COAL AS AN ENERGY SOURCE FOR BARROW, ALASKA *

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***~~Situation Report~~

UNITED STATES DEPARTMENT OF THE INTERIOR

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John J. Morgan, Acting Director

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COAL AS AN ENERGY SOURCE FOR BARROW, ALASKA

by

Robert Bottge 1/

ABSTRACT

In answer to a request by the Alaska Power Administration, the Alaska Field Operation Center, U.S. Bureau of Mines, conducted a study to examine the possible costs of providing coal to Barrow, Alaska, as an alternative energy source in the absence of future natural gas supplies. The cost of mining coal near Wainwright was determined using two methods of strip mining and one method of underground mining. The costs for two mine sizes were obtained, one for 46,000 tons of coal per year if coal were used to replace the energy now supplied by natural gas; and one for 143,000 tons per year if coal were used to generate electricity at the mine site or in Wainwright for transmission to Barrow. The cheapest source of coal would be from an area about 17 airmiles south of Wainwright where overburdens of less than 20 feet are encountered. There, the coal could be mined by ripping the overburden with crawler tractors and carrying it away with scrapers for 36 cents or 55 cents per million Btu's depending upon the mine size. For other coal sources closer to Wainwright but under greater cover, underground methods look to be advantageous assuming no ventilation problems are encountered.

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INTRODUCTION

In January 1977, the Alaska Power Administration requested the Alaska Field Operation Center of the U.S. Bureau of Mines to furnish a rough estimate of the cost of mining coal for use as an alternate energy source for the village of Barrow, in northern Alaska (fig. 1). Coal is one of four energy sources available to the village should its present supply of natural gas become depleted, the others being oil and wind. This report was meant to provide a quick appraisal of the possible methods which could be used to mine coal near Barrow and their approximate costs. Although standard engineering techniques were used to derive the cost data given here, this report should not be considered anything other than a first appraisal, a point from which to mount an in-depth engineering study of the subject should further study seem warranted.

In 1976, the South Barrow gasfield produced 828,971.8 Mcf or 828,971,800,000 Btu's. To replace this quantity of energy with coal would require about 46,000 short tons of coal having 9,000 Btu's per pound. If electricity were generated at the mine site and brought to Barrow for heating and lighting approximately 146,000 short tons of 9,000-Btu coal would be required.

Coal is an abundant energy resource in northwest Alaska (3)2/. Surface outcrops occur at Meade River approximately 60 miles south of Barrow and near Wainwright, 90 miles to the southwest (fig. 1). In this report those coals near Wainwright were chosen to develop cost estimates,

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2/ Underlined numbers in parentheses refer to items in the list of references at the end of this report.

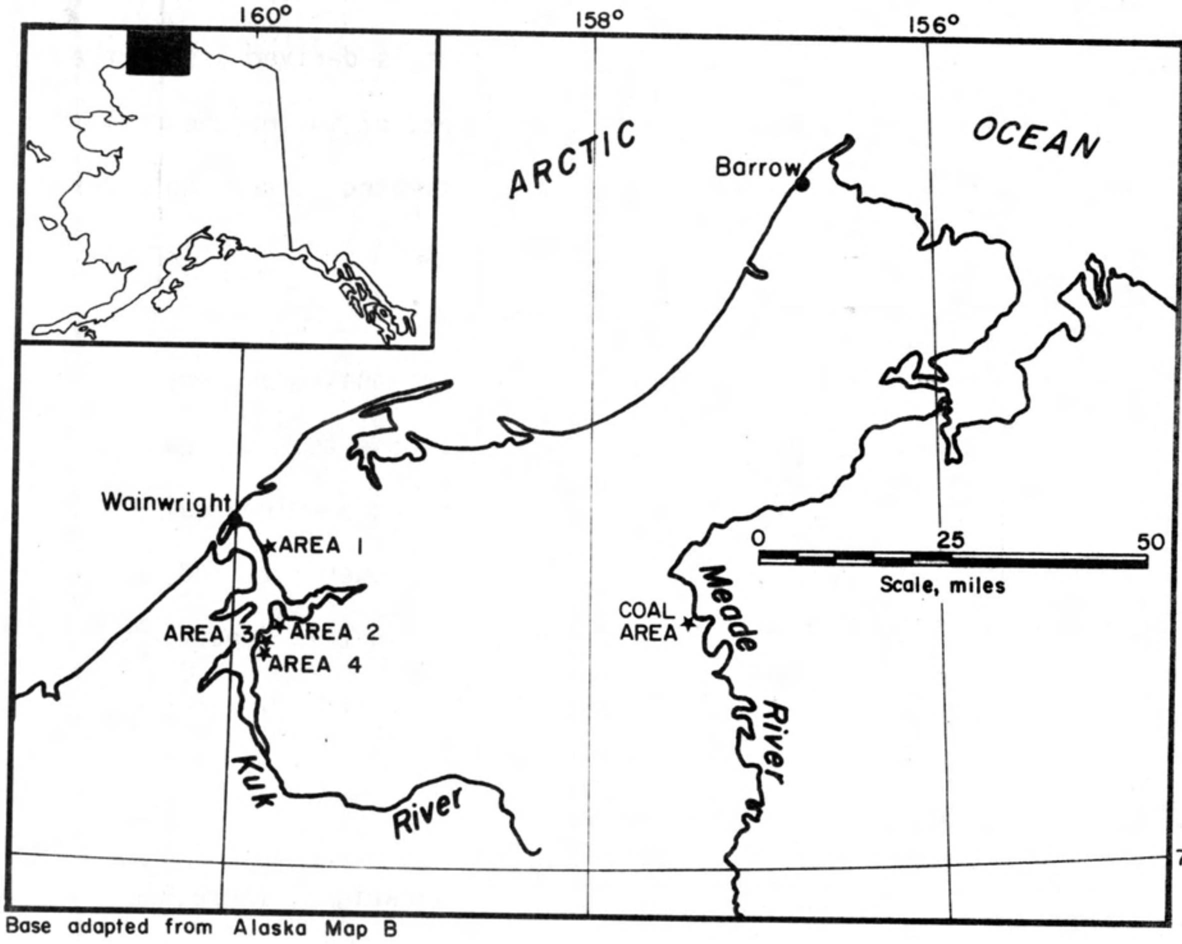

FIGURE 1.—Location map for study area

for a coal mine near Wainwright would benefit two villages. Fulfilling the coal requirements for Wainwright would add about 3,000 short tons per year to the quantities required for Barrow (1). In this report, the cost of mining coal at three sites near Wainwright is derived as are the costs for hauling the coal to Wainwright. The cost of moving the coal from the mine sites to Barrow is only roughly estimated to show an order of magnitude. Presumably it could be hauled overland in the winter or barged to Barrow from Wainwright in the summer.

As coal mining operations go, neither size is considered very large. This can be an advantage if the Natives choose to mine coal to replace the natural gas. The required quantities can be mined quite rapidly. On the other hand, it can be mined at a slower rate and can provide jobs and income during the winter months. In this report, all mining is assumed to occur during the 8-month period from mid-September to mid-May.

GEOLOGY

In spite of the rather remote location of Wainwright, there has been considerable exploration of the existing coal deposits. The coal located near Wainwright is rather uniform occurring in beds ranging from 2 to 26 feet in thickness. Both anticlines and synclines occur with dips ranging from 5° to 7°. These nearly horizontal beds have been traced for several miles along the east shore of the Kuk River, giving indication that coal deposits may exist generally over the entire area.

Area 1

Area 1 is approximately 7-1/2 airmiles southwest of Wainwright on the east bank of the Kuk River. The coalbed lies close to the river and extends about 1,000 feet along the shoreline. Some small amount of mining has been done from the outcrop in the past. Analysis of a coal deposit mined by the Natives in 1945 is given in table 1.

Area 2

Area 2 is about 14-1/2 miles south-southwest of Wainwright on the east bank of the Kuk River. Coal seams of 2, 3 and 5 feet occur in this area and dip at 5° away from the river (fig. 2). An analysis of the upper bed and a composite of the two lower beds is given in table 1. These samples show calorific values of approximately 9,500 Btu's.

Area 3

This mine area is located about 16 miles south of Wainwright on the east bank of the Kuk River. Two coal seams outcrop for a distance of approximately one mile along the river and have a dip of 5° (fig. 2). A combined analysis of the two coal beds given in table 1 shows a calorific value of 9,230 Btu's.

Area 4

Coal in this area, located about 17 airmiles south of Wainwright, may be a continuation of the coal seams in Area 3. Two seams having a combined thickness of over 11 feet outcrop for about one mile along the east bank of the Kuk River (fig. 2). As received analyses show calorific values of 9,570 Btu's for the top bed and 9,850 Btu's for the bottom bed (table 1).

Figure 2 shows coal sections for Areas 2, 3 and 4.

MINING METHODS

Because the coal seams occur near the surface, they could be strip mined or auger mined. Because the ground is permanently frozen,

TABLE 1.- Coal analyses from deposits along the Kuk River near Wainwright, Alaska 1/

Mine area	Condition 2/	Proximate Percent: Moisture	Proximate Percent: Volatile Matter	Proximate Percent: Fixed Carbon	Proximate Percent: Ash	Ultimate Percent: Sulfur	Ultimate Percent: Hydrogen	Ultimate Percent: Carbon	Ultimate Percent: Nitrogen	Ultimate Percent: Oxygen	Calorific Value, B.T.U.	Ash Fusion Temp., 3/	Agglomerating Index
Area #1	1	25.9	28.8	43.3	2.0	0.2	-	-	-	-	9,350	-	-
Area #2													
C-61133	1	25.7	30.0	42.3	2.0	0.3	6.6	54.6	1.1	35.4	9,470	2,320 IDT	NAb
	2	-	40.4	57.0	2.6	0.4	5.0	73.5	1.5	17.0	12,750	2,420 ST	
	3	-	41.5	58.5	-	0.4	5.1	75.5	1.5	17.5	13,100	2,810 FT	
C-61134	1	24.3	30.8	42.5	2.4	0.2	6.5	55.1	1.2	34.6	9,510	2,570 IDT	NAb
	2	-	40.6	56.3	3.1	0.3	5.0	72.9	1.6	17.1	12,560	2,710 ST	
	3	-	41.9	58.1	-	0.3	5.2	75.2	1.6	17.7	12,970	2,750 FT	
Area #3													
C-61135	1	26.7	29.1	41.9	2.3	0.2	6.6	53.4	0.9	36.6	9,230	2,080 IDT	NAb
	2	-	39.7	57.2	3.1	0.3	4.9	72.8	1.3	17.6	12,590	2,200 ST	
	3	-	41.0	59.0	-	0.3	5.1	75.1	1.3	18.2	13,000	2,650 FT	
Area #4												Air Dry Loss,%	Ash Soften Temp.
Bottom Bed	1	19.3	32.0	45.7	3.0	0.3	5.7	57.0	1.2	32.8	9,570	10.6	
	2	-	39.6	56.7	3.7	.4	4.5	70.6	1.5	19.3	11,850	-	
	3	-	41.1	58.9	-	.4	4.6	73.3	1.6	20.1	12,310	-	
Top Bed	1	18.9	34.1	43.4	3.6	0.4	5.8	58.1	1.1	31.0	9,850	10.5	
	2	-	42.0	53.6	4.4	.5	4.5	71.6	1.4	17.6	12,140	-	
	3	-	44.0	56.0	-	.5	4.7	74.9	1.5	18.4	12,700	-	

1/ Source: BuMines Report of Investigation 4150 (6).
2/ 1) Sample as received; 2) dried at 105° C; 3) moisture and ash-free.
3/ IDT = Initial Deformation Temperature; ST = Softening Temperature; FT = Fluid Temperature.

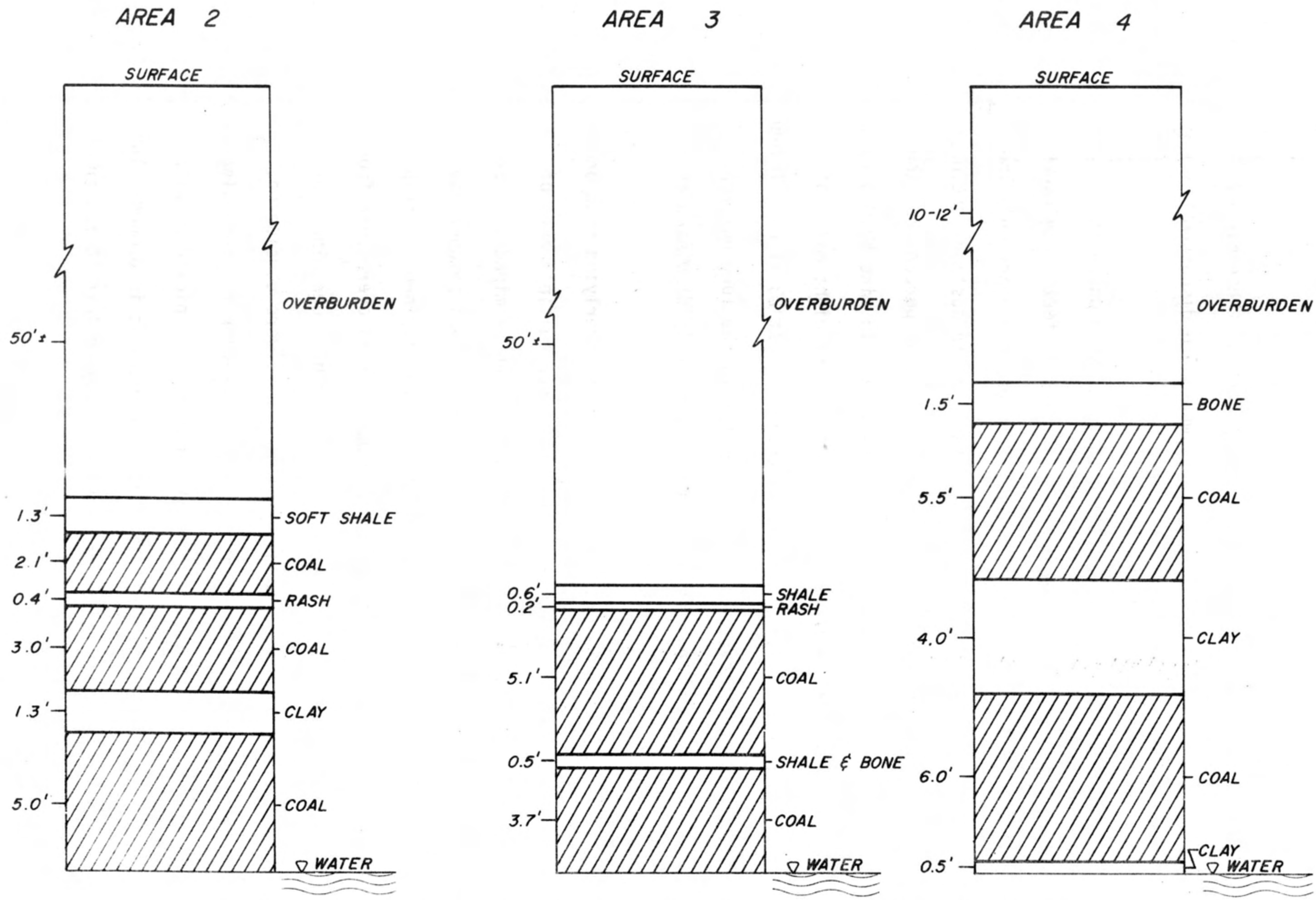

FIGURE 2.— Coal sections along the Kuk River near Wainwright, Alaska

underground mining is another possibility. Each of these mining methods has advantages and disadvantages which are discussed briefly below.

Augering is done by drilling into the coal seam where it is exposed along hillsides. Coal seams of two to six feet in thickness can be mined fairly rapidly and cheaply. As one can auger only 150 feet into a hillside, a long outcrop is required to sustain continued production. The recovery factor is low at 35 to 40 percent and the final appearance of an augered area is unsightly. To mine 50,000 tons of coal from a 6-foot seam each year would require eight miles of outcrops; 145,000 tons per year would require almost 23 miles. Thinner seams would require longer outcrops. Because of the long outcrops requirements and the low recovery rates, augering is dismissed as a viable option.

Strip mining is the process of removing the overlying rock and material (overburden) to expose the coal. Since multiple beds of coal exist near Wainwright, considerable coal can be mined just by going deeper and removing the intervening rock layers between coal seams. Recoveries of nearly 100 percent can be attained in strip mining,and reclamation is an on-going procedure, as overburden from one area is placed in the adjoining area which has been mined out.

In this report, two methods of strip mining were considered. In scenario A, the overburden is broken by a crawler tractor using a single shank ripping tooth. The broken material is picked up with a scraper and carried to the mined out area where it is dumped. The crawler tractor then rips the coal which is loaded into 20-ton trucks for haulage to an adjacent electrical generator or to Wainwright. Mining would be conducted 240 consecutive days, 24 hours per day from mid-September to mid-May.

In scenario B, the overburden is broken by drilling 3-inch holes with air-power percussion drills, filling the holes with ammonium nitrate and fuel oil, and detonating the mixture with dynamite. The broken material is loaded into 20-ton rear-dump trucks and hauled to the adjacent mined out area. The coal is then drilled, blasted, loaded and hauled to a generating site near the mine or to Wainwright. This mining operation would also run 240 consecutive days, 24 hours per day through the winter months.

Underground mining of a 5-foot coal seam is a final possibility considered in this report. Normally, the 20 to 50 feet of overburden over a coal seam would require strip mining; however, where the overlying rocks and material are permanently frozen, underground mining may be very possible as long as thawing is not allowed. Along with fairly high recoveries, about 75 percent, the temperatures underground can be controlled and hence would be more pleasant during the winter months than what would be encountered on the surface. The Arctic winters which can cause a severe strain on machinery used out-of-doors would not present a problem to underground mining.

In scenario C, a 5-foot coal seam is mined using underground methods. Once access is made to the coal seam, conventional underground methods are used. Coal augers drill 1 1/4-inch holes across the coal face and permissible explosives are used to break the coal. The broken coal is picked up with 4-ton capacity battery-powered load-haul-dump units and carried to a conveyor which takes the coal to an outside stockpile. From the stockpile the coal is taken to a nearby electrical generator or to Wainwright.

COSTING PROCEDURES

Two procedures were used to estimate mining costs in this report. For the two strip mining examples, the sizes of the various pieces of equipment were estimated using standard books on earthmoving. The cost for each piece of equipment was taken from the Construction Equipment Cost, Reference Guide (2) which has current cost figures. The operating costs given in the manual were multiplied by a factor of three to account for Arctic winter operation in a remote location. The depreciation and overhead costs given in the manual were raised by 50 percent. An operator cost of $12 per hour was added to the equipment operating costs. No consideration was given to the fact that some equipment was operated only part of the year and a driver would have to be employed full-time. Because these are small-sized mines, probably the personnel can be shifted from one piece of equipment to another as demand requires.

The underground mine costs were determined in a more conventional manner and were based upon small operating mines currently in operation. Lower 48 costs for manpower and operating supplies were provided by the Process Evaluation Group of the Bureau of Mines. The manpower requirements were left the same as for Lower 48 mines; however, wages and supply costs were doubled. The cost to haul the coal to Wainwright was borrowed from the strip mining examples. Although the equipment and manpower requirements for hauling the coal to Wainwright is shown in the capital and manpower tables, these costs were calculated separately from the mining costs.

Because the mining operations are fairly small, an economy of scale does not always occur with the bigger mine. For example, the cost to load coal is more per ton in the larger mine because a full-time loader operator is required. In the smaller mine, the truckdriver loads his own coal as only one truck is required and it takes about two hours to make a round trip from the mine to Wainwright.

DISCUSSION

In this report, the cost to mine coal at three sites south of Wainwright, Alaska, were estimated using three types of mining methods and for two mine sizes. These costs are summarized in table 2.

TABLE 2.- Summary of coal mining costs at three sites near Wainwright, Alaska 1/2/

49,000/50,000 ton-per-year

	Area 2	Area 3	Area 4
Mining cost			
Strip mining	12.71 (0.71)	13.96 (0.78)	9.86 (0.55)
Strip mining-drilling and blasting	19.74 (1.10)	23.02 (1.28)	14.66 (0.81)
Underground	23.47 (1.30)	23.47 (1.30)	23.47 (1.30)
Total cost delivered to Wainwright			
Strip mining-ripping	24.31 (1.35)	26.61 (1.48)	23.30 (1.29)
Strip mining-drilling and blasting	31.40 (1.74)	35.73 (1.98)	28.16 (1.56)
Underground	34.83 (1.94)	35.86 (1.99)	36.62 (2.03)
Total cost delivered to Barrow 3/			
Strip mining-ripping	52.71 (2.93)	53.96 (3.00)	49.86 (2.77)
Strip mining - drilling and blasting	59.74 (3.32)	63.02 (3.50)	54.66 (3.04)
Underground	63.47 (3.53)	63.47 (3.53)	63.47 (3.53)

143,000/145,000 tons-per-year

	Area 2	Area 3	Area 4
Mining cost			
Open pit-ripping	9.84 (0.55)	11.16 (0.62)	6.56 (0.36)
Open pit-drilling and blasting	16.64 (0.92)	17.84 (0.99)	9.72 (0.54)
Underground	16.23 (0.90)	16.23 (0.90)	16.23 (0.90)

1/ Numbers are dollars per short ton.
2/ Numbers in parentheses are dollars per million Btu's.
3/ Coal hauling costs to Barrow were assumed to be the same from all three mine sites.

TABLE 2.- Summary of coal mining costs at three sites near Wainwright, Alaska, Continued

	Area 2	Area 3	Area 4
Total cost delivered to Wainwright			
Open pit-ripping	20.04 (1.11)	22.28 (1.24)	18.29 (1.02)
Open pit-drilling and blasting	26.83 (1.49)	29.03 (1.61)	21.58 (1.20)
Underground	26.35 (1.46)	27.34 (1.52)	28.00 (1.56)

Table 2 indicates that, based upon the assumptions used in this report, strip mining the coal using ripping methods produces the cheapest coal at all three mine sites and for both mine sizes. Strip mining using drilling and blasting techniques is the next cheapest method for the small mine and for the larger mine at Area 4. Underground mining methods are slightly cheaper for the large mine at Areas 2 and 3 where the over-burden is about 50 feet thick. Area 4 is the cheapest to mine due to the relatively shallow coal beds. The cost of underground mining is the same at all three areas; however, the costs at Area 4 would have been slightly less had the development costs been calculated for a 20-foot depth instead of leaving them the same as for the coals having 50 feet of overburden.

Assuming trucks could haul overland in the winter and complete three round trips per 24-hour day hauling 20 tons of coal per trip, the cost to haul coal from the mine sites to Barrow is estimated to be about $40 per ton, or $2.22 per million Btu's. The cost to barge coal from Wainwright to Barrow during the summer months may be cheaper but was not estimated.

The capital costs to produce coal are given in table 3.

TABLE 3.- Capital costs to produce coal at three sites near Wainwright, Alaska 1/

	49,000/50,000 tpy	143,000/145,000 tpy
Mining method		
Strip mining-ripping	$1,829,500	$2,588,000
Strip mining-drilling and blasting	$2,691,000	$4,131,000
Underground	$4,319,000	$5,349,000

1/ Capital costs include the trucks and roadgraders needed to haul the coal to Wainwright.

The lowest capital costs occur for open pit mining using ripping methods. This is due to the simplicity of the operation. Open pit mining using drilling and blasting methods is the next cheapest as only slightly more equipment is necessary. The underground mine is the most expensive due to the need for extra surface facilities, electrical generating capability, and development costs. Capital cost figures include the cost for coal trucks and roadgraders needed to haul the coal to Wainwright. Capital costs would be greater if the coal were to be hauled to Barrow or less if the coal were burned at the mine site for electricity.

SUMMARY AND CONCLUSION

From the standpoint of capital and operating costs, the cheapest way to produce coal near Wainwright is by strip mining using ripping methods at area 4. Forty-nine thousand or 143,000 tons of coal can be mined for 55 cents or 36 cents per million Btu's. These costs would about double if the coal were moved to Wainwright. However, the assumptions used to derive the estimated costs for strip mining using ripping methods are probably the most vulnerable because they rely upon the assumption that the chosen equipment is really tough enough to rip permafrost in low temperatures. If ripping can really be done, even the addition of a second crawler tractor for ripping and the use of a larger size scraper or an additional crawler tractor for pushing would still maintain the attractiveness of this mining method.

For mining coal in Areas 2 and 3, the author would choose underground mining methods after small scale drilling and blasting tests are run underground, such as at an outcrop, to determine whether operating without water suppression of dust is practical. If ventilation is not a problem, the underground mine offers the best opportunity for reducing the estimated cost per ton because the equipment and manpower requirements can double the production shown over a long time period and for very short time periods, production could nearly triple. Also, future production can be increased by adding an additional shift or working seven days a week. Summertime operation is another way of increasing production using a helicopter or low ground pressure vehicle to ferry personnel and supplies to the mine. Coal haulage would still have to be a wintertime process,but additional coal haulage is only a matter of additional trucks.

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APPENDIX A.- STRIP MINING USING RIPPING METHODS

In this scenario, the basic assumption is made that the rocks and other materials can be ripped using a Caterpillar D-8 size crawler tractor with single shank ripper, in the case of the smaller mine, and using a Caterpillar D-9 size crawler tractor for the larger mine.3/ Fifty feet of overburden must be removed at Areas 2 and 3 and 20 feet from Area 4. As the ripping is proposed for the winter months in permafrost formations, the ripping rates, taken from the Caterpillar Performance Handbook (4), 150 bank cubic yards per hour for a single D-8 and 200 bank cubic yards per hour for a single D-9, may be too optimistic.

The ripping rates are 75 percent of the minimum rates given for ripping igneous rocks, the hardest of rocks that are considered rippable. At 150 bank cubic yards per hour, a crawler tractor must rip at 2-3/4 foot intervals, average four inches of penetration per pass, maintain a speed of 100 feet per minute, and 75 percent efficiency.

Following ripping, a single unassisted elevating scraper is assumed capable of picking up the broken material and carrying it to the mined out area. Again, this assumption may be too optimistic in which case another tractor dozer would be needed to push the scraper to maintain production, or a larger scraper chosen. Doubling the estimated scraping time, although doubling the operating cost, would be possible without adding more equipment as the chosen equipment can move the overburden in less than half the time available.

3/ Use of trade names does not imply endorsement of the product by the Bureau of Mines but is rather an attempt to clarify equipment sizes.

Once the overburden is removed, the tractor dozer is used to rip the coal to loosen it for loading. In the case of the 49,000 ton-per year mine, it is assumed the truckdriver will load his own truck, taking ten minutes to start the front-end loader, load the truck, and return the loader to an enclosed shelter. Only one truck would be required for the smaller mine. For the larger mine where three trucks are used, a full-time driver is required and the loader is left running between loadouts.

The coal is hauled to Wainwright in 20-ton 2-axle rear-dump trucks at an average rate of 25 miles per hour on the frozen Kuk River. Whether the ice is strong enough to carry a gross weight of 36 tons from mid-September to mid-May is unknown. If the ice has sufficient strength during only four months, then twice as many trucks would be required. Front-end loader requirements would remain the same in either case.

One round trip per day from Wainwright to the mine site is assumed sufficient to maintain the ice haul road used to haul the coal. Road grading requirements may range from nil to massive. It is possible a raised road may be required on the ice or a raised ice road on the adjoining shore may be required, in which case grading costs would become substantial.

It is assumed that mine personnel would be brought to the mine site in 4-wheel drive one-ton pickups with crew cabs. These pickups and the coal trucks would bring supplies to the mine site as needed. A 2,000-gallon capacity fuel truck would be used to bring diesel fuel to the storage tanks at the mine site as needed.

Based upon the above assumptions, the following costs were derived for mining coal using ripping methods.

TABLE A-1.- Cost per ton to strip mine coal at three sites near Wainwright, Alaska, using ripping methods.

49,000 ton-per-year mine

	Area 2	Area 3	Area 4
Mining:			
Ripping, overburden	$ 4.40	$ 5.20	$ 2.45
Ripping, coal	0.80	0.77	0.84
Scraping, overburden	2.09	2.56	1.16
Reclamation	1.52	1.52	1.52
Fuel Truck	0.18	0.19	0.17
Pickup	1.62	1.62	1.62
Facilities depreciation and insurance	2.10	2.10	9.86
Subtotal for mining	$12.71	$13.96	$ 9.86
Loading, coal	0.94	0.94	0.94
Hauling coal to Wainwright	8.11	8.93	9.54
Road grading	2.55	2.78	2.96
Total, dollars per ton	$24.31	$26.61	$23.30
Total, dollars per million Btu's	$ 1.35	$ 1.48	$ 1.29

143,000 ton-per-year mine

	Area 2	Area 3	Area 4
Mining:			
Ripping, overburden	$ 3.78	$ 4.58	$ 1.69
Ripping, coal	0.81	0.78	0.85
Scraping, overburden	2.22	2.76	1.01
Reclamation	1.42	1.42	1.42
Fuel truck	0.09	0.10	0.07
Pickups	0.55	0.55	0.55
Facilities depreciation and insurance	0.97	0.97	0.97
Subtotal for mining	$ 9.84	$11.16	$ 6.56

TABLE A-1.- Cost per ton to strip mine coal at three sites near Wainwright, Alaska, using ripping methods, Continued

	Area 2	Area 3	Area 4
Loading coal	$ 1.86	$ 1.86	$ 1.86
Hauling coal to Wainwright	7.47	8.39	9.00
Road grading	0.87	0.87	0.87
Total, dollars per ton	$20.04	$22.28	$18.29
Total, dollars per million Btu's	$ 1.11	$ 1.24	$ 1.02

Table A-1 indicates that mining costs for the 49,000 ton per year mine range from $9.86 to $13.96 per ton. The estimated costs for the 143,000 ton per year mine range from $6.56 to $11.16 per ton. Hauling the coal to Wainwright would double these costs, generally speaking. Assuming the coal averaged 9,000 Btu's per pound, the cost of the coal ranged from $1.29 to $1.48 per million Btu's delivered to Wainwright from the smaller mine and $1.02 to $1.24 per million Btu's for the larger mine. The cheapest source of coal is Area 4 due to its lesser thicknesses of overburden, 20 feet versus 50 feet, and its thicker coal seams, 11 feet versus 8 feet and 10 feet.

The following pages contain the rough calculations for this scenario.

A-2.- Equipment list for 49,000 tpy strip mine

Item	Cost, dollars
Crawler tractor, 270 hp, diesel unit w/ U-dozer, rear ripper, ROPS cab, heater, defroster, 73,000#	$ 118,000
Motor scraper, 150 hp, diesel unit, elevating, ROPS cab, 30,000#	66,000
Wheel loader, 100 hp, diesel unit w/3-yd bucket, ROPS cab, heater, defroster, 19,000#	42,000
Truck, 225 hp, diesel unit, 20-ton capacity, off-road, rear-dump w/high sideboards, heater, defroster, 33,000#	75,000
Motor grader, 135 hp, diesel unit w/scarifier, ROPS cab, heater, defroster lights, snowplow, 30,000#	67,000
Fuel truck, 2,000-gallon capacity, 9000#	19,000
Pickup (2), 4 x 4, 1-ton crew cab, 8,000#	16,000
	$ 403,000
Freight: 202,000# @50¢/#	101,000
Total	$ 504,000

A-3.- Facilities for a 49,000 tpy strip mine

Item	Cost, dollars
Office in Wainwright 20 x 30-ft. building @$150/sf	$ 90,000
Repair shop in Wainwright 40 x 40-ft metal building @$90/sf	144,000
Repair shop and office area at mine 40 x 60-ft. metal building @$100/sf	240,000
Fuel tanks at Wainwright, diesel, 5 - 25,000-gallon tanks	250,000
Fuel tanks at mine site, diesel, 3 - 25,000-gallon tanks	150,000
Fuel tank at Wainwright, 15,000 gallon, gasoline	37,500
	$ 911,500
Site development, 10%	92,000
Engineering and construction, 20%	184,000
Contingencies, 15%	138,000
	$ 1,325,500
Equipment	504,000
Total	$ 1,829,500

Depreciation on facilities over 20 years = $1,325,500 ÷ 20-yr = $66,275/yr ÷ 49,000 tpy = $1.35/ton

Insurance at 2% of total cost = $1,829,500 x .02 = $36,590 = $0.75/ton

A-4.- Equipment list for a 143,000 tpy strip mine

Item	Cost, dollars
Crawler tractor, 385 hp, diesel unit w/U-dozer, rear ripper, ROPS cab, heater, defroster, 93,000#	$ 170,000
Motor scraper, 330 hp, diesel unit w/ROPS cab, 65,000#	136,000
Wheel loader, 100 hp, diesel unit w/3-yd. bucket, no-spin differential, ROPS cab, heater, defroster, 19,000#	42,000
Truck (3), 225 hp, diesel unit, 20-ton capacity, off-road, rear-dump w/high sideboards, heater, defroster, 99,000#	225,000
Motor grader, 135 hp, diesel unit w/scarifier, ROPS cab, heater, defroster, lights, snowplow, 30,000#	67,000
Fuel truck, 2,000-gallon capacity, 9,000#	19,000
Pickup (2), 4 x 4, crew cab, 1-ton, 8,000#	16,000
	$ 675,000
Freight: 323,000 x 50¢/#	162,000
Total	$ 837,000

A-5.- Facilities for a 143,000 strip mine

Item	Cost, dollars
Office in Wainwright 25 x 30-ft. building @$150/sf	$ 112,500
Repair shop in Wainwright 40 x 60-ft. building @$90/sf	216,000
Repair shop and office at mine 50 x 60-ft. building @$100/sf	300,000
Fuel tanks at Wainwright Diesel, 6800 bbl @ $50/bbl	340,000
Fuel tanks at mine site Diesel, 4,000 bbls @$50/bbl	200,000
Fuel tank at Wainwright 15,000 gallons, gasoline	37,500
	$1,206,000
Site development, 10%	121,000
Engineering and construction, 20%	242,000
Contingencies, 15%	182,000
	$1,751,000
Equipment	837,000
Total	$2,588,000

Depreciation on facilities over 20 years=$1,751,000 ÷.20
= $ 87,550/yr ÷ 143,000 tpy = $0.61/ton

Insurance @2% of total = $2,588,000 x .02 = 51,760 ÷ 143,000 = $0.36

A-6.- Overburden calculations for strip mines

49,000 tpy

Area 2

10 ft of coal in 3 seams

10 cf/sf = 10 cf/25cf/ton = 0.40 ton/sf

49,000 tons = 122,500 sf = 2.81 acres/yr

$\sqrt{122,500}$ sf = 350 ft/side

2.81 acres/yr x 80,665 bcy 1/ /acre +
1/2 (350 ft x 50 ft x 50 ft) ÷ 27 cf/yd =
226,668 bcy + 16,204 bcy = 242,872 bcy/yr 2/

Area 3

8 ft of coal in 2 seams

8 cf/sf = 8 cf/25cf/ton = 0.32 ton/sf

49,000 tons = 153,125 sf = 3.52 acres/yr

$\sqrt{153,125}$ sf = 391 ft/side

3.52 acres/yr x 80,665 bcy/acre +
1/2 (391 ft x 50 ft x 50 ft) ÷ 27 cf/yd =
283,940 bcy + 18,102 bcy = 302,042 bcy/yr

Area 4

11 ft of coal in 2 seams

11 cf/sf = 11 cf/25 cf/ton = 0.44 ton/sf

49,000 tons = 111,364 sf = 2.56 acres/yr

$\sqrt{111,364}$ sf = 334 ft/side

2.56 acres/yr x 32,266 bcy/acre +
1/2 (344 ft x 20 ft x 20 ft) ÷ 27 cf/yd =
82,601 bcy + 15,926 bcy = 98,527 bcy/yr

143,000 tpy

Area 2

10 ft of coal in 3 seams

10 cf/sf = 10 cf/25 cf/ton = 0.40 ton/sf

143,000 tons = 357,500 sf = 8.21 acres/yr

$\sqrt{357,500}$ sf = 598 ft/side

8.21 acres/yr x 80,665 bcy/acre +
1/2 (598 ft x 50 ft x 50 ft) ÷ 27 cf/yd =
662,260 bcy + 27,685 bcy = 689,995 bcy/yr

Area 3

8 ft of coal in 2 seams

8 cf/sf = 8 cf/25 cf/ton = 0.32 ton/sf

143,000 tons = 446,875 sf = 10.26 acres/yr

$\sqrt{446,875}$ sf = 668 ft/side

10.26 acres/yr x 80,665 bcy/acre +
1/2 (668 ft x 50 ft x 50 ft) ÷ 27 cf/yd =
827,623 bcy + 30,926 bcy = 858,549 bcy/yr

Area 4

11 ft of coal in 2 seams

11 cf/sf = 11 cf/25 cf/ton = 0.44 ton/sf

143,000 tons = 325,000 sf = 7.46 acres/yr

$\sqrt{325,000}$ sf = 570 ft/side

7.46 acres/yr x 32,266 bcy/acre +
1/2 (570 ft x 20 ft x 20 ft) ÷ 27 cf/yd =
240,704 bcy + 4,222 bcy = 244,926 bcy/yr

1/ bcy = bank cubic yards

2/ Flat area plus slope at 45°

A-7.- Ripping time and cost calculations for strip mines

49,000 tpy 1/

Area 2

242,872 bcy/yr ÷ 150 bcy/hr ÷ .75 eff.3/= 2159 hrs/yr

2159 hrs/yr x $74.55/hr =

$160,953	hourly
54,816	fixed
$215,769	total

$215,769/yr ÷ 49,000 tpy (coal) = $4.40/ton

Area 3

302,042 bcy/yr ÷ 150 bcy/hr ÷ .75 eff. = 2685 hrs/yr

2685 hrs/yr x $74.55/hr =

$200,167	hourly
54,816	fixed
$254,983	total

$254,983/yr ÷ 49,000 tpy (coal) = $5.20/ton

Area 4

98,527 bcy/yr ÷ 150 bcy/hr ÷ .75 eff. = 876 hrs/yr

876 hrs/yr x $74.55/hr =

$ 65,306	hourly
54,816	fixed
$120,122	total

$120,122/yr ÷ 49,000 tpy (coal) = $2.45/ton

143,000 tpy 2/

Area 2

689,995 bcy/yr ÷ 200 bcy/hr ÷ .75 eff.3/= 4600 hrs/yr

4600 hrs/yr x $100.95/hr =

$464,370	hourly
76,983	fixed
$541,353	total

$541,353/yr ÷ 143,000 tpy (coal) = $3.78/ton

Area 3

858,549 bcy/yr ÷ 200 bcy/hr ÷ .75 eff. = 5724 hrs/yr

5724 hrs/yr x $100.95/hr =

$577,838	hourly
76,983	fixed
$654,821	total

$654,821/yr ÷ 143,000 tpy (coal) = $4.58/ton

Area 4

244,926 bcy/yr ÷ 200 bcy/hr ÷ .75 eff. = 1633 hrs/yr

1633 hrs/yr x $100.95/hr =

$164,852	hourly
76,983	fixed
$241,835	total

$241,835 ÷ 143,000 tpy (coal) = $1.69/ton

1/ Using a 270 hp crawler tractor.

2/ Using a 385 hp crawler tractor.

3/ eff. = efficiency factor.

A-8.- Scraping time and cost calculations for strip mines

49,000 tpy 1/

Area 2

Average haul distance = 350 feet

bcy/hr = 223   bcy = 242,872

242,872 bcy ÷ 223 bcy/hr÷.75 eff 3/
1452 hrs/yr

1452 hrs/yr x $52.26/hr =

$ 75,882	hourly
26,510	fixed
$102,392	total

$102,392/yr ÷ 49,000 tpy (coal) = $2.09/ton

Area 3

Average haul distance = 391 feet

bcy/hr = 213   bcy = 302,042

302,042 cy ÷ 213 bcy/hr ÷ .75 eff.=
1891 hrs/yr

1891 hrs/yr x $52.26/hr =

$ 98,824	hourly
26,510	fixed
$125,334	total

$125,334/yr÷49,000 tpy (coal) = $2.56/ton

Area 4

Average haul distance = 334 feet

bcy/hr = 227   bcy = 98,527

98,257 cy ÷ 227 cy/hr ÷ .75 eff. =
579 hrs/yr

579 hrs/yr x $52.26/hr =

$ 30,259	hourly
26,510	fixed
$ 56,769	total

$56,769/yr÷49,000 tpy (coal) = $1.16 ton

143,000 tpy 2/

Area 2

Average haul distance = 598 feet

bcy/hr = 334   bcy = 689,995

689,995 bcy ÷ 334 bcy/hr ÷ .75 eff. 3/ =
2754 hrs/yr

254 hrs/yr x $96.27/hr =

$265,128	hourly
52,461	fixed
$317,589	total

$317,589/yr ÷ 143,000 tpy (coal) = $2.22/ton

Area 3

Average haul distance = 668 feet

bcy/hr = 322   bcy = 858,549

858,549 cy ÷ 322 cy/hr ÷ .75 eff. =
3555 hrs/yr

3555 hrs/yr x $96.27/hr =

$342,240	hourly
52,461	fixed
$394,701	total

$394,701/yr÷143,000 tpy (coal) = $2.76/ton

Area 4

Average haul distance = 570 feet

bcy/hr = 340   bcy = 244,926

244,926 bcy ÷ 340 cy/hr ÷ .75 eff. =
960 hrs/yr

960 hrs/yr x $96.27/hr =

$ 92,419	hourly
52,461	fixed
$144,880	total

$144,880/yr÷143,000 tpy (coal) = $1.01/ton

1/ Using a 150 hp scraper.
2/ Using a 330 hp scraper.
3/ eff. = efficiency factor.

A-9.- Coal ripping time and cost calculations for strip mines

49,000 tpy 1/

Area 2: 13-ft. zone

13 ft x 122,500 sf ÷ 27 cf/yd = 58,981 bcy

58,981 bcy/yr ÷ 150 bcy/hr ÷ .75 eff.3/= 524 hrs/yr

524 hrs/yr x $74.55/hr =

$39,064	hourly
0	fixed 4/
$39,064	total

$39,064/yr ÷ 49,000 tpy (coal) = $0.80/ton

Area 3: 10-ft. zone

10 ft x 153,125 sf ÷ 27 cf/yd = 56,713 bcy

56,713 bcy/yr ÷ 150 bcy/hr ÷ .75 eff.= 504 hrs/yr

504 hrs/yr x $74.55/hr =

$37,573	hourly
0	fixed 4/
$37,573	total

$37,573/yr ÷ 49,000 tpy (coal) = $0.77/ton

Area 4: 15-ft. zone

15 ft x 111,364 sf ÷ 27 cf/yd = 61,869 bcy

61,869 bcy/yr ÷ 150 bcy/hr ÷ .75 eff. = 550 hrs/yr

550 hrs/yr x $74.55/hr =

$41,002	hourly
0	fixed 4/
$41,002	total

$41,002/yr ÷ 49,000 tpy (coal) = $0.84/ton

143,000 tpy 2/

Area 2: 13-ft. zone

13 ft x 357,500 sf ÷ 27 cf/yd = 172,130 bcy

172,130 bcy/yr ÷ 200 bcy/hr = .75 eff.3/= 1,148 hrs/yr

1148 hrs/yr x $100.95/hr =

$115,890	hourly
0	fixed 4/
$115,890	total

$115,890 ÷ 143,000 tpy (coal) = $0.81/ton

Area 3: 10-ft. zone

10 ft x 446,875 sf ÷ 27 cf/yd = 165,509 bcy

165,509 bcy/yr ÷ 200 bcy/hr - .75 eff. - 1103 hrs/yr

1103 hrs/yr x $100.95/hr =

$111,348	hourly
0	fixed 4/
$111,348	total

$111,348/yr ÷ 143,000 tpy (coal) = $0.78/ton

Area 4: 15-ft. zone

15 ft x 325,000 sf ÷ 27 cf/yd = 180,556 bcy

180,556 bcy/yr ÷ 200 bcy/hr ÷ .75 eff. = 1203 hrs/yr

1203 hrs/yr x $100.95/hr =

$121,443	hourly
0	fixed 4/
$121,443	total

$121,443/yr ÷ 143,000 tpy (coal) = $0.85/ton

1/ Using a 270 hp crawler tractor.
2/ Using a 385 hp crawler tractor.
3/ eff. = efficiency factor.
4/ fixed cost included with overburden ripping.

A-10.- Loading time and cost calculations for strip mine

Coal weight at 25 cf/ton = 80#/cf x 27 or 2160#/yd

2160#/bcy x .74 shrinkage factor = 1600#/lcy 1/

2-yd bucket will lift 3200# = 1.6 tons/pass

3-yd bucket will lift 4800# = 2.4 tons/pass

3-yd. bucket heaped = 3.3 yd will lift 5280# or 2.64 tons/pass
(say 2.5 tons/pass)

49,000 tpy 2/, 3/	143,000 tpy 2/, 4/
coal loads per year = 2450	continuous running
running time per load = 10 minutes	240 days x 24 hours/day = 5760 hrs/yr
total running time per year = 24,500 min.	75% efficiency = 4320 hrs/yr
24,500 minuts ÷ 45 min/hr = 544 hrs.	4320 hrs/yr x 39.84/hr =
544 hrs/yr x $39.84 hr =	$172,109 hourly 24,156 fixed
$21,673 hourly 24,156 fixed $45,829 total	5760 hrs/yr x $12/hr = 69,120 labor $265,385 total
$45,829/yr ÷ 49,000 tpy (coal) = $0.94/ton	$265,385/yr ÷ 143,000 tpy (coal) = $1.86/ton

1/ lcy = loose cubic yards.

2/ Using a 100 hp wheel loader.

3/ No driver included; truckdriver loads own truck.

4/ Loader operator required full-time.

A-11.- Coal hauling to Wainwright: time and cost caulculations

49,000 tpy 1/

Area 2: Distance to Wainwright=16 miles

Haul time @ 25 mph = (16 mi x 60 mph) / 25 mph =38.4 min
Return time =38.4 min
Man. and dump = 1.0 min
Loading time 3/ =10.0 min
1.46/hr =87.8 min/trip

49,000 tpy÷20 tons/trip=2450 trips x
1.46/hr ÷ .75 eff.=
4769 hrs/yr x $76.26/hr =
$363,684 hourly
33,852 fixed
$397,536 total

$397,536/yr÷49,000 tpy (coal) = $8.11/ton

Area 3: Distance to Wainwright=18 miles

Haul time @25 mph = (18 mi x 60 mph) / 25 mph =43.2 min
Return time =43.2 min
Man. and dump = 1.0 min
Loading time 3/ =10.0 min
1.62/hr =97.4 min/trip

49,000 tpy÷20 tons/trip = 2450 trips x
1.62/hr ÷ .75 eff. =
5292 hrs/yr x $76.26/hr =
$403,568 hourly
33,852 fixed
$437,420 total

$437,420/yr÷49,000 tpy (coal) = $8.93/ton

Area 4: Distance to Wainwright=19.5 miles

Haul time @25 mph=(19.5 mi x 60 mph) / 25 mph = 46.8 min
Return time = 46.8 min
Man. and dump = 1.0 min
Loading time 3/ = 10.0 min
1.74/hr =104.6 min

49,000 tpy÷20 tons/trip = 2450 trips x
1.74 hr/trip ÷ .75 eff. =
5,684 hrs/yr x $76.26 hr =
$433,462 hourly
33,852 fixed
$467,314 total

$467,314/yr ÷49,000 tpy (coal = $9.54/ton

143,000 tpy 2/

Area 2: Distance to Wainwright=16 miles

Haul time @ 25 mph = (16 mi x 60 mph) / 25 mph =38.4 min
Return time =38.4 min
Man. and dump = 1.0 min
Loading time = 3.2 min
1.33/hr =81.0 min/trip

143,000 tpy÷20 tons/trip=7150 trips x
1.33 hr ÷ .75 eff.=
12,679 hrs/yr x $76.26/hr =
$ 966,900 hourly
101,556 fixed
$1,068,456 total

$1,068,456/yr÷143,000 tons(coal) = $7.47/ton

Area 3: Distance to Wainwright=18 miles

Haul time @25 mph = (18 mi x 60 mph) / 25 mph =43.2 min
Return time =43.2 min
Man. and dump = 1.0 min
Loading time = 3.2 min
1.51/hr =90.6 min/trip

143,000 tpy÷20 tons/trip = 7150 trips x
1.51/hr ÷ .75 eff. =
14,395 hrs/yr x $76.26/hr =
$1,097,763 hourly
101,556 fixed
$1,199,319 total

$1,199,319/yr÷143,000 tpy (coal) = $8.39/ton

Area 4: Distance to Wainwright=19.5 miles

Haul time @25 mph=(19.5 mi x 60 mph) / 25 mph =46.8 min
Return time =46.8 min
Man. and dump = 1.0 min
Loading time = 3.2 min
1.63/hr =97.8 min

143,000 tpy÷ 20 tons/trip = 7150 trips x
1.63 hr/trip ÷ .75 eff. =
15,539 hrs/yr x $76.26/hr =
$1,185,004 hourly
101,556 fixed
$1,286,560 total

$1,286,560/yr÷143,000 tpy (coal)=$9.00/ton

1/ Using one truck. 2/ Using three trucks. 3/ Truckdriver loads his own truck.

A-12.- Strip mine reclamation time and cost calculations

49,000 tpy	143,000 tpy
1000 hours per year	2000 hours per year
1000 hrs/yr x $74.55/hr =	2000 hrs/yr x $100.95/hr =
$74,550 hourly	$201,900 hourly
0 fixed 1/	0 fixed 1/
$74,550 total	$201,900 total
$74,550/yr÷ 49,000 tpy (coal) = $1.52/ton	$201,900/yr÷ 143,000 tpy (coal) = $1.42/ton
1000 hrs/yr x $70.02/hr =	3000 hrs/yr x $70.02/hr =
$ 70,020 hourly	$ 210,060 hourly
47,572 fixed	47,572 fixed
$117,592 total	$257,632 total
$117,592/yr ÷ 49,000 tpy (coal) = $2.40/ton	$257,632/yr ÷ 143,000 tpy (coal) = $1.80/ton

1/ Fixed time charged to ripping.

A-13.- Road grading time and cost calculations for strip mining

49,000 tpy	143,000 tpy
<u>Area 2</u>	<u>Area 2</u>
16 miles, 1 round trip per day at 4 miles per hour, 240 days per year	
16 mi ÷ 4 mph x 240 dpy ÷ .75 eff.=	
1280 hrs/yr x $71.31/hr =	
$ 91,277 hourly 33,732 fixed $125,009 total	
$125,009/yr ÷ 49,000 tpy (coal) = $2.55/ton	$125,009/yr ÷ 143,000 tpy (coal) = $0.87/ton
<u>Area 3</u>	<u>Area 3</u>
18 miles, 1 round trip per day at 4 miles per hour, 240 days per year	
18 mi ÷ 4 mph x 240 dpy ÷ .75 eff. =	
1440 hrs/yr x $71.31/hr =	
$102,686 hourly 33,732 fixed $136,418 total	
$136,418/yr ÷ 49,000 tpy (coal) = $2.78/ton	$136,418/yr ÷ 143,000 tpy (coal) = $0.95/ton
<u>Area 4</u>	<u>Area 4</u>
19.5 miles, 1 round trip per day at 4 miles per hour, 240 days per year	
19.5 mi ÷ 4 mph x 240 dpy ÷ .75 eff. =	
1560 hrs/yr x $71.31/hr =	
$111,244 hourly 33,732 fixed $144,976 total	
$144,976/yr ÷ 49,000 tpy (coal) = $2.92/ton	$144,976/yr ÷ 143,000 tpy (coal) = $1.01/ton

A-14.- Fuel truck time and cost calculations for strip mining

49,000 tpy

Area 2

44,850 gpy ÷ 2000 g = 23 trips/yr

Haul time @ 25 mph = $\frac{16\text{ mi} \times 60\text{ mph}}{25\text{ mph}}$ = 38.4 min
Return time = 38.4 min
Loading-unloading time = 40.0 min
1.95 hr = 116.8 min/trip

23 trips/yr x 1.95/hr trip ÷ .75 eff. = 60 hrs 1/

60 hrs/yr x $29.67/hr =
$1,780 hourly
6,950 fixed
$8,730 total

$8,730/yr ÷ 49,000 tpy (coal) = $0.18/ton

Area 3

52,886 gpy ÷ 2000 g = 27 trips/yr

Haul time @ 25 mph = $\frac{18\text{ mi} \times 60\text{ mph}}{25\text{ mph}}$ = 43.2 min
Return time = 43.2 min
Loading-unloading time = 40.0 min
2.11 hr = 126.4 min/trip

27 trips/yr x 2.11/hr trip ÷ .75 eff. = 76 hrs

76 hrs/yr x $29.67/hr =
$2,255 hourly
6,950 fixed
$9,205 total

$9,205/yr ÷ 49,000 tpy (coal) = $0.19/ton

Area 4

28,666 gpy ÷ 2000 g = 15 trips/yr

Haul time 25 mph = $\frac{19.5\text{ mi} \times 60\text{ mph}}{25\text{ mph}}$ = 46.8 min
Return time = 46.8 min
Loading-unloading time = 40.0 min
2.23 hr = 133.6 min/trip

15 trips/yr x 2.23 hr/trip ÷ .75 eff. = 45 hrs

45 hrs/yr x $29.67/hr =
$1,335 hourly
6,950 fixed
$8,285 total

$8,285/yr ÷ 49,000 tpy (coal) = $0.17/ton

143,000 tpy

Area 2

134,885 gpy ÷ 2000 g = 68 trips/yr

Haul time @ 25 mph = $\frac{16\text{ mi} \times 60\text{ mph}}{25\text{ mph}}$ = 38.4 min
Return time = 38.4 min
Loading-unloading time = 40.0 min
1.95 hr = 116.8 min/trip

68 trips/yr x 1.95/hr trip ÷ .75 eff. = 177 hrs 1/

177 hrs/yr x $29.67/hr =
$ 5,252 hourly
6,950 fixed
$12,202 total

$12,202/yr ÷ 143,000 tpy (coal) = $0.09/ton

Area 3

159,355 ÷ 2000 g = 80 trips/yr

Haul time @25 mph = $\frac{18\text{ mi} \times 60\text{ mph}}{25\text{ mph}}$ = 43.2 min
Return time = 43.2 min
Loading-unloading time = 40.0 min
2.11 hr = 126.4 min/trip

80 trips/yr x 2.11/hr trip ÷ .75 eff. = 225 hrs

225 hrs/yr x $29.69/hr =
$ 6,680 hourly
6,960 fixed
$13,630 total

$13,630/yr ÷ 143,000 tpy (coal) = $0.10/ton

Area 4

73,212 gpy ÷ 2000 g = 37 trips

Haul time @25 mph = $\frac{19.5\text{ mi} \times 60\text{ mph}}{25\text{ mph}}$ = 46.8 min
Return time = 46.8 min
Loading-unloading time = 40.0 min
2.23 hr = 133.6 min/trip

37 trips/yr x 2.23 hr/trip ÷ .75 eff. = 110 hrs

110 hrs/yr x $29.67/hr =
$ 3,264 hourly
6,950 fixed
$10,214 total

$10,214/yr ÷ 143,000 tpy (coal) = $0.07/ton

1/ eff. = efficiency factor.

A-15.- Pickup time and cost calculations

49,000 tpy	143,000 tpy
200 miles/day x 240 dpy = 48,000 mpy 1/	
48,000 mpy ÷ 25 mph = 1920 hrs	
1920 hrs x $18.03/hr =	
$34,618 hourly	
5,004 fixed	
$39,622 total	
x 2 $79,244 total	
$79,244/yr ÷ 49,000 tpy (coal) = $1.62/ton	$79,244/yr ÷ 143,000 tpy (coal) = $0.55/ton

1/ mpy = miles per year

A-16.- Diesel fuel requirements for strip mining

Area 2

Ripping	2683 hrs x 270 hp x .06 gph 1/ x .6 eff. 2/	26,079 g	5748 hrs x 385 hp x .06 gph x .6 eff.	79,667 g
Scraping	1452 hrs x 150 hp x .06 gph x .6 eff.	7,841 g	2754 hrs x 330 hp x .06 gph x .6 eff.	32,718 g
Reclaim	1000 hrs x 270 hp x .06 gph x .6 eff.	9,720 g	1000 hrs x 385 hp x 2 gph x .6 eff.	13,860 g
Loading	544 hrs x 100 hp x .06 gph x .6 eff.	1,958 g	4320 hrs x 100 hp x .06 gph x .6 eff.	8,640 g
Hauling	4769 hrs x 225 hp x .06 gph x .6 eff.	38,629 g	12679 hrs x 225 hp x .06 gph x .6 eff.	102,700 g
Grading	1280 hrs x 135 hp x .06 gph x .6 eff.	6,221 g	1280 hrs x 135 hp x .06 gph x .6 eff.	6,221 g
	Wainwright	90,448 g	Wainwright	243,806 g
	Mine site=90,448 g-44,495 g=45,943 g		Mine site=243,806 g - 108,921 g=134,885 g	

Area 3

Ripping	3189 hrs x 270 hp x .06 gph x .6 eff.	30,997 g	6827 hrs x 385 hp x .06 gph x .6 eff.	94,622 g
Scraping	1891 hrs x 150 hp x .06 gph x .6 eff.	10,211 g	3555 hrs x 330 hp x .06 gph x .6 eff.	42,233 g
Reclaim	1000 hrs x 270 hp x .06 gph x .6 eff.	9,720 g	1000 hrs x 385 hp x .06 gph x .6 eff.	13,860 g
Loading	544 hrs x 100 hp x .06 gph x .6 eff.	1,952 g	4320 hrs x 100 hp x 2 gph x .6 eff.	8,640 g
Hauling	5292 hrs x 225 hp x .06 gph x .6 eff.	42,865 g	14395 hrs x 225 hp x .06 gph x .6 eff.	116,600 g
Grading	1440 hrs x 135 hp x .06 gph x .6 eff.	6,998 g	1440 hrs x 135 hp x .06 gph x .6 eff.	6,998 g
	Wainwright	102,749 g	Wainwright	282,953 g
	Mine site=102,749 g-49,863 g=52,886 g		Mine site=282,953 g-123,598 g=159,355 g	

Area 4

Ripping	1426 hrs x 270 hp x .06 gph x .6 eff.	13,861 g	2836 hrs x 385 hp x .06 gph x .6 eff.	39,307 g
Scraping	579 hrs x 150 hp x .06 gph x .6 eff.	3,127 g	960 hrs x 330 hp x .06 gph x .6 eff.	11,405 g
Reclaim	1000 hrs x 270 hp x .06 gph x .6 eff.	9,720 g	1000 hrs x 385 hp x .06 gph x .6 eff.	13,860 g
Loading	544 hrs x 100 hp x .06 gph x .6 eff.	1,958 g	4320 hrs x 100 hp x 2 mph x .6 eff.	8,640 g
Hauling	5684 hrs x 225 hp x .06 gph x .6 eff.	46,040 g	15539 hrs x 225 hp x .06 mph x .6 eff.	125,866 g
Grading	1560 hrs x 135 hp x .06 gph x .6 eff.	7,582 g	1560 hrs x 135 hp x .06 mph x .6 eff.	7,582 g
	Wainwright	82,288 g	Wainwright	206,660 g
	Mine site=82,288 g-53,622 g=28,666 g		Mine site=206,660 g-133,448 g=73,212 g	

1/ gph = gallons per hour.

2/ eff. = efficiency factor.

A-17.- Equipment Operating Costs

Item	Fixed	Hourly
Crawler tractor, 270 hp		
base	$30,328	$ 18.88
dozer	1,387	.46
ripper	4,827	1.51
	$36,544	$ 20.85x3
+ 50%	12,272	62.55
		driver:12.00
	$54,816	$ 74.55
Crawler tractor, 385 hp		
base	$45,106	$ 27.68
dozer	1,387	.46
ripper	4,829	1.51
	$51,322	$ 29.65x3
+ 50%	25,661	59.30
		driver:12.00
	$76,983	$100.65
Scraper, 150 hp		
total	$17,673	$ 13.42x3
+ 50%	8,836	40.26
		driver:12.00
	$26,510	$ 52.26
Scraper, 330 hp		
total	$34,974	$ 28.09x3
+ 50%	17,487	84.27
		driver:12.00
	$52,461	$ 96.27

Item	Fixed	Hourly	
Front-end loader, 100 hp			
total	$ 16,104	$ 13.28	x 3
+ 50%	8,052	39.84	
		12.00	driver
	$ 24,156	$ 51.84	
20-ton truck	$ 22,568	$ 21.42	x 3
+ 50%	11,284	64.26	
		12.00	driver
	$ 33,852	$ 76.26	
Fuel truck	$ 4,639	$ 5.89	x 3
+ 50%	2,320	17.67	
		12.00	driver
	$ 6,959	$ 29.67	
Pickup, 1-ton, 4x4	$ 3,336	$ 2.01	x 3
+ 50%	1,668	6.03	
		12.00	
	$ 5,004	$ 18.03	
Roadgrader			
base	$ 19,378	$ 17.36	
snowplow	1,135	.87	
scarifier	595	.46	
ROPS cab	1,380	1.08	
	$ 22,488	$ 19.77	x 3
+ 50%	11,244	59.31	
		12.00	
	$ 33,732	$ 71.31	

APPENDIX B.- STRIP MINING USING DRILLING AND BLASTING METHODS

In this scenario, the frozen overburden and the coal are broken using drilling and blasting methods. A track-type percussion drill using a three-inch bit is used along with a companion 600 cfm mobile compressor. Frozen rock has been successfully broken in Arctic mining operations in Canada. Penetration rates of 400 feet per shift are assumed adequate to drill the three-inch holes 25 feet deep on seven foot centers. Records of drilling in northern Canada indicate drilling rates of 400 feet per shift could be attained, drilling 50-foot deep holes. One drill and compressor would be sufficient for the smaller mine and at Area 4 for the large mine; two drills and compressors would be required at Areas 2 and 3 for the large mine. Two benches of 25 feet each would be required at Areas 2 and 3, and one bench of 20 feet is drilled at Area 4.

Following the drilling of 60 holes in a three by twenty pattern on seven-foot centers, a mixture of ammonium nitrate and fuel oil (ANFO) is put in the holes and detonated with dynamite. The ANFO and dynamite would be brought from the storage area in Wainwright after the sixty holes were drilled. The truckdriver and the driller would load the holes and detonate the round.

The broken overburden would be loaded by a front-end loader with a 3-1/2 cubic yard bucket into a 20-ton off-the-road rear-dump truck for haulage to the mined out area. Two trucks would be required at Area 3 of the large mine; only one truck would be necessary for all other mine sites. A D-8 size crawler tractor was assumed adequate to level the spoil piles in the worked out pit.

The assumptions made in the previous scenario regarding coal hauling to Wainwright, road grading requirements, and the movement of personnel, supplies and fuel were made for this scenario. With the exception of the costs required for the fuel truck, all other cost estimates for this scenario were just taken from the costs of the previous section.

Based on the above assumptions, the following cost estimates were derived for mining coal using drilling and blasting methods.

TABLE B-1.- Cost per ton to strip mine coal at three sites near Wainwright, Alaska, using drilling and blasting methods

49,000 ton-per-year mine

	Area 2	Area 3	Area 4
Mining			
Drilling, overburden	$ 3.76	$ 4.42	$ 1.98
Blasting, overburden	1.98	1.85	0.60
Drilling, coal zone	0.74	0.69	0.76
Blasting, coal zone	0.30	0.29	0.32
Loading, overburden	2.47	3.80	1.55
Hauling, overburden	2.77	4.20	1.76
Reclamation	2.40	2.40	2.40
Fuel truck	0.18	0.20	0.17
Explosives truck	0.36	0.38	0.33
Pickups	1.62	1.62	1.62
Facilities depreciation and insurance	3.17	3.17	3.17
Subtotal for mining	$19.74	$23.02	$14.66
Loading, coal	1.00	1.00	1.00
Hauling coal to Wainwright	8.11	8.93	9.54
Road grading	2.55	2.78	2.96
Total, dollars per ton	$31.40	$35.73	$28.16
Total, dollars per million Btu's	$ 1.74	$ 1.98	$ 1.56

TABLE B-1.- Cost per ton to strip mine coal at three sites near Wainwright, Alaska, using drilling and blasting methods, Continued

149,000 ton-per-year mine

	Area 2	Area 3	Area 4
Mining			
Drilling, overburden	$ 3.44	$ 4.12	$ 1.34
Blasting, overburden	1.45	1.80	0.51
Drilling, coal zone	0.74	0.69	0.76
Blasting, coal zone	0.30	0.29	0.32
Loading, overburden	3.11	2.13	1.25
Hauling, overburden	3.30	4.49	1.30
Reclamation	1.80	1.80	1.80
Fuel truck	0.11	0.11	0.08
Explosives truck	0.17	0.19	0.14
Pickups	0.55	0.55	0.55
Facilities depreciation and insurance	1.67	1.67	1.67
Subtotal for mining	$16.64	$17.84	$ 9.72
Loading, coal	1.85	1.85	1.85
Hauling coal to Wainwright	7.47	8.39	9.00
Road grading	0.87	0.95	1.01
Total, dollars per ton	$26.83	$29.03	$21.58
Total, dollars per million Btu's	$ 1.49	$ 1.61	$ 1.20

The estimated cost to mine coal at the three mine sites as a rate of 49,000 tons per year ranged from $14.66 per ton at Area 4 to $23.02 per ton at Area 3. These costs for the 143,000 ton per year mines ranged from $9.72 to $17.84 per ton. In general, hauling the coal to Wainwright added about $13 per ton. The total cost for the coal delivered in Wainwright ranged from $1.56 to $1.98 per million Btu's for the smaller mine and from $1.20 to $1.61 per million Btu's for the larger mine. As in the previous scenario, the cheapest source of coal comes from Area 4.

The following pages contain the rough calculations for this scenario.

B-2.- Equipment list for 49,000 tpy strip mine

Item		Cost, dollars
Crawler tractor - 270 hp, diesel unit w/U dozer, ROPS cab, heater, defroster	68,000#	$ 100,000
Wheel loader - 170 hp, diesel unit w/3-1/2 yd bucket, ROPS cab, heater, defroster	33,000#	75,000
Track drill - 4-1/2" bore, heavy duty w/ cab, heater, dust collector	20,000#	50,000
Compressor - 600 cfm rotary vane, mobile		43,000
Truck (2) - 225 hp, diesel unit,-20 ton -13 yd, off-road rear dump w/heater, defroster	66,000#	150,000
Motor grader - 135 hp, diesel unit w/ scanifier, ROPS cab, heater, defroster, lights, snow plow	30,000#	67,000
Fuel truck - 2,000 gal capacity	9,000#	19,000
Explosives truck - 5-ton capacity	10,000#	20,000
Pickup (2) - 4 x 4, 1-ton crew cab	8,000#	16,000
		$540,000
Freight - 244,000# @ 50¢/#		122,000
Total		$ 662,000

B-3.- Facilities for a 49,000 tpy strip mine

Item		Cost, dollars
Office in Wainwright 20 x 30 ft @ $150/sf		$ 90,000
Repair shop in Wainwright 40 x 40 ft @ $90/sf		144,000
Repair shop and office area at mine 50 x 60 ft @ $100/sf		300,000
Fuel tanks at Wainwright, diesel 5 - 25,000 gal tanks		250,000
Fuel tanks at Wainwright, gasoline 1 - 25,000 gal tank		50,000
Fuel tank at mine site, diesel 3 - 25,000 gal tanks		150,000
ANFO tank, Wainwright 10,000 bbl @ $40/bbl		400,000
Explosives building, Wainwright		15,000
		$1,399,000
Site development	- 10%	140,000
Engineering and construction	- 20%	280,000
Contingencies	- 15%	210,000
		$2,029,000
Equipment		662,000
Total		$2,691,000

Depreciation on facilities over 20 yrs = $2,029,000 ÷ 20 = $101,450 =	$	2.07/ton
Insurance @ 2% of total cost = $2,691,000 x .02 = $53,820		1.10

B-4.- Equipment list for a 143,000 tpy strip mine

Item		Cost, dollars	
Crawler tractor - 270 hp, diesel unit w/U dozer, ROPS cab, heater defroster	68,000#	$ 100,000	
Wheel loader - 170 hp, diesel unit w/3-1/2 yd bucket ROPS cab, heater, defroster	33,000#	75,000	
Wheel loader - 100 hp, diesel unit w/3 yd bucket, ROPS cab, heater, defroster	19,000#	42,000	1/
Track drill (2) - 4-1/2" bore, heavy duty w/cab, heater, dust collector	20,000#	100,000	
Compressor (2) - 600 cfm rotary vane, mobile		86,000	
Truck (4) - 225 hp diesel unit, 20-ton, 13 yd, off road, rear dump w/heater, defroster	132,000#	300,000	2/
Motor grader - 135 hp, diesel unit w/ scanifier, ROPS cab, heater, defroster, lights, snow plow	30,000#	67,000	
Fuel truck - 2,000 gal capacity	9,000#	19,000	
Explosives truck - 5-ton capacity	10,000#	20,000	
Pickups (2) 4 x 4, 1-ton, crew cab	8,000#	16,000	
		$ 825,000	
Freight - 349,000# @ 50¢/#		174,500	
Total		$ 999,500	

1/ Not needed for area 4

2/ 5 required for area 3

B-5.- Facilities for a 143,000 tpy strip mine

Item		Cost, dollars
Office in Wainwright 25 x 30 ft @ $150/sf		$ 112,500
Repair shop in Wainwright 40 x 60 ft @ $90/sf		216,000
Repair shop and office at mine 60 x 60 ft @ $100/sf		360,000
Fuel tanks at Wainwright, diesel 7,800 bbl @ $45/bbl		351,000
Fuel tanks at Wainwright, gasoline 1 - 25,000 gal tank		50,000
Fuel tank at mine site 5,800 bbl @ $50/bbl		290,000
ANFO tank, Wainwright 30,000 bbl @ $25/bbl		750,000
Explosives building, Wainwright		30,000
		$2,159,500
Site development	- 10%	216,000
Engineering and construction	- 20%	432,000
Contingencies	- 15%	324,000
		$3,131,500
Equipment		999,500
Total		$4,131,000

Depreciation on facilities over 20 years =
$3,131,500 ÷ 20 = $156,575 ÷ 143,000 = $ 1.09/ton

Insurance @ 2% of total cost = $4,131,000 x
.02 = $82,620 ÷ 143,000 = $ 0.58/ton

B-6.- Track drilling time and cost calculations for strip mines

3" holes - 7 x 7 centers, 60 holes/round - 25 ft depth @ 400 ft/shift - each round is 21 ft x 140 ft = 2940 sf - 60 holes require 30 hrs for 2940 sf

<u>49,000 tpy</u>

<u>Area 2</u> - 122,500 sf÷ 2940 sf/rd = <u>1</u>/

42 rds @ 30 hrs/rd =1260 hrs x 2 benches

2520 hrs x $54.15/hr = $136,458 hourly
47,439 fixed
$183,897 total

$183,897/64 ÷ 49,000 tpy(coal)=$3.75/ton

<u>Area</u> 3 - 153,125 sf ÷ 2940 sf/rd

52 rds x 30 hrs/rd =1560 hrs x 2 benches

3120 hrs x$54.15/hr = $168,948 hourly
47,439 fixed
$216,387 total

$216,387/yr ÷ 49,000 tpy(coal)=$4.42/ton

20 ft depth - 24 hrs per rd

<u>Area 4</u> - 111,364 sf ÷ 2940 sf/rd

38 rds x 24 hrs/rd = 912 hrs - 1 bench

912 hrs x $54.15/hr = $49,385 hourly
47,439 fixed
$96,824 total

$96,824/yr ÷ 49,000 tpy(coal)=$1.98/ton

<u>143,000 tpy</u>

<u>Area 2</u> - 357,500 sf÷ 2940 sf/rd = <u>1</u>/

122 rds @ 30 hrs/rd= 3660 hrs x 2 benches

7320 hrs x $54.15/hr = $396,378 hourly
94,878
$491,256 total

$491,258/yr ÷ 143,000 tpy(coal)=$3.44/ton

<u>Area 3</u> - 446,875 sf ÷ 2940 sf/rd:

152 rds x 30 hrs/rd =4560 hrs x 2 benches

9120 hrs x $54.15/hr = $493,848 hourly
94,878 fixed
$588,726 total

$588,726/yr ÷ 143,000 tpy(coal)= $4.12/ton

20 ft depth - 24 hrs/rd

<u>Area 4</u> - 325,000 sf ÷ 2940 sf/rd =

111 rds x 24 hrs/rd = 2664 hrs - 1 bench

2664 hrs x $54.15/hr = $144,256 hourly
47,439 fixed
$191,695 total

$191,695/yr ÷ 143,000 tpy(coal)= $134/ton

<u>1</u>/rd = round

B-7.- Loading time and cost requirements for overburden and coal

49,000 tpy

Area 2 - 1335 hours overburden
544 hours coal
1879 hours fuel

1879 hrs/yr x $70.50= $132,470 hourly
37,969 fixed
$170,439 total

$170,439/yr ÷ 49,000 tpy = $3.48/ton

Area 3 - 2254 hrs overburden
544 hrs coal
2798 hrs total

2798 hrs/yr x $70.50/hr = $197,259 hourly
37,969 fixed
$235,228 total

$235,228/yr ÷ 49,000 tpy(coal)= $4.80/ton

Area 4 - 689 hrs overburden
544 hrs coal
1233 hrs total

1233 hrs/yr x $70.50/hr = $86,927 hourly
37,969 fixed
$124,896 total

$124,896/yr ÷ 49,000 tpy = $2.55/ton

143,000 tpy

Area 2

5750 hrs/yr x $70.50/hr = $405,375 hourly
37,969 fixed
overburden $443,344
coal 265,385
$708,729 total

$708,729/yr ÷ 143,000 tpy = $4.96/[illegible]

Area 3

3766 hrs/yr x $70.50/hr = $265,503 hourly
37,969 fixed
overburden $303,472
coal 265,385
$568,857 total

$568,857/yr ÷ 143,000 tpy(coal) = $3.98/ton

Area 4

1991 hrs/yr x $70.50/hr = $140,366 hourly
37,969 fixed
overburden $178,335
coal 265,385
$443,720 total

$443,720/yr ÷ 143,000 tpy(coal)= $3.10/ton

B-8.- Overburden haulage time and cost calculations for strip mines

49,000 tpy

Area 2 - 242,872 bcy-haul distance=350 ft

hauling time-350 ft@10 mph= $\frac{350\ ft}{10x.4x88}$=1.00 min	
return time = $\frac{350\ ft}{10\ x.6\ x\ 88}$	.66 min
man. & dump	.50 min
loading time-5 passes x.4m/pass	2.00 min
mpc. minutes/cycle	3.16 m/cy
45 min/hr÷3.16 mpc=14 trips/hr x 13 bcy	182 bcy/hr
242,872 bcy÷182 bcy/hr=1335 hr x 76.26/hr	$101,807
	33,872
	$135,679
$135,679/yr÷ 49,000 tpy(coal)=	$2.77/ton

Area 3 - 302,042 bcy; haul distance = 391 ft

haul time = $\frac{391\ ft}{10mph\ x.4\ x88\ ft}$ =	1.11 min
return time = $\frac{391\ ft}{10\ mph\ x.6x\ 88\ ft}$	.74 min
man. & dump	.50 min
loading time - 5 passes x.4 mpp	2.00 min
	4.35 m/cy
45 min/hr÷4.35 mpc=10.34 trips/hr x 13 bcy	134 bcy/hr
302,042 bcy÷134 bcy/hr=2254 hrs x $72.26/hr	$171,890
	33,872
	$205,762
$205,762/yr÷ 49,000 tpy(coal) =	$4.20/ton

Area 4 - 98,527 bcy; haul distance= 334 ft

haul time = $\frac{334\ ft}{10\ mph\ x\ .4\ x\ 88\ ft}$ =	.95 min
return time = $\frac{334\ ft}{10mph\ x.6\ x\ 88\ ft}$ =	.63 min
man. & dump	.50 min
loading time -5 passes x.4 min/p	2.00 min
	4.08 "/cy
45 min/hr÷4.08 min/cy=11.03 trips/hr x 13 bcy	143 bcy/hr
98,527 bcy÷143 bcy/hr=689 hrs x $76.26/hr	$52,543
	33,872
	$86,415
$86,415/yr ÷ 49,000 tpy(coal) =	$1.76/ton

143,000 tpy

Area 2 - 689,995 bcy - haul distance = 598 ft.

haul time = $\frac{598\ ft}{12\ x.4\ x\ 88}$ =	$1.42 min
return time = $\frac{598\ ft}{12\ x\ .6\ x\ 88}$ =	.94 min
man. & dump	.50 min
loading time 5 passes x.4m/p	2.00 min
	4.86 "/cycle
45 min/hr÷4.86 mpc=9.26 trips/hr x 13 bcy	120 bcy/hr
689,995 bcy÷120 bcy/hr=5750 hr x $76.26/hr	$438,495
	33,872
	$472,367/yr
$472,367/yr÷143,000 tpy(coal)=	$3.30/ton

Area 3 - 858,549 bcy; haul distance = 668 ft

haul time = $\frac{668\ ft}{12mph\ x.4\ x\ 88\ ft}$ =	1.58 min.
return time = $\frac{668\ ft}{12\ mph\ x.6x\ 88\ ft}$ =	1.05 min.
man. & dump	.50 min.
loading time - 5 passes x.4m/pass	2.00 min.
	5.13 m/cycle
45 min/hr÷5.13 m/cycle=8.77 trips /hr x 13 bcy =	114 bcy
858,549 bcy÷114 bcy/hr=7,531 hrs x $76.26/hr	$574,314
	67,744
	$642,058
$642,058/yr÷ 143,000 tpy(coal)	$4.49/ton

Area 4 - 244,926 bcy; haul distance= 570 ft

haul time = $\frac{570\ ft}{12\ mph\ x.4\ x\ 88\ ft}$ =	1.35 min
return time= $\frac{570\ ft}{12\ mph\ x.6\ x88\ ft.}$ =	.90 min
man. & dump	.50 min
loading time - 5 passes x.4 min/p	2.00 min
	4.75 min/cy
45 min/hr÷4.75 min/cy=9.47 trips /hr x 13 bcy	123 bcy/hr
244,926 bcy÷123 bcy/hr=1991 hrs x $76.26/hr	$151,833
	33.982
	$185,705
$185,705/yr ÷ 143,000 tpy(coal) =	$1.30/ton

B-9.- Coal drilling time and cost calculations for strip mines

49,000 tpy

Area 2

13-ft. zone, 16 hrs/rd
122,500 sf ÷ 2940 sf = 42 rds x
16 hrs/rd 1/
672 hrs x $54.15/hr =
$36,899 hourly
0 fixed 2/
$36,389 total

$36,389/yr ÷ 49,000 tpy (coal) =
$0.74/ton

Area 3

10-ft. zone, 12 hrs/rd
153,125 sf ÷ 2940 sf/rd = 52 rds x
12 hrs/rd
624 hrs x $54.15/hr =
$33,790 hourly
0 fixed
$33,790 total

$33,790/yr ÷ 49,000 tpy (coal) =
$0.69/ton

Area 4

15-ft. zone, 18 hrs/rd
111,364 sf ÷ 2940 sf/rd = 38 rds x
18 hrs/rd
684 hrs x $54.15/hr =
$37,039 hourly
0 fixed
$37,039 total

$37,039/yr ÷ 49,000 tpy (coal) =
$0.76/ton

143,000 tpy

Area 2

13-ft. zone, 16 hrs/rd
357,500 sf ÷ 2940 sf = 122 rds x
16 hrs/rd 1/
1952 hrs x $54.15/hr =
$105,701 hourly
0 fixed 2/
$105,701 total

$105,701/yr ÷ 143,000 tpy (coal) =
$0.74/ton

Area 3

10-ft. zone, 12 hrs/rd
446,875 sf ÷ 2940 sf/rd = 152 rds x
12 hrs/rd
1824 hrs x $54.15/hr =
$98,770 hourly
0 fixed
$98,770 total

$98,770/yr ÷ 143,000 tpy (coal) =
$0.69/ton

Area 4

15-ft. zone, 18 hrs/rd
325,000 sf ÷ 2940 sf/rd = 111 rds x
18 hrs/rd
1998 hrs x $54.15/hr =
$108,192 hourly
0 fixed
$108,192 total

$108,192/yr ÷ 143,000 tpy (coal) =
$0.76/ton

1/ rd = round.

2/ Fixed time charged to overburden.

B-10.- Explosives requirements and truck time and cost calculations

Area 2 - 242,872 bcy waste 1/
58,981 bcy coal zone
301,853 bcy total
301,853 bcy x 1.2#/cy = 181 tons ANFO
201,233 tons x .45#/ton =
90,556# = 45 tons
46 trips/yr x 1.95 hr/trip
÷ .75 eff = 120 hrs
120 hrs/yr x $29.85/hr = $3,582 hourly
13,956 fixed
$17,538 total
$17,538/yr÷ 49,000 tpy(coal) = $0.36/ton

Area 3 - 302,042 bcy waste
56,713 bcy coal
358,755 bcy total
358,755 bcy x 1.2#/cy = 215 tons ANFO
239,170 tons x .45#/ton =
107,626# = 54 tons
54 trips/yr x 2.11 hr/trip
÷ .75 eff = 152 hrs
152 hrs/yr x $29.85/hr = $4,537 hourly
13,956 fixed
$18,493 total
18,493/yr÷ 49,000 tpy(coal) $0.38/ton

Area 4 - 98,527 bcy waste
61,869 bcy coal
160,396 bcy total
160,396 bcy x 1.2#/cy = 96 tons ANFO
106,930 tons x .45#/ton =
48,118# = 24 tons
24 trips/yr x 2.23 hr/trip
÷ .75 eff = 71 hrs
71 hrs/yr x $29.85/hr = $2,119 hourly
13,956 fixed
$16,075 total
$16,075/yr÷ 49,000 tpy(coal) $0.33/ton

Area 2 - 689,995 bcy waste 1/
172,130 bcy coal
862,125 bcy total
862,125 bcy x 1.2#/cy = 517 tons ANFO
574,749 tons x .45#/ton =
285,637# = 129 tons
130 trips/yr x 1.95 hr/trip
÷ .75 eff = 338 hrs
338 hrs/yr x $29.85/hr = $10,089 hourly
13,956 fixed
$24,045 total
$24,045/yr÷ 143,000 tpy(coal) $0.17/ton

Area 3 - 858,549 bcy waste
165,509 bcy coal
1,024,058 bcy total
1,024,058 bcy x 1.2#/cy = 614 tons ANFO
682,705 tons x .45#/ton =
307,217# = 154 tons
154 trips/yr x 2.11 hr/trip
÷ .75 eff = 433 hrs
433 hrs/yr x $29.85/hr = $12,925 hourly
13,956 fixed
$26,881 total
$26,881/yr÷ 143,000 tpy (coal) $0.19/ton

Area 4 - 244,926 bcy waste
180,556 bcy coal
425,482 bcy total
425,482 bcy x 1.2#/cy = 255 tons
283,654 tons x .45#/ton =
127,644# = 64 tons
64 trips/yr x 2.23 hr/trip
÷ .75 eff = 190 hrs.
190 hrs/yr x $29.85/hr = $5,672 hourly
13,956 fixed
$19,628 total
$19,628/yr÷ 143,000 tpy(coal) $0.14/ton

1/ bcy = bank cubic yards

B-11.- Fuel truck time and cost calculations for strip mining

49,000 tpy

Area 2 - 45,953 gpy÷2,000 g= 23 trips/yr 1/

haul time@25mph= $\frac{16m \times 60}{25 \text{ mph}}$ = 38.4 min
return time = 38.4 min
loading-unloading 40.0 min
1.95 hr = 116.8 min

23 trips/yr x 1.95 hr/trip ÷.75 eff = 60 hrs 2/
60 hrs/yr x $29.67/hr = $1780 hourly
6950 fixed
$8730 total
$8730/yr ÷ 49,000 tpy(coal) $0.18/ton

Area 3 - 72,058 gpy÷2000 g= 37 trips

haul time @ 25 mph = $\frac{18m \times 60}{25 \text{ mph}}$ = 43.2 min
return time = 43.2 min
loading-unloading 40.0 min
2.11 hr = 126.4 min

37 trips/yr x 2.11 hr/trip ÷.75 eff = 105 hrs
105 hrs/yr x $29.67/hr = $3,115 hourly
6,950 fixed
$10,065 total
$10,065/yr÷ 49,000 tpy(coal)= $0.20/ton

Area 4 - 35,388 gpy÷2000 g = 18 trips/yr

haul time @ 25 mph= $\frac{19.5 m \times 60}{25 \text{ mph}}$ 46.8 min
return time 46.8 min
loading-unloading 40.0 min
2.23 hr = 133.6 min

18 trips/yr x 2.23 hr/trip ÷ .75 eff = 54 hrs.
54 hrs/yr x $29.67/hr = $1602 hourly
6950 fixed
$8552 total
8552/yrs÷ 49,000 tpy(coal)= $0.17/ton

143,000 tpy

Area 2 - 215,483 gpy÷2000 g= 108 trips/yr 1/

haul time @ 25mph= $\frac{16m \times 60}{25 \text{ mph}}$ = 38.4 min
return time 38.4 min
loading-unloading 40.0 min
1.95 hr = 116.8 min

108 trips/yr x 1.95 hr ÷ .75 eff = 281 hrs 2/
281 hrs/yr x $29.67/hr = $8337 hourly
6950 fixed
$15287 total
$15,287/yr ÷ 143,000 tpy(coal $0.11/ton

Area 3 - 200,646 gpy÷2000 g= 101 trips/yr

haul time @ 25 mph= $\frac{18m \times 60}{25 \text{ mph}}$ = 43.2 min
return time 43.2 min
loading - unloading 40.0 min
2.11 hr = 126.4 min

101 trips/yr x 2.11 hr/trip ÷ .75 eff = 284 hrs
284 hrs/yr x $29.67/hr = $ 8,426 hourly
6,950 fixed
$15,376 total
$15,376/yr÷ 143,000 tpy(coal)= $0.11/ton

Area 4 - 99,679 gpy÷ 2000 g = 50 trips/yr

haul time @ 25 mph = $\frac{19.5 \times 60}{25 \text{ mph}}$ = 46.8 min
return time 46.8 min
loading-unloading 40.0 min
2.23 hr = 133.6 min

50 trips/yr x 2.23 hr/trip ÷ .75 eff = 149 hrs.
149 hrs/yr x $29.67/hr = $4421 hourly
6950 fixed
$11371 total
$11,371/yr÷ 143,000 tpy(coal) = $0.08/ton

1/ gpy = gallons per year

2/ eff. = efficiency

B-12.- Diesel fuel requirements for strip mining

			1/2/		
	Drilling	2520 hrs x 200 hp x .06 gph x .6 eff.	9,072 g 1/2/	7320 hrs x 200 hp x .06 x .6 eff.	52,704 g 1/2/
c	Drilling	672 hrs x 200 hp x .06 gph x .6 eff.	4,838 g	1952 hrs x 200 hp x .06 x .6 eff.	14,054 g
	Loading	1879 hrs x 170 hp x .06 gph x .6 eff.	11,499 g	5750 hrs x 170 hp + 8640 g	43,830 g
	Hauling	1335 hrs x 225 hp x .06 gph x .6 eff.	10,814 g	5750 hrs x 225 hp x .06 x .6 eff.	46,575 g
c	Hauling	4769 hrs x 225 hp x .06 gph x .6 eff.	38,629 g	12679 hrs x 225 hp x .06 x .6 eff.	102,700 g
	Reclaim	1000 hrs x 270 hp x .06 gph x .6 eff.	9,720 g	3000 hrs x 270 hp x .06 x .6 eff.	29,160 g
	Grading	1280 hrs x 135 hp x .06 gph x .6 eff.	6,221 g	1280 hrs x 135 hp x .06 x .6 eff.	6,221 g
		Wainwright	90,793 g		324,404 g
		Minesite-90,793 g- 44,850 g = 45,943 g		324,404 g-108,921 g = 215,483 g	
	Drilling	3120 hrs x 200 hp x .06 gph x .6 eff.	22,464 g	9120 hrs x 200 hp x .06 x .6 eff.	65,664 g
c	Drilling	624 hrs x 200 hp x .06 gph x .6 eff.	4,493 g	1824 hrs x 200 hp x .06 x .6 eff.	13,133 g
	Loading	2798 hrs x 170 hp x .06 gph x .6 eff.	17,124 g	3766 hrs x 170 hp + 8640 g	31,688 g
	Hauling	2254 hrs x 225 hp x .06 gph x .6 eff.	18,257 g	7531 hrs x 225 hp x .06 x .6 eff.	61,001 g
c	Hauling	5292 hrs x 225 hp x .06 gph x .6 eff.	42,865 g	14395 hrs x 225 hp x .06 x .6 eff.	116,600 g
	Reclaim	1000 hrs x 270 hp x .06 gph x .6 eff.	9,720 g	3000 hrs x 270 hp x .06 x .6 eff.	29,160 g
	Grading	1440 hrs x 135 hp x .06 gph x .6 eff.	6,998 g	1440 hrs x 135 hp x .06 x .6 eff.	6,998 g
		Wainwright	121,921 g		324,244 g
		Minesite-121,921 g- 49,863 g=72,058 g		324,244 g- 123,598 g = 200,646 g	
	Drilling	912 hrs x 200 hp x .06 gph x .6 eff.	6,566 g	2664 hrs x 200 hp x .06 x .6 eff.	19,181 g
c	Drilling	684 hrs x 200 hp x .06 gph x .6 eff.	4,925 g	1998 hrs x 200 hp x .06 x .6 eff.	14,386 g
	Loading	1233 hrs x 170 hp x .06 gph x .6 eff.	7,546 g	1991 hrs x 170 hp + 8640 g	20,825 g
	Hauling	689 hrs x 225 hp x .06 gph x .6 eff.	5,581 g	1991 hrs x 225 hp x .06 x .6 eff.	16,127 g
c	Hauling	5684 hrs x 225 hp x .06 gph x .6 eff.	46,040 g	15539 hrs x 225 hp x .06 x .6 eff.	125,866 g
	Reclaim	1000 hrs x 270 hp x .06 gph x .6 eff.	9,720 g	3000 hrs x 270 hp x .06 x .6 eff.	29,160 g
	Grading	1560 hrs x 135 hp x .06 gph x .6 eff.	7,582 g	1560 hrs x 135 hp x .06 x .6 eff.	7,582 g
		Wainwright	88,960 g		233,127 g
		Minesite-88,960 g- 53,622 g = 35,338 g		233,127 g- 133,448 g = 99,679 g	

1/ gph = gallons per hour

2/ eff. = efficiency factor.

B-13.- Equipment operating costs

	Fixed	Hourly
4 1/2-in. tract drill and 600 cfm compressor		
base, drill	$14,610	$ 5.87
cab	945	.39
heater	256	.12
dust collector	1,507	.62
flood lights	584	.24
compressor	13,724	6.81
	$31,626	$14.05x 3
+ 50%	15,813	42.15
		12.00
	$47,439	$54.15
Front-end loader, 170 hp		
base	$22,670	$18.18
bucket	1,595	.87
ROPS cab	1,048	.45
	$25,313	$19.50 x 3
+50%	12,656	58.50
		12.00
	$37,969	$70.50
5-ton truck		
base	$ 9,304	$ 5.95 x 3
+50%	4,652	17.85
		12.00
	$13,956	$29.85

APPENDIX C.- UNDERGROUND MINING

This scenario considers a room and pillar underground mining method to mine a five-foot thick coal seam. Conventional coal mining methods are assumed feasible with coal augers used to drill 1 1/4-inch holes across the coal face and permissible explosives used to break the coal following undercutting. The broken coal is picked up with four-ton capacity battery-powered load-haul-dump units and carried from the face to an 18-inch conveyor located in the entryway where it is conveyed to an outside stockpile.

Entry to the coal seam would be by a 10° slope. If the coal seam is 50 feet underground, the slope would be about 300 feet long. Where the coal depth is 20 feet the slope would be about 115 feet long. A main entry 20 feet wide is driven in the coal seam with 20-foot wide production headings driven at right angles to the right and left. As the coal is mined, ten-foot pillars of coal are left between the headings. After a heading is mined to a distance of 2500 feet from the main entry it would be sealed, flooded, and frozen. The resulting ice block would act as a pillar and add additional support against possible subsidence. All mining would be done at temperatures of 20° to 25° F to prevent thawing of the pillars and of the coal. Thawed coal would present a handling problem once it was brought to the surface and exposed to freezing temperatures. Following mining, the ceiling would be roof bolted on five-foot centers and the coal sprayed with fine limestone dust.

The advent of the battery powered load-haul-dump units, or scoop trams, have made possible high productivity underground mining. Production of 94 tons per shift for each man at the face has been reported in the literature (5). In this scenario, only one-half of that productivity is assumed due to the uncertainties associated with this proposal. The greatest uncertainty may arise with ventilation. As no water will be used in the mine, assuming an operating variance can be obtained, dust suppression may make working conditions impossible without a life support unit for each person. How efficiently a person can work underground in below freezing temperatures wearing an oxygen mask, if needed, is a major unknown. Assuming working in these conditions is possible, and that 425 tons per shift can be attained, then only 118 working days would be necessary to produce 50,000 tons of coal, and 171 days would be needed for 145,000 tons of coal. The smaller mine would be worked one shift per day and the larger mine two shifts per day.

As the underground mining equipment runs on batteries, a 400 kilowatt coal-fired generator is proposed. Although the mine would operate five days per week, the boiler system is assumed to run seven days a week during the months the mine is operating. Operating the boiler would require about 1,000 tons of coal per year for the small mine and 1,500 tons of coal per year for the large mine.

The mined coal would be loaded from an outside stockpile into 20-ton trucks and hauled to Wainwright 24 hours a day, 240 consecutive days each year. The same loading procedure employed in scenario A for a strip mine would be used here. The same assumptions and costs estimated for loading, hauling, and road grading in that scenario were used here.

Based upon the assumptions stated, the following cost estimates were derived for underground mining.

TABLE C-1.- Cost per ton to mine coal at three sites near Wainwright, Alaska, using underground mining methods

50,000 ton-per-year mine

	Area 2	Area 3	Area 4
Mining	$ 23.47	$ 23.47	$ 23.47
Loading	0.94	0.94	0.94
Hauling coal to Wainwright	8.11	8.93	9.54
Grading	2.31	2.52	2.67
Total, dollars per ton	$ 34.83	$ 35.86	$ 36.62
Total, dollars per million Btu's	$ 1.94	$ 1.99	$ 2.03

145,000 ton-per-year mine

	Area 2	Area 3	Area 4
Mining	$ 16.23	$ 16.23	$ 16.23
Loading	1.86	1.86	1.86
Hauling coal to Wainwright	7.47	8.39	9.00
Grading	0.79	0.86	0.91
Total, dollars per ton	$ 26.35	$ 27.34	$ 28.00
Total, dollars per million Btu's	$ 1.46	$ 1.52	$ 1.56

Table C-1 indicates that the cost to mine coal underground was $23.47 per ton for 50,000 tons per year and $16.23 per ton for 145,000 tons per year, or $1.30 and $0.90 per million Btu's, respectively. Transporting the coal to Wainwright would add about $12 per ton to the mining cost of the small mine and $11 per ton to the cost at the large mine bringing the total cost to approximately $35 and $27 per ton at the small and large mine, respectively. The approximate total cost per million Btu's for coal delivered in Wainwright would be $2.00 and $1.50 for the small and large mines, respectively.

Capital costs for mining, loading, hauling, roadgrading equipment, and all surface facilities at Wainwright and at the mine sites was $4.3 million for the small mine and $5.3 million for the large mine with 13 hourly and five salaried people. For the large mine 33 people would be required, 26 hourly and seven salaried.

The following pages contain the calculations that were used to derive the cost data for this scenario.

C-2- Equipment list for conventional underground 50,000 tpy coal mine

Item	Cost,dollars
Coal drill - battery, 75 hp	$ 60,000
Cutting machine - 12 ft head, 100 hp	140,000
Scoop trams (2) - battery 150 hp	260,000
Roof bolter - dual boom @ 50 hp	60,000
Feeder breaker - 125 hp	55,000
Supply vehicles - battery, 80 hp	40,000
Triple duty rock duster - battery, 30 hp	40,000
Mechanic jeep - battery, 15 hp	15,000
Personnel jeep - 7.5 hp	14,000
Battery charger	5,000
Conveyor system - 500 ft, 18 inch @ 20 hp	100,000
Ventilation fan - 60,000 cfm, 50 hp	40,000
Ventilation fan, auxilary - 3,000 cfm, 10 hp	5,000
All service mask - 15	2,000
Breathing apparatus - 2	2,000
Self rescuer - 15	1,000
Stretcher set - 2	500
Safety light - 15	1,000
Methanometer - 5	2,000
Fire chemical car	5,000
Lamps - 15	1,000
Dust sampler (2)	1,000
Conveyor fire protection	1,000
Automatic controls and alarms	2,000

Item	Cost, dollars
Site preparation	$ 20,000
Concrete portal	40,000
Bulk rock dust facility	20,000
Bath house, office, and lamp house 20 x 30 ft @ $100/sf	60,000
Shop and warehouse @ mine 40 x 60 ft @ $100/sf	240,000
Powder and cap house	12,000
Electrical generator and building, coal fired, 400 kw	325,000
Pickup truck (2 - 4 x 4 crew cab)	16,000
Front end loader, gasoline, 1 yd bucket	26,000
Office in Wainwright - 20 x 30 ft @ $150/sf	90,000
Warehouse in Wainwright - 40 x 60 ft @ $100/sf	240,000
Fuel tanks @ Wainwright - 15,000 gal. gasoline	37,500
Fuel tanks @ Wainwright - 2-25,000 gal. diesel	100,000
Road grader - 12- G	82,000 1/
Fork lift (2)	50,000
Crane @ Wainwright - 13 tons	98,000
Front end loader - 3 yd bucket	52,000 1/
Truck - 20 tons	93,000 1/
Road grader	50,000
Exploration	$2,504,000
Site development - 10%	250,000
Engineering and construction - 20%	500,000

1/ Not included in depreciation, accounted for separately

Item	Cost, dollars
Contingencies - 15%	$ 375,000
	$3,629,000
Estimated development cost	690,000
TOTAL	$4,319,000

Working capital not included. Equal to one year's operating cost plus trucking and/or barging costs.

C-3.- Development cost for 50,000 tpy underground coal mine

Item	Cost, dollars
Ramp- 300 ft to coal - 16 ft wide, 6 ft high 28,800 cf @ $3/cf x 2 inflation x 3 for place	$ 518,000
Development - 100 ft into coal - 20 ft wide, 5 ft high, 10,000 cf @ $3	180,000
Credit for coal mined - 400 tons @ $20/ton	- 8,000
	690,000

C-4.- Depreciation table for 50,000 tpy underground coal mine

Item	Depreciation Years	Cost Dollars
Underground equipment	10	$ 78,400
Ventilation fans	20	2,200
Safety equipment	5	3,700
Surface equipment	10	17,900
Buildings and facilities	20	43,000
Generator and building	20	16,200
Pickup trucks	5	3,200
Exploration	20	2,500
		$167,100
Depreciation for site development, engineering and construction, contingencies, and development costs	20	90,800
Total		$257,900

C-5.- Manning table for 50,000 tpy underground coal mine

	No.	Wages/day	Cost per 118 days, dollars
Underground:			
Coal driller and shot firer	1	$ 98.50	$ 11,620
cutting machine operator	1	104.00	12,270
Scoop trammers	2	100.00	23,600
Roof bolter	1	105.00	12,390
Utility man	1	94.00	11,090
Electrician/mechanic	1	110.00	12,980
Beltman	1	104.00	12,270
Foreman	1	136.00	16,050
	9		$112,270
Surface:			
Electricain/mechanic	1	100.00	11,800
Truck driver	1	96.00	1/
Grader operator	1	96.00	1/
Helper (gofer)	1	90.00	10,620
	4		$ 22,420
Salary:			
Superintendent/engineer	1		50,000
Survey/drafting	2		40,000
Timekeeper	1		15,000
Purchasing agent & office mgr.	1		30,000
	5		$135,000
Total	18		$269,690 = $5.50/ton

1/ Accounted for separately.

C-6.- Power requirements for 50,000 tpy underground coal mine

Item	hp	Kw	hr/day	Total Kw-hr
Coal drill	75	56	6	336
Cutting machine	100	75	6	450
Scoop tram (2)	300	224	5	1120
Roof bolter	50	37	5	185
Feeder-breaker	125	93	6	558
Supply vehicles	80	60	3	180
Rock duster	30	22	2	44
Mechanic jeep	15	11	2	22
Personnel jeep	7.5	6	2	12
Conveyor system	20	15	8	120
Ventilation, main	50	37	9	333
Ventilation, aux.	10	7	9	63
Lights, shop tools, etc.				300
Total				3723

3723 Kw-hrs/day x 10,000 Btu/Kw-hr = 37,230,000 Btu/day

37,230,000 Btu/day ÷ 18,000,000 Btu/ton coal = 2.07 tons/day x 118 days = 244 tons/yr ; 6.21 tons/day x 180 days = 1118 tons/yr

C-7.- Estimated annual production cost for 50,000 tpy underground coal mine

Item	Cost, dollars
Direct costs	
Production labor	$ 83,240
Maintenance labor	35,400
Salary and supervision	151,050
	$ 269,700
Operating supplies	
Machinery parts, 90¢/ton	$ 45,000
Lubricants, 80¢/ton	40,000
Roof belts and timber, $1/ton	50,000
Rock dust, 11#/ton x 50,000 tpy x $200/ton	55,000
Explosives, $1.20/ton	60,000
Ventilation, 80¢/ton	40,000
Drilling rods and bits, 30¢/ton	15,000
Miscellaneous	25,000
	$ 330,000
Power, 6.21 tons/day x 180 days x $22/ton	$ 24,600
Payroll overhead @40% of payroll	107,900
	$ 732,200
Indirect cost	
10% of labor and supplies	$ 100,300
Fixed cost	
Insurance, 2% of capital cost	$ 83,000
Depreciation	257,900
	$ 340,900
Total	$1,173,400 = $23.47/ton

C-8.- Equipment list for a conventional underground 145,000 tpy coal mine

Item	Cost, dollars
Coal drill, battery, 75 hp	$ 60,000
Cutting machine, 12-ft. head, 100 hp	140,000
Scoop tram (2), battery, 150 hp	260,000
Roof bolter, dual boom, 50 hp	60,000
Feeder breaker, 125 hp	55,000
Supply vehicles, battery, 80 hp	40,000
Triple duty rock duster, battery, 30 hp	40,000
Mechanic jeep, battery, 15 hp	15,000
Personnel jeep, battery, 7.5 hp	14,000
Battery charger	7,000
Conveyor system, 500 ft., 18-in., 20 hp	100,000
Ventilation fan, 60,000 cfm, 50 hp	40,000
Ventilation fan, auxiliary, 3,000 cfm, 10 hp	5,000
All service mask (15)	2,000
Breathing apparatus (2)	2,000
Self rescuer (15)	1,000
Stretcher set (2)	500
Safety light (15)	1,000
Methanometer (5)	2,000
Fire chemical car	5,000
Lamps (15)	1,000
Dust sampler (2)	1,000
Conveyor fire protection	1,000
Automatic controls and alarms	2,000
Site preparation	20,000
Concrete portal	40,000
Bulk rock dust facility	40,000
Bathhouse, office & lamphouse, 20 ft x 30 ft x $100/sf	60,000
Shop and warehouse at mine, 60 ft x 60 ft x $100/sf	360,000
Powder and cap house	12,000
Electrical generator, building, coal-fired, 400 Kw	325,000
Pickup truck (2), 4 x 4, 1-ton, crew cab	16,000
Front-end loader, gasoline, 1-yd bucket	26,000
Office in Wainwright, 20 ft x 30 ft x $150/sf	90,000
Warehouse in Wainwright, 60 ft x 60 ft x $100/sf	360,000
Fuel tanks at Wainwright, 25,000 gallon, gasoline	50,000
Fuel tanks at Wainwright, 7,000 bbls x $50/bbl (diesel	350,000
Roadgrader	82,000 1/
Front-end loader, 3-yd	52,000 1/
Fork lift (2)	50,000
Crane at Wainwright, 13-ton	98,000
Truck (3), 20-ton	279,000 1/
Exploration	50,000
	$ 3,214,500
Site development, 10%	321,000
Engineering and construction, 20%	642,000
Contingencies, 15%	481,500
	$ 4,659,000
Estimated development cost	690,000
Total	$ 5,349,000

1/ Not included in depreciation table; accounted for separately.
Working capital not included. Equal to two month's operating plus trucking costs.

C-9.- Development cost for 145,000 tpy underground coal mine

	Cost, dollars
Ramp - 300 ft to coal, 16 ft wide, 6 ft high 28,800 cf @ $18/cf	$ 518,000
Development - 100 ft into coal, 20 ft wide, 5 ft high	180,000
Credit for coal mined, 400 tons X $20/ton	-8,000
Total	$ 690,000

C-10.-Depreciation table for 145,000 underground coal mine

	Depreciation Years	Cost Dollars
Underground equipment	10	$ 78,400
Ventilation fans	20	2,200
Safety equipment	5	3,700
Surface equipment	10	18,100
Buildings and facilities	20	69,100
Generator and building	20	16,200
Pickup trucks	5	3,200
Exploration	20	2,500
		$ 193,400
Depreciation for site development, engineering and construction, contingencies and development cost	20	106,700
Total		$300,100

C-11.- Manning table for 145,00 tpy underground coal mine

Underground:	No.	Daily wages	Cost per 171 days, dollars
Coal driller & shot firer	2	$ 98.50	$ 33,690
Cutting machine operator	2	104.00	35,570
Scoop trammer	4	100.00	68,400
Roof bolter	2	105.00	35,910
Utility man	2	94.00	32,150
Electrician/mechanic	2	110.00	37,620
Beltman	2	104.00	35,570
Foreman	2	136.00	46,510
	18		$ 325,420
Surface:			
Electrician/mechanic	2	$ 100.00	$ 34,200
Truck driver	3	96.00	1/
Grader operator	1	96.00	1/
Helper (gopher)	2	90.00	30,780
	8		$ 64,980
Salary:			
Superintendent	1		$ 50,000
Engineer	1		40,000
Survey/drafting	2		40,000
Time keeper	2		30,000
Purchasing agent & office manager	1		30,000
	7		$ 190,000
	33		$ 580,400

1/ Accounted for seperately

C-12 - Power requirements for 145,00 tpy underground coal mine

	hp	Kw	hr/day	Total Kw-hr
Coal drill	75	56	12	672
Cutting machine	100	75	12	900
Scoop tram (2)	300	224	10	2240
Roof bolter	50	37	10	370
Feeder breaker	125	93	12	1116
Supply vehicles	80	60	6	360
Rock duster	30	22	4	88
Mechanic jeep	15	11	4	44
Personnel jeep	7.5	6	4	24
Conveyor system	20	15	16	240
Ventilation, main	50	37	18	666
Ventilation, aux.	10	7	18	126
Lights, shop tools, etc.				600
Total				7446

7446 Kw-hr/day X 10,000 Btu/Kw-hr = 74,460,000 Btu/day

74,460,000 Btu/day ÷ 18,000,000 Btu/ton coal = 4.14 tons/day X 171 days/yr

708 tons/yr   6.21 tons/day X 240 days 1490 tons/yr

C-13.- Estimated annual production cost for 145,000 tpy underground coal mine

Direct cost	Cost, dollars
Production labor	$ 241,290
Maintenance labor	102,600
Salary and supervision	236,510
	$ 580,400
Operating supplies	
Machinery parts, 90¢/ton	130,500
Lubricants, 806/ton	116,000
Roof bolts and timber, $1/ton	145,000
Rock dust, 11#/ton x 145,000 tonx x $200/ton	159,500
Explosives, $1.20/ton	174,000
Ventilation, 80¢/ton	116,000
Drilling rods and bits, 30¢/ton	43,500
Miscellaneous	75,000
	$ 959,500
Power, 6.21 tons/day x 240 days x $16/ton	23,800
Payroll overhead, 40% of payroll	232,200
Subtotal of production costs	$1,795,900
Indirect cost	
10% of labor and supplies	$ 154,000
Fixed cost	
Insurance, 2% of capital cost	$ 104,000
Depreciation	300,100
	$ 404,100
TOTAL	$2,354,000 = 16.23/ton

C-14.- Scoop tram requirements

Production capability for continuous miner in 5-ft. seam = 425 tps

shift = 6 hours or 75% efficiency

50,000 tpy ÷ 425 tps = 118 shifts

118 shifts = 6 months @ 1 shift/day - 5 dpw

145,000 tpy ÷ 425 tps = 341 shifts

341 shifts ÷ 2 = 171 days = 8 months

425 tons/8 hrs @ .75% eff.
425 tons/6 hrs @ 100% eff.

425 tps ÷ 8 hrs/shift = 53.1 tph

travel distance = 1250 ft (average)

travel time @ 6 mph = $\frac{24 \text{ mi} \times 60 \text{ mph}}{6 \text{ mph}}$ = 2.4 min
return time = 2.4 min
load and dump = 1.0 min
1/hr = 5.8 min

53.1 tph ÷ 4 tons/trip = 13.2 trips/hr x 10 hr/trip

1.3 machine, say 2 machines