Very organ 5%	tine grained in ic trash; hi	one parting nicceous; alludont gh rlay content locally ally goody work locally vitreous;
102-							Dark to	o med brown it as mucky a	Organic mudstones
Notes	.	-						<u> </u>	<u>4C-85</u> Bole No.

5/th. 4.3/fl. 17 18 17 18 18 18 18 18 18 18	Solid black col, no visible layers Solid black col, brownish layers Solid black col, brownish layers (silly?) are vertical Solid black col, brownish layers Solid black col, brownish layers Solid black col, brownish layers Solid black col, brownish layers Solid black col, brownish layers Solid black col, brownish layers Solid black col, brownish layers Solid black col, brownish layers Solid black col, brownish layers Solid black col, brownish layers	EPTH (FT)	RUN	RECOV- ERY (FT)	BOX	ANALY-	FROZEN / THAWED	LITHIC	DESCRIPTION
52-	51	46 - \\ 47 - \\ 48 - \\ 49 - \\	5/4						solid blick coll, no visible layering
	54-	21-			 	 	! ! ! -		
	otes:	[- -		

5 C-	85	
Hole	No.	

Proje	ct:	CH	ICAG	O CR	FFK			<u> </u>	Date:	7/2/85
Geolog	gist:	_T.K	- Him	tornov	^	r	riller:	A. Th	vasher	
Drill	Туре	: May	heu	10077	Air /	Rot 8	Sample Ty	p e: <u>5</u> 5	/10'	DIA: 23/8"
	RUN	ERY	BOX	ANALY-	FROZEN / THAWED	LITHIC	 	DES	CRIPTIO	ON
101-	F2 1 7		 	 	F		λί			by tragmented
102 –			 	1 			 Solid	black co		k in 1" zone; elly fragmented vitreous luster
103-		7.2 X	 	 		Lyfinillin	Ckavege Brokev		_	
105-	1 B AF		 	 			id Solid	coal		
105-	,	}	 	! 	 	30 0 E	Dull -	on throws	black c	Oit.
107 -	! (
107-	! 		 !	! !	-	 				
110	! 	 	[<u> </u>	 	 			
Notes										
				-						-85

50-85
 Hole No.

Proje	ct:	<u> </u>	KAG	0 (1	PERK				Date:	719185
Geolog	gist:	TK	Hir	dermo	<u>n</u>	D	riller:	_A.	Thrushur	-
Drill	Type	: May	how	1000	Air/R	<u>st</u> s	ample Ty	p e: <u>55</u>	5/10'	DIA: 23/8"
DEPTH (FT)	RUN	ERY		TYPE ANALY- SIS	FROZEN / THAWED	LITHIC	1	DE	SCRIPTIO	N
108			1	 	F		.		-10-1	oal; dull to vitreous
109-	<u> </u>		<u>ii</u>	ii	.i / .		1	DIFOR.	216000	
110_	1 } 1 <u> </u>	3.1) 1.	<u> </u>	i 	-					
111-	 	}	[[1			
112-) 		<u></u>	 	-	L L				
!13-	 		 	 		L !				
112-			<u> </u>	[-	I L I				
115-	!		<u> </u>	! 	 	[<u> </u> 	 			
_			<u> </u>	[-	<u> </u>	<u> </u>	. <u> </u>		
-	 		<u> </u>	 	-	 <u> </u> 				
	 		! 	! 	 	 				
Notes:										
		_								01e No.

Proje	ct:		CHICI	160	CREEK	· ·		_	Date:	7/9/85
Geolo:	gist:	TIK	Hin	dam.	<u> </u>	D ₁	riller:	A .	Thrashur	
Drill	Туре	· May	hour	סממו	Air/Po	<u></u> Sa	ample Typ	pe: <u>5</u>	5/10′	DIA: 75/8"
DEPTH (FT)	RUN	ERY		TYPE ANALY- SIS	FROZEN / THAWED	LITHIC	<u> </u>	D	ESCRIPTIO	N
TEO	1 4 4	5	. 	ļ 	F	111/2/2/1	Broke	n are	<u>а</u>	3 13 1 I
131-	1 3		!				Solid [very	darle brown	to black coal
132-			<u> </u>				-tree	dure	_	
	{ }	1 5/H.		1	}	000	Broken	coul	; trace to	oone
133-	<u> </u>		¦				Solid	dull	oroun to	blade semi-
134-	8/4	<u> </u>	ļ				 	treas	C041	
	! {	\ \ \ \	l]]			Broko.	n coal	- 3/4" 4	sony parting
135-			 			 	 			
156-	 	<u> </u>	<u> </u>		.l .l	1	 			
137-		l	1	1	.l .l .		 			· · · · · ·
121]		 	[!	<u> </u>	<u> </u>			
138-	<u> </u>		!	!	. !	<u> </u>	 			
139-				<u> </u>	-	<u>}</u>	 			
V.	!] 			
120			<u> </u>		i <u></u>		İ			
Notes	• L	est c	ircu la	1,00 -4	Lathan	a of h	nle			
WOLEB			// <u> </u>	776					•	
										C-85 Nole No.

	-			TYPE		1	
DEPTH		ERY (FT)		ANALY-	/ THAWED	LITHIC!	DESCRIPTION
	[<u> </u>			I †	
. 48	 	} {	Box	}		Marsan	
69_		 	₩1	1	 	min	
6) -	i (i		i	į .	miller	run, two narrow zones with some
	}	[)	!	ļ		MATHEMAN	run, two norrow zones with some
70 <u>—</u>	 	}	¦]]	naporal	tragnos re 2"6".
	i {	i {	i	i	1	111117777	some brown color your scutching.
71-		!	ļ	<u> </u>	!.	MINICIA	
		} {] 	מודו ומונים	pyrite nodules (convitors?) noticeable in upper I toot; perfectly spherical
٦,	i }	¦ }			<u> </u>	mm7811	Imm nodules w/ bring that sorm
72 —		!	1		!	MINNIN	1 mm noclules we brims that somm to prolled bedding; look like tiny del
	¦ (}]	MANAMIN	
73 —	 	¦ 	¦		,	LING WEY	
	i \	i }	į	į	į	Marina	
74-	ļ_ <i>_</i>	<u> </u> ₩	. -	<u> </u>		Borrow	·
	1	J I		1	! !	! ! !	
75-		i	.i	i	i _	Ĺ	
7 7 –		1	į –	İ	!	<u> </u>	
		 		 	[! !	
74 —	-	¦		¦	, i		
		ĺ	į	Ì	ļ	į į	
77-	 	l	·}		<u> </u>	<u> </u>	
	!	r !	i	i	i İ	! 	
78.	<u>_</u>	Í	i	i	i	ii	
	l			1	l	ll	

Proje	ct:	CH	ICAGO	O CRE	FEK		.	Date:	713185
Geolo	gist:	[8.W	. Ret	er ford	,	D1	iller: _	A. Thrisher	
Drill	Туре	: Mayh	ما امع	ن و	ot/Air	S &	ample Type:	55/10'	DIA: 25/8"
78 79 - 80 - 81 - 82 - 83 -	RUN (FT)		BOX	ANALY-	FROZEN THAWED	LITHIC	Slowyh & c	DESCRIPTION includes coal from lay mix-plug mosts 3-6" frogmats al chip to partings.	gr, shile etc
85- 86- 87- Notes:	71	run /b st run			ich top		recover and fill solothi litholo	ed larger shile	e . ran 85.7'-86.5 115' primurily slogh. A coal trays har
									lole No.

6C.Z	- 85
Hole	No.

EPTR	 RUN	RECOV-	BAG/ BOX	TYPE ANALY-	FROZEN	 LITHIC	
	1	(FT) 	1 NO.	SIS	THAWED	LOG 	DESCRIPTION
86	44	 7	1 12	1	F		
B7 -	<u> </u>	i		<u></u>	-		Cod fragments 2° and larger; dull black
88		i	V 	! 		0600 8	Coal Chips
,		! }		[[Kilmin	solid coal
в9—) a0 a		¦ 	; ;		Coal dips
90_	<u> </u>	}	 -	ļ	¦		crel trags 1 chips:
91-	<u> </u>	i) !		 	-	5,00	Massive cont. Coil chips parting = reddish sands w/ coat bits.
9Z —		! }		[3 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	doct thips the same sand sailt
93-	45	* 	<u>i</u>	<u> </u>	i	Fried S	<u> </u>
04	}	}		 	۔		Cool chips / Stough - picked out large shale
94-				J		1000	Lord tragmats 2x + 5-the
95-	 	▼ 	 	 	<u>'</u>		Vitreous black could very hand i began to plug borral especially as we were using the tragmost entrare
<u> </u>		[! !	 	! !!	
		l	l	l	l	lI	

60	22-	-85	
Н.	ole	No.	

Proje	ct:	<u> </u>	ICAG	ro cr	٤،		Date: <u>7/4/85</u>
Geolog	gist:	R.M	. Ret	har ford		Dr	iller: A. Thrusher
Drill	Type	· My	ا سمط	0010		S &	mple Type: <u>\less/lo'</u> DIA: <u>23/8</u>
DEPTH (FT)	RUN	ERY	BOX	TYPE ANALY- SIS		LITHIC	DESCRIPTION
95- 95- 97- 98- 9)-	#6		BX #3				Black vitreas unessive and 3"5" Parting - med course loose sand Coal fragments 2"1 or better Chips of Fragments 112"-1" Some visible ice.
Notes:				 			6 C 2 - 85
							Hole No.

Proje	ct:	_CHIO	AGO	CR.					Date:	7/9/8	<u> 15</u>
Geolog	gist:	R.N	1. Ret	herford	l	Dr	riller:	A. T			
Drill	Type:	Meyt	m 100	00 Air	/Rot.	S &	ample Ty	/pe: <u>- 3</u>	5/10'	DIA:	23/8"
DEPTH (FT)	RUN	ERY		TYPE ANALY- SIS	FROZEN / THAWED	LITHIC	 	DI	ESCRIPTIO	ON	
23 24- 25-	 	}	BX] 		al chips to slough		
26 –		}		 	 		l 		o 411 w/ 0° u/bands o ht vitrain		
27 — 28 —				 	 		Chips.	rgmods (3	المرازة الم	le ize ti	> 5% .
29-			 	 	 	<u> </u> 					
30 -	V 		 	 	: - 	<u> </u>					
31 -			 	 	; 	 					
32-			 	 	 	 					
Notes: follors shele,	Local Design	Ajon new	rotagines (hole# 3	14-85 ; 14-85 ; 14-601	Surpeo to	22' sh	rohymphy 2' brown	*S	1 0	
										C-85 lole No.	

Proje	ct:	CHIC	A60	(RE	K				Date:	7/9	185
Geolo;	gist:	R.M	reth	er ford		D:	riller	: <u>_</u> A	Thresher		
Dril1	Type:	Magh	me 1	200	Air/Rot-	S:	ample 7	[ype: _	55/10'	_ DIA:	23/8"
	 RUN (FT)	ERY		TYPE ANALY- SIS	FROZEN / THAWED	1	30.5	Smaller	DESCRIPTI	ON	· / eren erle er
	#2	}	 	 	F		ا <u>سه بي بي بي ا</u> ا حصا 4	agnos s	1. 1°	5/grasasi	/ WW.328 3CKIS
32-		1		 	·		Conl	musive			
73 —	 - -	5		 	-	Alining.	Cool	fragmon	b		
34-				 	-		Cool	chips c	1 trym-17.		
35—			 								
34 —						<u> </u>					
37-	 - 		,—— 1		!	 					
<i>38-</i>			! !		- 	<u> </u> 					
3% —					 	 			•		
40-					 	<u> </u> 					
					Ì						
Notes:									_		
										70-85	
										Hole No.	•

7C-	-85	
Hole	No.	

Proje	ct:	CHI	CAGI	O CRE	ek.		Date: 7/10/85
Geolo;	gist:	_R.M	Ret	her foro	٨,	Dr	iller: A. Thrusher
Drill	Type:	Mayh	o~ 01	so Ai	~ /Rot.	S <i>e</i>	mple Type: <u>SS / 10'</u> DIA: <u>Z3/6"</u>
DEPTH (FT)		ERY	BOX	TYPE ANALY- SIS	FROZEN	LITHIC	DESCRIPTION
80	 		BX #2	 	F	OFF	Coel tragments to 1/2"
81 —	! <u>}</u> }					020	Cal traymol to 2"
8 <u>7</u> —							Coel Chip, 1/4-3/4"
83~]{_ 						Lod fragma 13
84-	<u> </u>				-		brown "pasty" coal looks to be poor gutity
85—	 		 			 	no recovery - could alter have down!
84 —]	! 	no recovery - could ather have drapped off will ground this meterial any.
87—				[]	- 1		
86_			<u> </u>				·
<i>8</i> 9 –	·			 	-	 	
20	 			! 	 	 	
Notes:	: AA	er Run	#2 ro	itmied an	other hale	to 80'	
							7C-85 Hole No.
							TOTE NO.

80-85 Hole No.

(FT)	RUN (FT)	ERY	BOX	ANALY-	FROZEN / THAWED	LITHIC	DESCRIPTION
15 16- 17- 18- 19- 20- 21- 22- 23-	日 ()	3.5					relatively solid black, dull to vitreous a locally has pyrite blobs on fract; locally broken

80-	35	
 Hole	No.	

DEPTH (FT)	RUN	ERY		ANALY-	FROZEN / THAWED	TITHIC	DESCRIPTION
70	#2	2.8	 	 	 	 	Broker black dull to vitreous coal laminited section and woodier
72 - 73 -			 	 	i	69C	Boken coatch ps w/ local fragments toxtures Solid coal Clowerge B & 50-60°
71-	1 		 	 	 - 	 <u> </u>	
75-	 		 	 	 	 	
74-	 		! 	 	 		
77-			 	! !	 	 <u> </u>	
78 —] 	
79	 		 		 	<u> </u> 	
Notes:			 	i	i		
				'			3C-85 Hole No.

BC-85	
Hole No.	

Proje	ct:	CHIC	A60	CPE	とと			Date: _	7-110/85
Geolog	gist:	T.K.	Hind	erman		D1	iller: A.Th	risher_	
Drill	Type	· My	pu 10	00 A	ir/Rot	S &	mple Type: <u>ح</u>	10'	DIA: 23/8"
DEPTH (FT)	RUN (FT) 	ERY (FT) 	BOX	TYPE ANALY- SIS		LITRIC		CRIPTION	
73 74 —	<#3 } (2.4	 	 	F 		Solid black	coel ; dul	1 to vitreous
75 –		2.5	 	 	! ! !		Solid cool		
76-	 		 	 	. .				
-	 		 	 	 .				· · · · · · · · · · · · · · · · · · ·
_	 		i 	i 	i !	<u> </u>			
-			! 	[[!] 			
_ :]] 	! ! !	<u> </u>			
			[[[
Notes:	·		r	·	I	'			
									8 (- <i>8</i> 5
							•		le No.

8C-85	
 Hole No.	

Proje	ct:	CHI	CAGO	o cra	K		Date: <u>7/10/85</u>
Geolog	gist:	R.N	1, Re	therfore	J	D1	riller: A. Throshor
Drill	Type	May	how 1	000 A	ir/Rst.	Sı	ample Type: DIA:
DEPTH (FT)	RUN	ERY	BOX	TYPE ANALY-		 LITHIC LOG	DESCRIPTION
75	#4	{	 	1		6 - 6 - K	slough gtz publiss on top (2") cly s broken coal chips next 2ft.
', 	i_{	i <u> </u>	<u> </u>	i	i !	2017	cly 1 broken coul chips next ZTT.
77—	-			! !	 		o coal fragments (2-2") and drips
78 —	}_		<u> </u>	 	 - 		atan cilty layers Vx o thick
79-	 		 	 	 	 	
80-	 			 	 - 	<u> </u> 	
B1 —			! 	 	 	<u> </u> 	
82-				! 	 -	 <u> </u> 	
83 —	 		i !	i 	i !	<u>†</u> <u>1</u>	
81-			j 	 	 -	<u> </u> 	
85	→		<u> </u>	<u> </u> 	<u> </u> 	i !	
'	·I		'				
Notes:	<u> </u>	eun & Ki	.t.her	- ruined			
							8C-85
							Hole No.

80	<u>L-85</u>
Hole	No.

Proje	ct:	CHI	CKG) (R.				-	Date:	7/11	185
Geolog	gist:	12. M	1. Ro-	her for	J	D1	iller:	A. Thra			
Drill	Type:	Myha	, 000	Air	(Col.	S.	ample Ty	pe: _ <u>S</u>	5/10'	DIA:	23/6"
	RUN I	ERY		TYPE ANALY- SIS		LITHIC	 	DE	SCRIPTIO	N	
90 91 92 93 94 97 99 Notes:		Zotariel					(col) col w/ gray of sand -	many soul	coal (30/2)	hings (b)	PARTIN
										8C-1	
									Ħ	ole No.	

3C-85
Hole No.

Proje	ct:		HICA	460	CREEK			Date	: 7/11/85
Geolo _i	gist:		C, H;	inderma	n	Dr	iller:	A. Throsh	2
Dril1	Type	· May	how 1	5000	Air/Rot	S £	ample Typ	e: <u>55/10</u>	DIA: 23/8"
DEPTH (FT)	RUN		BOX	ANALY-		LITHIC		DESCRIP	TION
	#6				F		Cood, bre bedding	oken, dark b	rown to dull block
116-				 	-		gray Neither	id strate ponti	لمراء لارد و لا
117-			<u> </u>	 	-			·	
!1g —		\ \frac{\lambda}{\cdot \	 	 	-		_ Cod ,	dirt brown . u	maki V
119—			!	 	- -		Cly pa!	inj	
120-			<u> </u>	i					
121-		1	<u></u>	1			. Coal		
122— 		─	1	 	[]	<i> </i>	· (la) pa	rting.	
123—			 	<u> </u> 	i .! _ !				
174-1	₩ 		! !		. .				
 !			 		.¦!				
, I					.''	II			
lotes:							_		
						•	_		80-85 Hole No.

	26-85	
•	Hole No.	

Projec	ct:	CH	1CA6	-0 (1	PEFK				Date:	7/11/85
Geolog	gist:	Ţ.K.	Hin	dorman		Dr	iller:	A. Thr	سيماء	
Dril1	Type:	May	hour 1	000 A	tir/Pot	Sa	ample Ty	pe: <u>S.S</u> /	10'	DIA: <u>23/3"</u>
DEPTH (FT)	RUN	ERY	BOX	TYPE ANALY- SIS	FROZEN /	LITHIC		DESC	CRIPTIC	ON .
37	41		¦		F	<u> </u>				
39 –	 	<u>{</u>	¦	1		Digo D		مامر ب		rk brown; some
?n —			i 				vitre	ous ; local	ly re l	agers; Il bedding
40_		<u> </u>	. [<u></u>			10001	forderes	w/limon	ite stains
4: —			 	 						
42-	i 		. <u> </u>	i		<u>i</u> !				
43-			<u> </u>	<u> </u> 	-	<u> </u> 				
41 -] 	-	<u>[</u> .]				
15-			 	<u> </u> 	-	<u> </u> 				
45—]	 :] 	! 	_	 				_
			 	[
·	''	011	·				-			
Notes:	100	והע עהו.	л ; Г	Tr 201	0					
			_							9C-85.

Proje	ct:	<u>CH</u>	ICAG	0 1	PEK			Date:	7/11/85
Geolog	gist:	<u></u>	· Hi	dorma	Λ	D1	iller:	A. Thrusher	
Drill	Type	Ma	phone !	1000	Air./Rot	<u>.</u> Sa	ample Type	: <u>SS /10'</u>	DIA: 23/8"
DEPTH (FT)	RUN		BOX	ANALY-		LITHIC		DESCRIPTIO	N
57 38 —	=2		 	 			liveon	blede cools - ite on traduces earthy broken	dull to vitneous
52 —			i 	 	- - 		· .	ures @ 45°; E	celling not apparent
40-			 	 					
21—			<u>i</u>	Í	.	<u> </u> 			
12-			<u> </u>	 	-				
43-			<u> </u>						
44—			[
15-	! [! !	! 					
46-			! ! !	 			-		
47.			! !		1	 			
Notes:	<u> </u>	en red	tilling	bejan	_ 4	·-tar	1 ca cun	# <u> </u>	
				,					(-85 ole No.

		RECOV-	BAG/	TYPE	FROZEN	1 1	mple Type: <u>SS/10'</u> DIA: 278"
FT) i	(FT)	ERY (FT)		ANALY- SIS 	THAWED	LITHIC	DESCRIPTION
131-	#3	}		 			Froken coel
1 <u>?</u> 2_	 			 			trice bone
133- 133-			i 	i !	.		Broken coal
134-) 			 !	-		Solid core - black to very dick bro vitrous locally.
135-		∀		! 			
136-				 	 		
137— j 1 1			i	i ! !	i 	<u> </u>	
ાદઇ !			 	 	 !	<u> </u>	
139— []] 	<u> </u>		1	 	 	<u> </u>	
i			<u> </u>	İ		íi	