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ECONOMIC FACTORS AFFECTING THE MINING, PROCESSING, GASIFICATION, AND MARKETING OF COOS BAY COALS

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Summary

The coal reserves of the Coos Bay field constitute a resource which although exploited in the past has lain idle for several decades. Present economic conditions, the rapidly rising cost of all types of energy, and both short- and long-term projections for shortages in some areas prompted the present study. Despite the increase in coal prices in recent months there has been no comparable improvement in the overall economic picture for mining Coos Bay coal. Modern coal mining technology has advanced steadily, but new methods and machines are designed for large operations and are not readily adaptable to small mines. Furthermore, nearly all coal presently being mined underground in the United States comes from coal beds which are at least 5 feet thick, are flat or gently dipping, and lie less than 1,000 feet beneath the surface. Unfortunately, Coos Bay coals commonly are steeply dipping, are less than 5 feet thick on the average, and much of the reserve is located more than 1,000 feet below the surface.

Capital investment would be high for an underground mine and surface preparation plant capable of handling a million tons per year. Since the reserves at any one mine site are limited, the amortization charges would be correspondingly high.

While it is felt that present conditions do not favor mining, the situation could change at any time and positive steps should be taken to insure that the coal resource is preserved until such time that it can be mined either to supply energy or chemical products derived from it.

Introduction

Purpose and scope

More than 30 years have elapsed since the coal reserves in the Coos Bay area have been studied. The present report has been designed to: (1) review the earlier studies, mining activity, and production; (2) assess the present economic posture of the reserve in the light of today's demand for energy and the cost of producing it; and (3) develop guidelines which would insure that the reserves be adequately protected until such time as they are developed.

The items listed above are discussed in the following pages. With the realization that the report would be read by both professionals and non-professionals, a minimum of technical terminology has been used. Inevitably some terms peculiar to either coal mining or geology must be used but in these instances the terms have been defined in the glossary at the end of the report.

Aside from taking a few samples of coal, no field work was performed during the study. Since the thrust of this study was to ascertain the economic factors involved, no attempt was made to revise earlier studies of the stratigraphic or structural geology of the coal basin.

Numerous estimates of the tonnage of coal in the basin have been made over the years. Changing economics and improved geologic information have resulted in somewhat widely varying reserve figures. The parameters for the present tonnage estimate are given in the "Coal Reserves" section. For the first time in the long history of Coos Bay coal the environmental impact is being considered. Also for the first time the economic effect of national and regional sources of coal and alternative forms of energy are being included

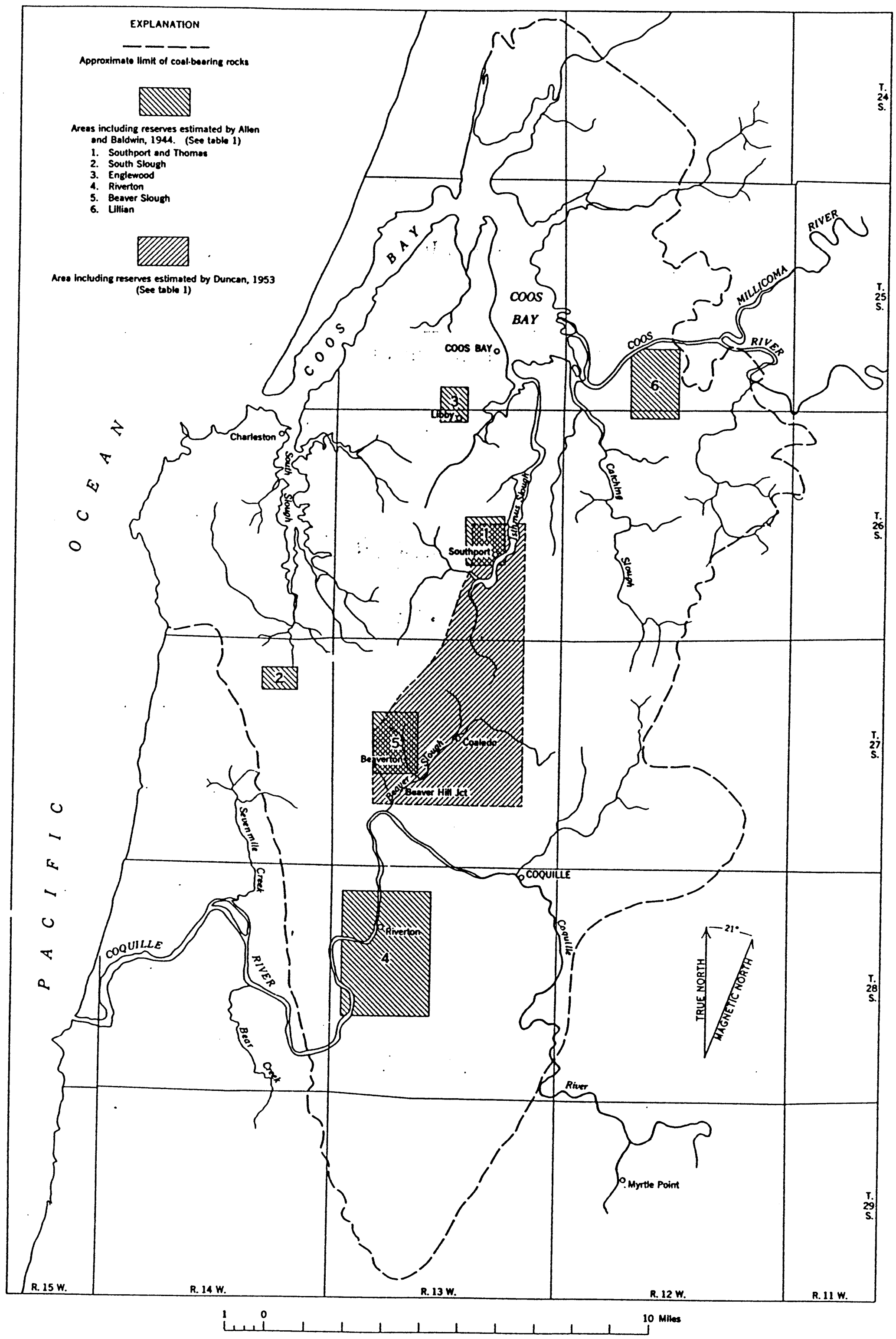

Figure 1.—Map of the Coos Bay coalfield.

since present and projected transportation methods can have an important bearing on any local developments.

Location

The Coos Bay coalfield underlies more than 400 square miles of land and water in an elliptical basin extending roughly from the city of North Bend south to the village of Riverton on the Coquille River. Coos Bay is the dominant geographic feature of the area. During the early period of coal mining which began more than 100 years ago, the waters of the Bay and its various sloughs provided the means of transportation for coastal steamers which often were able to dock near the mine portals. The cities of Coos Bay and North Bend at the northern end of the area and Coquille near the southern end are the principal urban centers for Coos County.

Figure 1 shows the general outline of the Coos Bay coalfield and the principal coal-producing areas discussed by Allen and Baldwin (1944) and by Duncan (1953). The areas shown are somewhat different from those used in the present study. The map is from Mason and Erwin (1955).

Domestic coal resources

In assessing the economic potential of a natural resource, it is not sufficient to evaluate the resource solely on its own merits. It is necessary to make at least some basic comparisons with other similar deposits which could conceivably be competing for the same market. Alternative sources should be considered also since trade-offs are often possible.

Although comparisons are never quite perfect, the relative size of some of the productive (and possibly competitive) coalfields in the Midwest and the Northern Great Plains is enlightening. In the State of Illinois there are nearly 100 billion tons of coal remaining in two of the thickest and most extensive coal beds (Smith and Stall, 1975).

In the Northern Great Plains area there are 160 billion tons of coal scattered over 63 counties, all less than 1,000 feet beneath the surface and with 80 billion tons surface minable.

The following table, abstracted from the U.S. Bureau of Mines Minerals Yearbook, 1972, lists the recoverable reserves of coal in the principal coal-producing Midwestern and Western states, including Alaska. The reserves are calculated on the basis of a 50 percent recovery even though a substantial proportion of the tonnages shown would be surface mined with a recovery of better than 80 percent.

Table 1. Recoverable reserves of coal in selected Western and Midwestern states adapted from U.S. Bureau of Mines Minerals Yearbook, 1972

State	Reserves*
Alaska	65,040,000,000
Colorado	40,330,000,000
Illinois	69,562,000,000
Kansas	9,336,000,000
Montana	110,838,000,000
New Mexico	30,712,000,000
North Dakota	175,315,000,000
South Dakota	1,016,000,000

* Short tons, assuming 50% recovery

Environmental considerations

Any mining activity necessarily has a disruptive effect on the various elements collectively known as the environment. Underground coal mines, particularly those located at considerable distances beneath the surface, have a minimum effect on the surface. Surface installations necessary to the operation of an underground mine, treatment facilities for the preparation of coal for market, and other ancilliary structures do have a direct and adverse input on the environment. Since typical underground coal mines have an expected operational life of from 25 to 40 years, these environmental effects can be expected to continue for at least that long.

In humid, high rainfall climates, vegetative regeneration is rapid. In the Coos Bay area it is extremely difficult to identify most of the abandoned mines even though no rehabilitation of the site was performed. With planning and reasonable attention to the problems involved there should be a minimum of environmental degradation to the area, most of which will be rapidly effaced immediately the operation ceases and the surface structures removed.

If a large coal-fired, steam powered generating plant or a gasification or by-products plant should be built, there would be large volumes of warm water generated by the cooling circuit. The discharge and dissemination of such waters would have to be done in a manner that a minimum adverse effect on the environment would occur.

The problem of plant siting should involve consideration of the following factors: (1) relationship of the coal supply to the plant; (2) availability of process and cooling water; (3) availability of suitable and adequate discharge areas for heated water; (4) the engineering geology characteristics of the surface and subsurface at the plant site; (5) availability of suitable sites for disposal of coal mine refuse, washery wastes and chemical plant residues; and (6) the potential for reclamation of the site upon completion of the project.

Geological Framework

Rock units

About 6,000 feet of upper Eocene Coaledo sediments are confined to a complex structural basin occupying a roughly elliptical structural basin measuring 35 miles north and south by 11 miles east and west. No attempt was made during the present study to reexamine the geology of the Coos Bay area. It was felt that this was covered adequately by previous workers, notably Allen and Baldwin (1944), Baldwin (1966), and others (see bibliography). The following passages are abstracted from Allen and Baldwin (1944) and refer to the coal-bearing formations only.

> ". . .The lower and upper Coaledo members consist of medium-bedded tuffaceous sandstones made up largely of basaltic glass, separated by the middle Coaledo member consisting of as much as 2,300 feet of dark tuffaceous shale of more acidic composition. The principal coal beds occur in the upper and lower sandstone members of the Coaledo formation."
>
> "The Coaledo and the later Oligocene formations in the major basin were compressed during the Miocene into north-trending folds, and faulted by north-trending faults and by more numerous transverse faults."
>
> "The coals within the upper member of the Coaledo formation are known as the upper coal group. Of these coals, the Beaver Hill bed is the most prominent. This bed lies at or near the base of the coal group; only one thin bed is known to underlie it in the Newport basin and west of Beaver Hill. Attempts to mine other beds (Henryville, Empire, Gibbs) have in most cases been unsuccessful, the beds being either too thin or too dirty. However, the Riverton or Timon bed which lies several hundred feet above the

Beaver Hill has been mined for many years. The upper coal group consists of as many as six or seven coals in a stratigraphic distance of from 600 to 1,000 feet.

"The Beaver Hill bed is characterized by three benches of coal, which are about 6, 20 (top), and 30 (bottom) inches thick, although these vary considerably. The lower bench is generally bony in its lower portion. The roof is usually firm, which is not generally true of other upper coals.

"Toward the southern end of the Beaver Slough basin, the Beaver Hill bed becomes dirty, although it maintains its thickness (Panter, Lyons). Toward the north end of the basin it splits and the benches are widely separated (Englewood, Reservoir)."

No similar appraisal of the "Lower Group" of coals has been made at this time. The lower coals are described by Allen and Baldwin (1944) as follows:

"The coals occurring within the lower Coaledo member are known as the lower coal group and lie stratigraphically far below the Beaver Hill bed of the upper group, being separated by the middle Coaledo shale and much of the lower Coaledo formation. At least seven coals are known but only a few of these have ever been mined successfully, and these only on a limited scale. Several attempts have been made to mine these coals, especially in the Lampa Creek area. . . .

"The coals of the lower group have numerous and thick shaly partings and 'niggerheads' and a high content of bone. Their B.t.u. content and rank, when a clean sample is analyzed, are usually higher than those of the upper coals. Most of the beds have shaly or otherwise unfavorable roof conditions. The cleavage of these coals is more likely to be platy than blocky."

In view of the above it is felt that the economic importance of the lower coals as compared to upper coals, including the Beaver Hill bed, is so minor that little consideration be given them at this time. It is entirely possible that at some future date the need for energy will become such that, coupled with presently unavailable extractive and utilization techniques, the coals will be exploited.

Coals of varying thicknesses and of uncertain age crop out on the east side of Isthmus Slough and on the north and east sides of Coos Bay. Although

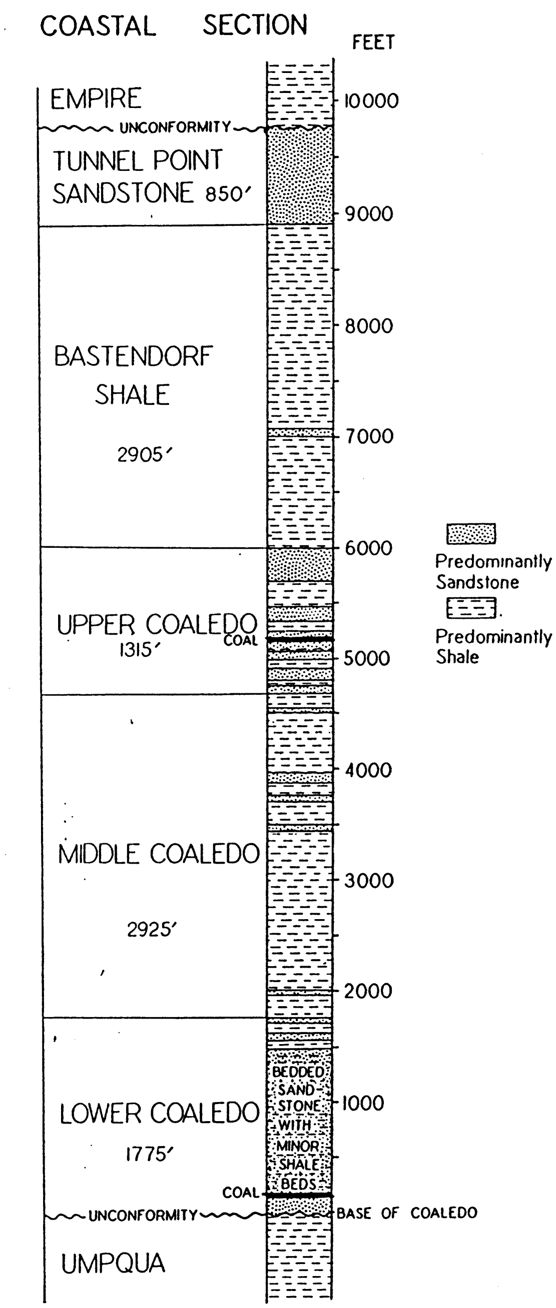

Figure 2. Stratigraphic chart of geologic formations in the Coos Bay area.

one or two mines have a fair record of production over the years, most of the attempts at mining have not been too successful. Lateral extent of the beds is often abruptly terminated by faulting, and the difficulty in tracing the beds for any great distance precludes the development of large-scale mines. Some of the reserves could doubtless be mined in a small way for local consumption when the economics as compared to other energy sources became more favorable. These coals, like those assigned to the "Lower Group" discussed a above, have not been included in the reserve calculations.

Water requirements

The amount of water that would be required in the mining process would be small and would probably fall in the range of from 10 to 15 gallons per ton of coal mined. Surface treatment of the solid coal in a typical washery would require in the neighborhood of 500 gallons per ton with a loss of about 10 gallons per ton of coal washed.

A typical coal gasification plant with a daily capacity of 250 million cubic feet of gas requires between 1.9 and 4.9 billion gallons of water per year. A conventional 1000-MW steam electric plant requires 10,000 to 15,000 acre feet of water per year, or from 3.25 to 4.88 billion gallons per year.

Whether or not these rather substantial quantities of water can be developed in the event that either a gasification or by-products plant was built has not been determined. Brackish or salt water might possibly be substituted for cooling water but process water would have to be fresh and probably treated. Fresh water might be developed by drilling a series of wells, or if this was not feasible it might be possible to impound stream flows in the area. The availability of large volumes of cooling and process water would be crucial to any plant operation.

Coal Resources

History of Coos Bay coal production

Mining in the coalfield which surrounds Coos Bay and extends south for more than 30 miles to a point beyond Coquille began soon after the region was settled in the early 1850's. Coal was discovered near Empire in 1854, and the mines just southwest of Coos Bay first operated in 1855. By 1880, when records were first kept, production was about 40,000 tons a year, and for 15 years annual production ranged between 30,000 and 75,000 tons. In 1896 and 1897 the production was mostly from the Eastport and Newport mines and exceeded 100,000 tons a year, a figure not reached again until 1904, the year of maximum production, when 111,540 tons of coal were shipped. The coal was often loaded for shipment to the San Francisco Bay region on coastwise steamers which came far up the sloughs, in some cases almost to the mine portals. Since 1905, there has been a general decrease in production, attributable in part to the decline of the California market, and because in the 1920's oil began to replace coal in railroad operation and in domestic heating. From 1903 to 1920, at least half of the total production came from the Beaver Hill mine, whicn was owned and operated by the Southern Pacific Company. When it closed down in 1923, it had reached a depth of 1,400 feet below sea level and a distance of 3,030 feet down the dip of the coal. Since that time, coal has been produced largely for local consumption, at a rate varying from 7,000 to 15,000 tons a year. The largest production in the Coos Bay district has been from the Newport basin, which includes the Eastport, the Newport or Libby, and the Englewood mines. This basin is a shallow canoe-shaped syncline located from 2 to 3 miles southwest and west of the city of Coos Bay. It has produced over a million tons but is now practically mined out. The recorded production of the Coos Bay field from 1880 to 1920 is 2,380,000 tons. Probably the total production is in the order of 3,000,000 tons.

Table 2. Proximate and Ultimate Analyses of Coal from Five Mines in the Coos Bay Field

	Proximate percent				Ultimate Percent							
	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Air dry loss %	B.t.u.	Ash-softening temperature °F.
Southport	17.2	33.6	40.8	8.4	0.6	6.2	56.1	1.2	27.5	3.3	9880	2080
	--	40.6	49.2	10.2	0.8	5.1	67.8	1.5	14.6	--	11940	--
	--	45.2	54.8	--	0.8	5.7	75.4	1.6	16.5	--	13290	--
Martin	16.9	34.6	42.8	5.7	0.5	6.2	57.5	1.4	28.7	9.1	10080	2340
	--	41.7	51.5	6.8	0.6	5.2	69.3	1.6	16.5	--	12140	--
	--	44.8	55.2	--	0.7	5.6	74.3	1.8	17.6	--	13030	--
Overland	16.7	35.7	42.2	5.4	0.7	--	--	--	--	6.4	10150	2330
	--	42.8	50.7	6.5	0.9	--	--	--	--	--	12190	--
	--	45.8	54.2	--	0.9	--	--	--	--	--	13030	--
Alpine	19.3	32.8	40.3	7.6	0.7	--	--	--	--	9.4	9250	2320
	--	40.6	50.0	9.4	0.8	--	--	--	--	--	11460	--
	--	44.8	55.2	--	0.9	--	--	--	--	--	12650	--
Riverton	10.1	36.1	37.8	16.0	4.3	5.5	55.1	0.9	18.2	3.5	10080	2070
	--	40.1	42.1	17.8	4.8	4.9	61.3	1.0	10.2	--	11220	--
	--	48.8	51.2	--	5.9	5.9	74.6	1.2	12.4	--	13650	--

The Coos Bay coals have been studied and examined several times over the past 75 years. One of the very first of these studies was made by J. S. Diller of the U.S. Geological Survey in 1899. The last comprehensive study of the field was made in 1944 by Allen and Baldwin of the State of Oregon Department of Geology and Mineral Industries. Additional reports on the field are included in the attached bibliography.

Character of the coal

The following coal analyses and comments on the physical properties of the Coos Bay coals have been abstracted from Allen and Baldwin (1944). The proximate and ultimate analyses for five representative mines are shown in Table 2. Each mine sample was analyzed on an "as received," "moisture free" and "moisture and ash free" basis. The results are tabulated in this order.

> "A noticeable feature of the analyses is the similarity in the composition of the Coos Bay coals. Except for the coal from the Riverton prospect, which is lower in moisture and somewhat higher in ash and sulfur content, these coals are similar in composition, in heating value, and in the softening temperature of their ash. An analysis typifying the Coos Bay coals would show 17 percent moisture, 8 percent ash, less than 1 percent sulfur, an ash-softening temperature of 2,200°F., and a heating value of 9,700 B.t.u. per pound on the as-received basis. . . ."
>
> ". . . The friability indices of the Oregon coals indicate that they will, under ordinary conditions, withstand breakage well in mining and preparation and consequently yield a relatively large proportion of the coarser sizes of coals."

Table 3. "Friability Indices of Oregon Coals

Mine	Bed	Friability (%)
Gilbert	Unnamed	21.2
Southport	Southport	27.6
Thomas	Beaver Hill	27.3
Overland	do	32.0
Alpine	Riverton	29.9
Riverton Prospect	Unnamed	37.6

Purely from the standpoint of the external forces that cause degradation in size on handling--the forces simulated in the friability test--these coals also would withstand handling in the operations that follow after a coal is prepared, such as storage, transportation, and use. However, the degradation in size that occurs in these subsequent operations is, with subbituminous coals, determined more by their weathering or slacking properties than by their friability.

Slacking Characteristics

Subbituminous coals and lignites show a pronounced tendency to disintegrate or slack on exposure to the weather, particularly when alternately wetted and dried or subjected to hot sunshine. This troublesome property of low-rank coals is attributable to their high moisture content. When they are exposed to dry atmosphere after removal from the mine they lose moisture rapidly. As the moisture is lost from the surface layers, shrinkage causes stresses that result in cracking and disintegration. Slacking, like the handling of a friable coal, causes the formation of excessive amounts of fine material at the expense of the coarser sizes, thus decreasing the value of the coal for some uses. Storage of coals that slack readily is unsatisfactory not only because of the loss of the more valuable coarse sizes but also because slacking greatly increases the tendency of coal to ignite spontaneously, owing to the increased surface area exposed."

Table 4. "Average Slacking Indices of Oregon Coals

Name	Bed	Slacking index percent
Gilbert	Unnamed	29.4
Southport	Southport	24.9
Thomas	Beaver Hill	50.1
Overland	do	37.7
Alpine	Riverton	60.8
Riverton Prospect	Unnamed	6.4

Slacking indices for the Oregon coals, shown in Table 4 range from a low of 6.4 percent for the Riverton prospect to a maximum of 66.8 percent for coal from the Alpine mine. Coals having slacking indices of less than 5 percent are considered nonslacking and indices of 5 to 15 percent represent coals that slack slightly. Moderate slacking is indicated by indices from 15 to 35 percent, and coals having indices of over 35 percent are strongly slacking."

Coal reserves and prospects

Definition of reserves. Three categories of reserves were identified for the study. "Minable" coal is defined as being at least 30 inches thick, with a dip of less than 45° and not more than 1,500 feet below sea level. Minable coal is located adjacent to areas from which coal has been either mined or the area has been explored in sufficient detail to indicate that there is a reasonable expectancy that coal can be recovered from it.

"Prospective" coal is similarly defined but this classification represents reserves about which there is less information, but also no information that would indicate unusual difficulties in mining. Quite possibly a modest exploratory drilling campaign could upgrade some of the tonnages in this category to the "minable" class.

"Remotely possible" coal includes reserves about which there is even less information than either of the first two classes. In addition, the coal lies usually below 1,500 feet and may be inclined steeper than 45°. This class is further divided into "clean" and "dirty." All Beaver Hill bed coal lying south of sections 7, 8, and 9, township 28 south, and range 13 west has been arbitrarily labelled "dirty" and all coal in this bed north of the boundary is "clean."

For the purposes of calculation, an acre-foot of coal is equivalent to 1,700 tons, which with an estimated recovery factor of 50 percent equals 850 recoverable tons per acre-foot. Reserve figures used in this study are in terms of recoverable coal.

Table 5 summarizes the tonnages of "minable," "prospective," and "remotely possible" coal of the Beaver Hill bed by quadrangle and by mine area. The "remotely possible" category is further subdivided into "clean" and "dirty" coal.

Table 5. Summary of the Coos Bay Coal Reserves (Beaver Hill Bed only)

By Quadrangle

Quadrangle	Minable	Prospective	Remotely Possible "Clean"	Remotely Possible "Dirty"	Total
Charleston	2,720,000	7,543,750	-----	-----	10,263,750
Coos Bay	11,975,650	1,346,400	10,995,600	-----	24,317,650
Coquille	7,384,800	3,039,600	12,831,600	1,305,600	24,561,600
Riverton	2,835,600	3,916,800	12,933,600	8,119,200	27,805,200
TOTALS	24,916,050	15,846,550	36,760,800	9,424,800	86,948,200

By Mine Area

Mine Area	Minable	Prospective	Remotely Possible "Clean"	Remotely Possible "Dirty"	Total
Southport-Thomas	1,551,250	-----	4,120,800	-----	5,672,050
Beaver Hill	20,644,800	5,263,200	20,767,200	-----	46,675,200
Riverton-Couqille	-----	3,039,600	11,872,800	9,424,800	24,337,200
South Slough	2,720,000	7,543,750	-----	-----	10,263,750
TOTALS	24,916,050	15,846,550	36,760,800	9,424,800	86,948,200

Table 6. Summary of the Coos Bay Coal Reserves (other than the Beaver Hill bed)

By Quadrangle

Quadrangle	Other Coal Upper Coal	Other Coal Coaledo Arch	Total Other Coal	Total Beaver Hill*	Total Coos Coal
Charleston	-----	-----	-----	10,263,750	10,263,750
Coos Bay	5,950,000	-----	5,950,000	24,317,650	30,267,650
Coquille	8,619,000	6,919,000	15,538,000	24,561,600	40,099,600
Riverton	10,948,000	-----	10,948,000	27,805,200	38,753,200
TOTAL	25,517,000	6,919,000	32,436,000	86,948,200	119,384,200

By Mine Area

Mine Area	Other Coal Upper Coal	Other Coal Coaledo Arch	Total Other Coal	Total Beaver Hill*	Total Coos Coal
Southport-Thomas	-----	-----	-----	5,672,050	5,672,050
Beaver Hill	16,592,000	-----	16,592,000	46,675,200	63,267,200
Riverton-Coquille	8,925,000	-----	8,925,000	24,337,200	33,262,200
South Slough	-----	-----	-----	10,263,750	10,263,750
Coaledo Arch	-----	6,919,000	6,010,000	-----	6,919,000
TOTAL	25,517,000	6,919,000	32,436,000	86,948,200	119,384,200

* From Table 5.

Table 6 summarizes the tonnages of "Other Coals" which include the "Upper Coals" and the "Coaledo Arch Coals" both of which lie above the Beaver Hill bed. These coals have been tabulated separately from the Beaver Hill bed coals shown in Table 5 since the historical record indicates that, with few exceptions, economics have heavily favored the Beaver Hill coals over those lying above. Whether new extractive techniques would erase this discrepancy, or even favor the "Other Coals" cannot presently be determined. Since there is a geographic overlap of the Beaver Hill and "Other Coals" in certain areas, the total of the two coals available has been combined.

Main coal areas. The Coos Bay field has been divided into four main areas for the purposes of this study, each of which is discussed at length. All of the coal in these four areas belongs to the Beaver Hill bed. In addition, there are several other areas in which the coal is believed to be less economically attractive at present but which at some point in the future might be exploited. These latter areas are on coal beds which lie either stratigraphically above the Beaver Hill bed or far below it.

SOUTHPORT-THOMAS MINE AREA

"Minable" coal has been limited to the area lying down dip from the old workings as far east as U.S. Highway 101 at the margin of Isthmus Slough. Rapid changes in strike immediately north of the Southport mine limit extending the area in that direction. To the south the area is truncated by the Davis Slough fault, the other side of which lies within the Beaver Hill mine area. A small tonnage of very shallow coal probably could be mined up dip from the old workings.

Uncertainty concerning the structures existing immediately east of Isthmus Slough suggests that any reserves lying east of the Southport mine "minable" area should be classified as "remotely possible" rather than "prospective." Quite possibly the coal exceeds the 1,500-foot depth limit for "minable" and faulting or **sharp** changes in dip and strike might be expected. The area included in the "remotely possible" class has been restricted to sec. 24 and that portion of secs. 23-37 lying east of Isthmus Slough.

BEAVER HILL MINE AREA

"Minable" coal assigned to this area covers parts of the Coos Bay, Coquille, and Riverton quadrangles. Numerous mines in addition to the Beaver Hill are located within the area. Margins of this comparatively large area are determined partly by faults, excessive depth, or lack of sufficient information. A narrow strip underlying the general vicinity of Green Acres and Noble Creek (Coos Bay quadrangle, Map area 3) probably contains coal deeper than 1,500 feet. This strip has been included in the "prospective" rather than "remotely possible" category since it is bordered by minable areas on two sides. The same rationale has been applied to the southern extension of this presumably deep coal lying beneath Overland and vicinity (northern edge of Coquille quadrangle).

"Prospective" coal associated with the Beaver Hill mine is distributed over portions of the Coos Bay, Coquille, and Riverton quadrangles. The area lying southwest of the Beaver Hill mine is terminated to the northwest by faulting, which probably would limit downslope mining along the northeast border as well. To the southeast the limits of the area are less easy to determine and could be extended for some distance along the strike as it turns southward and heads for the Riverton area.

SOUTH SLOUGH AREA

"Minable" coal has been restricted to a small area at the southwest corner of the basin. Two small mines, the McKenna and the Gibbs, were once active near the southeastern edge of the area. The coal crops out along a line close to and parallel with the county road which occupies the crest of the divide between Fivemile Creek and South Slough. The lower, or northeastern border of the area is arbitrarily determined by the 1,500-foot depth level which has been selected as the maximum depth for minable coal. Along the strike to the southeast the coal bed apparently abruptly swings around to the northeast and probably continues on in that direction, although there is little surface indication of coal for several miles. Along the strike to the northwest the coal becomes progressively steeper for several miles, too steep to be included as minable.

"Prospective" coal includes two elongate areas, one on each side of the Slough. The western area extends in a north-south direction for over 3 miles and roughly parallels the Seven Devils Road located approximately one-half mile east of the area. The only recorded production came from the Big Creek mine which produced a few thousand tons of coal from the Beaver Hill bed, which dips 48° at this point. The area could probably be extended northwards to the coast at Yokam Point (where the coal is exposed) if it were not for environmental considerations. Sunset Bay State Park lies immediately west of this extension and the Cape Arago Highway crosses it near the northern limit. Also, there are some homes and other structures sited randomly in the area.

RIVERTON-COQUILLE MINE AREA

No "minable" coal has been identified for the Beaver Hill bed in this area. "Prospective" coal is confined to one occurrence. On the Coquille quadrangle an area lying immediately northwest of the city of Coquille is limited by probably excessive depth to the northwest, by abruptly changing strike to the northeast and by State Route 42, which follows the edge of the Coquille River floodplain to the southwest.

Although the Beaver Hill bed extends over a fairly large area between Riverton and Coquille, all of this coal lying south of secs. 4, 5, and 6, T. 28 S., R. 13 W., has been classed as "dirty" coal and separately tabulated under the heading of "remotely possible."

REMOTELY POSSIBLE COALS

Certain areas adjacent to the mine areas discussed above are felt to have sufficient geologic information to allow them to be classed as reserves, which at present very probably could not be mined for a variety of reasons, but which at some later date might provide an energy reserve. The limits of these areas have been arbitrarily assigned, but it is felt that the resource in total is fairly well represented in the tabulations.

OTHER COALS

In addition to the various classifications of the Beaver Hill bed coals discused above, there are relatively considerable tonnages of "minable" coal in seams lying stratigraphically above the Beaver Hill. In general, the areal extent of the various areas underlain by these coals is the same as those detailed for the "minable" coal and in some cases the "prospective" coal of the Beaver Hill bed. The upper coals of the Coaledo Arch area have been segregated to aid in making economic appraisals of the various reserve units.

COALS BENEATH URBAN AREAS

In the northern portion of the Coos Bay coalfield some of the reserves underlie urban areas. Since much of this coal is relatively shallow, any mining would have adverse effects on the surface above. For this reason these areas have not been included in the tabulation of the total reserves. Early day mining at the Englewood, Libby, and other adjacent mines was conducted at some distance from any centers of population. Today these centers have expanded toward and in some cases overrun the old mined-out areas.

Additional data requirements. Before any large-scale mining activity is undertaken, some additional exploratory drilling is necessary. Although the continuity of the Beaver Hill bed over moderate distances is assumed with a fair degree of confidence, the location of any faults or abrupt changes in strike or dip are unknown quantities. Since some form of mechanized equipment would of necessity be used the exact location of these features must be determined before any mining plan can be devised or suitable equipment obtained.

Economics of Coos Bay Coal

Mine development costs

The coal mining industry, both domestically and worldwide, has seen a steady increase in production for the past 14 years. This increase has been made possible by the greatly improved technology at every step in the coal production operation. Although surface strip mining has received by far the greater share of attention, there have been many improvements in underground mining as well. All of these developments have been geared to the large, relatively flat, moderately thick, near-surface coal seams which have been subjected to a minimum of faulting or folding. By contrast, few, if any, advances in mining technology have been made for mining the relatively small, steeply pitching seams which descend to depths in excess of 1,000 feet.

Modern coal mining is a highly mechanized and automated operation with large output coupled to equally large preparation facilities and high speed transportation systems. In sharp contrast to such highly efficient mines are the small operations which either cannot afford the capital outlay necessary to achieve operating economies approaching those of the larger ones, or cannot be mechanized and automated effectively simply because no efficient hardware or system exists for them.

Large coal operations are conditioned upon long-term productivity and equally long-term delivery commitments. Both factors are necessary if large amounts of long-term financing are to be secured. The small mine, on the other hand, has difficulty in obtaining adequate financing since in most cases it is impossible to line up a dependable market during the projected life of the mine. Amortization charges are necessarily high since the cost of opening a mine and equipping it must be borne by the relatively small number of tons produced.

The coal mining industry has been thoroughly studied and documented by the U.S. Bureau of Mines and various state agencies. Statistics on every phase of the industry are available and in considerable detail. Since most of the coal in the United States is produced at relatively large mines, the available data refers almost exclusively to this type of operation, and little information of any economic importance is available on small mines. While broad similarities exist between large mines, both from a geologic and economic standpoint, small mines have widely varying physical characteristics which affect mining and ultimately the cost per ton of mined coal.

Although there is no clear definition for a "small" or "large" mine, there does seem to be a point of separation between the two classes at an anerage production of 1,000,00000 ts per year. In 1972 the U.S. Bureau of Mines reported that there were 159 mines producing over 1,000,000 tons annually in the United States, and that the 280 largest mines in the country accounted for 57 percent of the total coal produced. The total number of operating coal mines was 4,879. Exploration, development, and start-up costs for small mines are often inordinately high both in total expenditures and in costs per ton produced. For this reason it is most difficult, if not impossible, to even roughly estimate what the various steps in opening a new, small coal mine are likely to cost. Each small mine must be viewed as a completely unique undertaking and only intense study of all of the factors involved will yield the information necessary in arriving at a decision.

Table 7 gives the average value per ton of coal f.o.b. mine and the average tons of coal mined per day per man in each of the six Western coal-producing states. Nearly one-third of the Western states production is fed into mine-mouth generating plants.

Table 7. Average Value Per Ton of Coal and Average Tons Per Man-Day for Mines in Selected Western States, 1973*

	Av. Value Per Ton	Av. Tons Per Man-Day
Colorado	7.41	17.46
Montana (lignite)	2.82	127.11
New Mexico	3.51	48.84
North Dakota (lignite)	2.07	102.36
Utah	11.19	14.36
Wyoming	4.09	55.94

* Adapted from U.S. Bureau of Mines Minerals Yearbook, 1973

The recent studies by the U.S. Bureau of Mines (Katell and Hemingway, 1974) of the capital investment and operating costs for underground bituminous coal mines provide a wealth of detail into every phase of a mining venture. The two studies were based on mines with either an annual production of from 1.03 to 3.09 million tons of coal from a 48" coal bed, or with an annual production of from 1.06 to 4.99 million tons from a 72" thick coal bed. Neither of these studies fits the situation at Coos Bay but the identification of the numerous items involved in the development and operating phases should serve as a rough guide for any projected development on the Bay.

Table 8, taken from a study of the Northern Great Plains Resources Program, "Effects of coal development in the Northern Great Plains," summarizes the many elements involved in both surface and underground coal mining.

Table 8. *Comparison of surface and underground mining*

Item	Surface mining	Underground mining
1. Environmental impact		
a. Air	Considerable dust problem	Potential pollution of air and waste of coal from uncontrolled underground burning; dust problem from coal-refuse pile
b. Water	Possibly increased water infiltration and retention in reclaimed, disturbed areas; disturbed shallow aquifers; leaching from spoil piles	Altered drainage systems, a possible result of subsidence; leaching from above-ground, coal-refuse banks
c. Land surface	Insufficient fill material for thick, near-surface seams; topographic reclamation not difficult in some areas of NGP; some erosion problems from high winds, storms; revegetation a problem in the more arid areas or drought years	Important surface subsidence problems can be partly controlled but not eliminated by longwall mining where feasible. Subsidence generally reduced or eliminated by mining at considerable depth
2. Time lag for delivery of major equipment	6 years	3 years
3. Time lag to reach full production	1-3 years[1]	3-5 years
4. Capital requirements	$35 million for 9-million-ton/year mines	$75 million for two 4.5-million-ton/year mines, conventional room and pillar
5. Coal prices at mine, 1973 average[4]	$6.11/ton (U.S.)[4] $3.02/ton (NGP)[4]	$10.84/ton (U.S.) for conventional room and pillar
6. Average labor productivity	104 tons/man/shift[2]	12 tons/man/shift for conventional room and pillar;[3] 34 tons/man/shift for advanced European longwall[4]
7. Labor availability	Good, requires general construction experience	Poor, requires specialized training, work has less appeal

Continued

Table 8. *Comparison of surface and underground mining*—Continued

Item	Surface mining	Underground mining
8. Safety-fatal injuries per million short tons, 1970	0.12	0.53 conventional room and pillar; longwall may be significantly less
Nonfatal injuries per million short tons, 1970	4.94	25.8 conventional room and pillar; longwall may be significantly more
9. Resource conservation—coal recovery	80-95 percent (NGP)	Thin seams—40-60 percent (room and pillar), up to 85 percent (retrieving pillars if feasible), up to 90 percent (longwall, if feasible) Thick seams—very low conventional room and pillar; higher for longwall, if feasible

[1] Whereas an underground mine is dependent upon highly specialized equipment, a surface mine can be brought to full production using conventional construction-type equipment. If used equipment is unavailable, delivery of scrapers, dozers, and wheel loaders is approximately 9 to 15 months in comparison to several years for draglines and shovels. In addition to startup use, "surface mine" construction equipment can often be used for sustained, full-scale production, particularly in the NGP. A recent investment analysis of scraper and dragline mining systems by Caterpillar Tractor Company ("Caterpillar Western Coal Mining Systems") compared the two systems for production of 7.5 million tons of coal per year from a 75-foot coalbed under 75 feet of overburden. The scraper system compared quite favorably in cost with the dragline system, as well as being more mobile and flexible.

[2] Average of present high productive mines in NGP. This may increase to 170-250 tons/man-day in the future.

[3] National average. Would be greater with new large mines using latest technology.

[4] Production rate from advanced European longwall techniques. This may be improved if applied on large scale in the United States.

Minability and mining problems

The Coos Bay field has been mined in the past by many small operators using, for the most part, simple hand methods and little mechanical or labor-saving devices and equipment. The flexibility inherent in this method was well suited to the coal beds which were mined from surface crops and along the strike until either the property line was reached or a crushed and faulted zone was encountered. The steepness of the dip quickly took the mining operation to considerable depths where the weight of the overlying rock either crushed timbers or caused the floor to heave. Neither water mor gas seems to have been much of a problem, with only a few mines apparently having minor gas seepage.

Physical factors which enter into the problem of determining whether a coal prospect may be developed into a mine include; the character of the coal; the thickness of the coal; the number and thickness of the partings of either clay or bony material; the attitude or dip of the coal; and the competency of the roof and floor rock. Still other physical factors affect the mining costs, such as the cleavage or size of the blocks into which the coal breaks, the amount and distance water must be pumped, the amount of gas encountered, availability of power, the type of mining equipment which may be used, and the distance and difficulty of transportation to the nearest or principal market.

The thickness of the coal beds in the Coos Bay area ranges from less than an inch to more than 19 feet, but only the Beaver Hill and Riverton beds have been extensively mined. The Beaver Hill bed has a fairly uniform thickness over an outcrop distance of about 7 miles from the Southport on the north to the Klondike mine on the south.

Table 9. Average Thickness and Dip of Beds at Selected Coos Bay Mines

Mine	Average Thickness	Average Dip of Bed
Southport	5 ft.	7°-17°
Thomas	6	17°
Delmar	5	10°-24°
Beaver Hill	5-6	26°-45°
Riverton	3-4	15°
South Slough (area)	5	16° min.

Attempts to mine coal in thinner beds have been numerous (Wilcox, Belfast, Reservoir, and other mines) but the additional expense of brushing out the roof or taking up the floor in order to permit access for miners and equipment has restricted such mining. Attempts to mine thicker beds (Sevenmile, Gilbert, Gibbs) have been unsuccessful because of the steep attitude or bony nature of the coal.

Numerous partings in the coal raise production costs, as larger tonnages must be handled to produce a ton of finished product. The Steva and Hardy beds on the east side of Coos Bay have adequate thicknesses but they have several bony and clayey partings which make washing and sorting a prerequisite to the production of marketable coal. The Beaver Hill bed contains two partings, one of which must either be left in the roof (with the abandonment of the upper seam of coal) or must be gobbed inside the mine. In portions of the Beaver Hill bed (Overland, and parts of Beaver Hill mines) the lower part of the lower seam is bony and was left as floor. At the northern end of the

Newport basin in the Libby, Englewood, and South Marshfield mines, the lower parting thickens appreciably, and in portions of the South Marshfield mine became so thick that it could not be gobbed, and the thick lower bench was left in place.

Almost no mining has been attempted on beds dipping more than 45°, although there are many miles of outcrop of the Beaver Hill bed in the South Slough basin where the coal dips from 50° to 80°. The greatest success in mining appears to have been in the Newport basin where the mine haulageways ran along the axis of a relatively flat-bottomed basin. In the Beaver Hill mine the dip at the surface was 45°, which decreased gently to 26° at a point 3,000 feet down the dip. The 19-foot bed in Sevenmile Creek dips more than 50°.

The roof and floor conditions have frequently determined the minability of the coal. The Beaver Hill and Riverton beds generally have a hard sandstone roof which stands up well. Some of the workings in the old Southport mine have stood for over 50 years with very little timbering and only small amounts of caving. On the other hand, mining on the Steva bed of the lower coal group has been handicapped by the hard-to-hold clay roof commonly encountered. In some mines it has been found advisable to leave the upper bench of coal as a roof. In others, it has been necessary to gob the upper coal together with the upper parting (South Slough, Panter). The floor usually furnishes little difficulty except at depth. In the lower workings of the Beaver Hill mine it is reported that one of the reasons the mine was abandoned was the swelling of the clay floor, which, within an 8-hour shift, often rose 2 or even 3 feet. As a rule, it has not been difficult to timber rooms in mines on the Beaver Hill bed, although in the steeper portions of the bed, as at Overland and Martin, light timbering had to be fairly closely spaced, and the rooms were seldom more than 25-35 feet in width.

The cleavage of the Coos Bay coals is such that at any appreciable depth from the surface the coal usually breaks into large chunks which are relatively resistant to further mechanical breakdown (Yancey and Geer, 1940). The ratio between the size splits in mining and sorting as previously done in the Coos Bay area varies greatly, depending upon treatment of the coal. Average limits are probably:

Lump	50-80%
Nut	15-25
Pea and slack . .	2-20

Between 1900 and 1905 the Beaver Hill mine produced 224,517 tons, averaging over 40,000 tons a year for the last 3 years. During this time about one-third of the mine-run was burned for fuel, but the rest was classified with average size percentage as follows:

	Lump	Nut	Pea	Annaul Production
Average	76.5%	18.1%	5.4%	224,517 tons

The drainage problem in the Coos Bay area has been unimportant in the past. The rocks of the region are relatively impervious so that small pumps can take care of the daily inflow in a few hours' operation. Even in the deep Beaver Hill mine beneath Beaver Slough, water was a minor problem. Faults in the mine workings are generally sealed with impervious clays.

Gas in mine workings is not a serious problem. Open flame lamps have always been used in the Coos Bay mines, and safety lamps have only been used for testing. Explosions have occurred several times in some of the mines but have usually been due to negligence. Gas has been known to collect in the deeper mines which had insufficient ventilation. In the Overland mine it was customary to keep two or three pipes driven into fissures with flames burning at the ends of the pipes.

Before any mining can be undertaken in the near future a considerable amount of exploratory drilling would have to be done to determine definitely the character, attitude, depth, and thickness of the coal beds and the number and thickness of the partings, and the competency of the roof and floor. A well-planned drilling campaign should also provide some information on the location of any faulting of sufficient magnitude to affect mining seriously.

The steeply dipping coal beds of the Coos Bay field pose a number of problems for any potential mining operation. Compared to flat or gently dipping coal seams, mining steep coal beds is relatively inefficient due to: (1) the effort expended in hauling coal out of the mine; (2) the effort in pumping out mine water if present; (3) the added effort by workers when working on steeply inclined surfaces; (4) the increased expense of providing adequate safety protection from sliding or falling objects; (5) the lack of mechanical coal cutting, roof support, and conveyors having the same efficiency and capitalization costs as those designed for flatter slopes; and (6) the need for ever greater support as the mine is developed down the dip.

Some additional comments on the last two items above are perhaps necessary. At the present time there is no highly efficient mechanical coal-cutting and roof support equipment available that can be moved quickly and easily from one face to another on steeply dipping seams. This problem is not peculiar to the Coos Bay field. The steeply dipping anthracite beds in eastern Pennsylvania are no longer mined, and the mines at Cle Elum, Washington, are closed for the same basic reason. Coal mining technology has progressed steadily in the past few years making it possible for the coal industry to keep pace with the rapidly increasing demand for solid fuel. These developments, however, have been channeled toward the large, relatively flat-lying undisturbed coal seams covering large acreages. Little, if any, improvement has been made in coal mining equipment suitable for steep slopes and easy movement from place to place within the mine.

"Deep coal" generally refers to seams lying not more than 1,000 feet vertically below the surface. In the Coos Bay field this depth is quickly reached, with depths of 4,000 feet being postulated on indirect evidence from regional structural information. As pointed out elsewhere in the report, a cutoff depth of 1,500 feet was used to delimit areas of minable coal. It is understood that no coal in the United States lying below 1,000 feet is being mined at the present time.

Increasing thickness of overburden, as a slope is driven downwards, imposes ever more severe support problems. Either additional props must be used or a greater proportion of coal must be left unmined to support the roof or both. At depth the problems with weak roofs and floors become acute. Synclinal basins present special situations. Quite commonly any flexing and warping of the earth's crust imposes stresses and strains in the surrounding rocks. Man-made openings provide a means for relieving these pressures and special, often expensive, provisions must be made to accommodate them.

Possible mining systems*

The U.S. Bureau of Mines has been interested for the past 15 years in developing new systems for mining coal in steeply pitching beds. The methods that were sought were designed to overcome the problems encountered in mining on the pitch and utilize the pitch of the coal bed to an advantage. Two systems were tested extensively as follows: planer and high-pressure water jet (Anderson, 1962; and Nasiatka and Badda, 1963).

Both tests were conducted in the Roslyn No. 5 coal seam of the Roslyn No. 9 mine, 3 miles northeast of Cle Elum, Kittitas County, Washington. The Roslyn No. 5 coal seam is 54 to 60 inches thick, and the dip varies from 10 to 45 degrees. In the planer test area, the dip averaged 41 degrees. Immediately overlying the coal is 2 to 7 inches of shale, and over the shale is a roof of sandstone. The bottom, or floor, is interlayered sandstones and shales. Timber supports were required on 5-foot centers to support the roof, as the sandstone stratum overlying the coal measure was incompetent. The physical conditions of the test site for the planer are not exactly those that would be encountered in the coal beds in the Coos Bay area, but they are similar enough so that reasonable extrapolation of the planer test results at Roslyn can be made to the Coos Bay area.

The basic concept of the system and design of the planer were sound. The planer cut as it was pulled up the slope and swept the cuttings down the slope on its return trip to the lower level to start another cut. The conclusion was that it could be used effectively in the longwall retreat system of mining, with roof support only near the working face, and by allowing the mined-out area to cave as mining progresses. Production data at two test

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* Information supplied by Walter E. Lewis, State Liaison Officer, U.S. Bureau of Mines.

sites succeeded in producing 8.6 tons per man shift. The 8.6 tons per man shift figure does not include the man shifts required to develop the block of coal upon which the tests were conducted. Inclusion of the labor time required for development could lower the output per man shift as much as one-third. Nevertheless, the 8.6 figure is a reasonable amount of tonnage per man shift under the physical conditions encountered at Roslyn, and it would indicate that economical mining of a steeply pitching coal bed is not completely out of reach. New technology developments, especially in longwall, could eliminate some development work and the need for supports on 5-foot centers, except at the working face, and serve to decrease the cost of mining substantially.

The tests with a high-pressure jet were conducted in the same coal bed under essentially the same physical conditions as the tests with the planer. The average production, without charge for development, varied from 7.7 to 16.6 tons per man shift, and it was definitely proven that the steeply pitching Roslyn No. 5 coal bed could be mined more economically by hydraulic methods with a hand-held monitor than by conventional methods (blasting). The average productivity by hydraulic mining was about 50 percent higher than the average productivity by conventional mining.

There are certain conditions that must exist with the hydraulic system for it to be successful, and unfortunately, it is not possible to extrapolate the results of the hydraulic tests at Roslyn directly to the Coos Bay area coals. Two essential elements must be considered in selecting the hydraulic mining equipment as follows: (1) face equipment must be mobile, and (2) a pump that will deliver water at sufficient volumes and pressures to cut the coal. Coal varies greatly in hardness, and it is quite likely that the

Coos Bay area coals are harder than the Roslyn area coals. Thus, the danger exists that to obtain the necessary pressures needed to cut, mobility at the face would have to be sacrificed. As soon as the face mobility is sacrificed, the output per man shift would drop.

However, like the planer system, the basic concept of the high-pressure water jet system was proven to be sound. It was a system for mining steeply pitching coal under certain favorable physical conditions, and a reasonable production per man shift could be obtained. As in the planer mining test, advances in longwall mining technology and light equipment to maintain a highly mobile monitor could be needed improvements that will bring the Coos Bay area coals closer to economic reality.

In the longwall method of mining coal, the seam is removed in one operation by means of a long working face or wall. The workings retreat (or advance) in a continuous line which may be several hundred yards in length. The space from which the coal has been removed is either allowed to collapse (caving) or is completely or partially filled or stowed with stone and other debris. The system (either advance or retreat) normally requires less development work and removes 100 percent of the coal bed. However, not all coal beds are adaptable to the system. Flat-lying seams are much easier to longwall than steeply pitching seams. Support of the working face area is usually accomplished with adjustable props (steel supports for the roof) that can be mechanically propelled forward or backward. In the longwall retreating system of mining the development headings are driven narrow to the boundary or limit line, and then the coal seam is extracted by longwall faces retreating toward the shaft. In this method, all the roadways are in the solid coal seam, and the waste areas are left behind; development work is normally not required outside the coal seam. Virtually 100 percent of the coal is extracted.

The longwall system has been under intensive research investigation in Europe and the United States for the past 10 years. Progress in the research has been slow wherein attempts have been made to adapt the system to steeply pitching coal seams. Absolute control of the cave line back from the working face is a requirement of the system. Absolute control of the cave line in a steeply pitching coal seam is often impossible to obtain. The only way in which it can be determined whether control of the cave line can be achieved is to run actual tests in the mine. Such tests require highly trained and competent personnel and are time consuming and costly.

Operations in the Coos Bay area will always have to content with high development costs regardless of the system of mining. Because of the extensive faulting and folding in the area, development of the coal beds will be difficult and costly. If a longwall retreat system could be used in certain areas, the length of the longwall would often be limited by faults and unpredictable local folds; shortening of the longwall increases the development work.

Judging from the data now available on the coal beds, it appears that more than one method of mining will be needed to extract the coal. The development of the most efficient combination of methods can be accomplished only by actual mining practice. Preliminary design prior to entry can show possibilities, but the final most efficient combination may not be achieved until after 2 to 5 years of underground mining experience.

The uncertainty of the adaptability of the Coos Bay coal beds to the longwall retreat system of mining, the unknown combination of methods of mining, and the still unproven technologies of planer and hydraulic mining of steeply pitching coal seams are factors that work against opening up the Coos Bay field at this time. Additional research and development of a working technology for the planer, hydraulic, and longwall systems that can be extrapolated to all deposits could at some future date make the field economic to mine.

Market potential

Solid fuel for local markets. The local market for Coos Bay coals (or other competing coals) would be divided into: (1) domestic; (2) commercial, including schools and public buildings; and (3) industrial. Little, if any, coal is currently being consumed in Coos Bay. Should future changes in the energy picture place Coos coal in a favorable cost-per B.t.u. position, it is conceivable that some conversion by commercial and industrial units would occur. It is doubtful that much switching of fuels would occur in the domestic area unless those presently used either became difficult to obtain or exorbitantly expensive. At present the built-in convenience of gas, oil, and electricity makes them the preferred energy sources for domestic use.

In the commercial and industrial sector the use of solid fuels, once conversion has been accomplished, imposes relatively small burdens on the user. Mechanized materials handling, stoking and ash recovery systems have greatly narrowed the gap between coal and other forms of energy in large-scale applications. Another factor favoring the use of coal commercially and industrially is the ability of the consumer to obtain and store adequate supplies of coal well in advance of his needs, thus forestalling the threat of sudden cutbacks in supply. Large quantities of coal can be stored at relatively little expense compared to either gas or oil.

The volume of coal that would be consumed annually in the Coos Bay area, assuming a changeover from present energy sources to coal wherever possible is hard to predict. As pointed out above, the use of coal domestically would be made only as a last alternative and the total amount would be small in any event. The amount of coal consumed by commercial users would depend on several factors. Space heating and water heating for public buildings could be easily accommodated by coal-burning equipment. Since there is an abundance of waste wood in the Coos Bay area, there would very probably be an increased use of this energy source in direct competition with coal. It is doubtful that in-house, coal-fired, steam-powered electrical generation plants would be economic except in very special cases.

Industrial use of coal in the Bay area, assuming that other traditional sources of energy either became too expensive or unavailable, would be by those plants which required heated air or water (including steam) in their operation. As in the case of the commercial user, it is doubtful that small coal-fired electrical generation plants would be feasible. It is conceivable that a moderate sized steam electrical plant could be built in the area to service local needs and possibly provide a surplus. While the conversion to coal-fired heating of air, water, and steam can be accomplished rather speedily and inexpensively, the construction of a steam power plant requires considerable lead time and a large capital expenditure.

The following information, supplied by the U.S. Bureau of Mines Process Evaluation Group, was prepared in response to a request for an evaluation of the potential for the Coos Bay coal.

> "Mines being planned or opened today are high tonnage designed to feed powerplants or proposed coal gasification plants and are capable of maintaining constant tonnage over a 20- to 35-year period. The estimated capital investment of $233.6 million for an underground mining complex designed to provide coal for a powerplant in a western state includes total washing facilities and provides for a $35.2-million escalation cost during construction. The power station is rated at 3,000 MW and requires 9 million tons of raw coal per year. A 1,000-MW plant would need approximately 3 million tons per year. Coal reasonably similar to the Coos Bay area but located in Wyoming must produce 9.8 million tons of coal per year to feed a $636.5 million Synthane gasification plant that produces 250 million scfd of high-Btu gas.

In your summary of the Coos Bay Coal Reserves, the Beaver Hill Bed is listed separately because economics favor it. This seam represents 25 million tons of minable and 16 million tons of prospective coal or a total of 40.7 million tons. It is assumed that these figures are correct, although questionable due to the physical conditions known to exist in the field. The 40.7 million tons represents only 4.5 years of life and rules out a 3,000 MW power plant or a coal gasification plant. A 1,000-MW plant would have only 13.6 years of life. Other seams account for 32 million tons which increases the total to 73.2 million. This amount would sustain the smaller power unit for 24 years; however, is it known for sure that this tonnage can be mined?"

Solid fuel for non-local markets. The proximity of the Coos Bay coals to deep water port facilities presents the possibility of shipping solid coal to coastwise points or even overseas. Mined and processed coal could conceivably be delivered direct from the washery to barges in some cases, or by a relatively short truck haul to bottoms in others.

The cost per million B.t.u. at point of delivery would be a major determining factor in any movement of Coos coal. Competition from Intermountain and Northern Great Plains coals is a possibility. Unit train movement of Wyoming coal to the Boardman area in the near future could easily be expanded to either rail points in the Lower Columbia or by loading into barges at Boardman both lower river and coastal ports could be served. Low mining and freight costs for this coal could pose a very real threat to the Coos coal.

Gasification and by-products. During the course of the study, the possibility of either directly gasifying the Coos coals in place or, alternatively, mining the coal in the conventional manner and then processing it into various coal tar derivatives on the surface was considered. It became abundantly apparent as the study progressed that insufficient data on the nature of the unmined coal presently exists to permit anything more than a cursory investigation of in situ gasification. Nationally this procedure is being examined by the U.S. Bureau of Mines at a test installation located in Laramie, Wyoming. The reduction of coal into various by-products in a surface plant would necessarily depend upon a large supply of coal.

Chemical plants characteristically require large volumes of both process and cooling water, plus lesser amounts of service water for ancilliary activities. The cost of providing adequate supplies of water for plant use has not been investigated as part of the present study. It is felt, however, that the figure might be rather high, depending on the particular source chosen.

Since many coal-derived chemical products are relatively expensive, they can be shipped considerable distances to market. This condition is a two-edged sword and it is conceivable that other plants sited on or near very large deposits elsewhere in the United States or Canada would dominate this particular segment.

Modern coal gasification processes are considerably more complicated than the original "gashouse" which destructively distilled coal. Once common in urban areas in the United States, coal gas surrendered, starting after World War II, to natural gas which became increasingly abundant, had a higher unit heating value, and was comparatively cheap. Only recently has any interest been displayed in gasifying coal, and then only when supplies of natural gas and oil were threatened and the unit cost per B.t.u. increased markedly. Although this trend should be encouraging to the production of gas from coal, the plant costs are high, with estimates for a plant capable of producing 250 million cubic feet of gas per day ranging from $180 to more than $400 million. Annual operating costs for such a plant would be in the neighborhood of

$60 million. A gasification plant with a production of 250 million cubic feet of gas per day would require between 6 and 8 million tons of coal annually, depending on the B.t.u. content and a 55 percent coal-to-gas efficiency. A total of over 200 million tons of coal would be required to service the operation over a projected plant life of 30 years.

In situ gasification is being developed much more slowly than surface plant operations, which can be scaled up readily from small pilot plants. The large number of variables and unknowns associated with underground gasification will require both a longer development period for the process in general and detailed investigation and exploration of each individual area to be gasified. Estimated lead time for putting a gasification plant on the line is from 5 to 15 years. Without going into further detail, it is safe to say that for all practical purposes any in situ operations on the Coos Bay field are many years away.

Coal-based products. Coal is the rootstock for a veritable tree of coal-based products. Coos coal is suitable for many of these derivatives and the local economy could absorb quantities of fertilizer for agricultural purposes and adhesives for the plywood industry. The high cost of a chemicals-from-coal plant, the relatively small resource base, and the comparatively high mining cost would place some severe restrictions on such an undertaking. Water requirements are rather large and there is a possibility that obtaining water in sufficient quantity and of proper quality might be difficult.

At this time it would appear that any consideration of a coal-based products plant should be deferred until at least one large mine was developed and a history of mining costs developed.

Competing energy sources. When used as a source of energy, coal must often compete with a variety of other fuels and the final determination in many cases is made largely on the delivered cost per million B.t.u. It is for this reason, in part at least, that the consumption of coal has rapidly increased as the cost of petroleum has skyrocketed. Future curtailments of competitive fuels, principally natural gas and oil, will improve the demand for coal. With the development of efficient bulk transportation methods such as the unit-train and pipeline, the market radius for coal has greatly expanded in recent years. Only large mines can enjoy this expanded market area, however.

It would appear that the Coos Bay area coals presently are not in a too economically favorable situation. Competition from other forms of energy available in the area on a cost per B.t.u. basis, plus inherent economies or convenience in using either natural gas or oil severely limit the market for the coal. Outside the immediate Coos Bay area the opportunities for selling Coos Bay coal are diminished by the near-future possibility of unit-train deliveries of mid-continent coal to Willamette Valley points.

Should the relative costs of natural gas and oil increase significantly, or be available in sharply limited quantities, then it is entirely conceivable that a market could develop for Coos coals. As an energy source, coal enjoys the shortest start-up time of any alternate fuel. This assumes that the following conditions exist at the time: (1) deposits which have been explored by sufficient drilling to indicate their extent, grade, thickness, and attitude; (2) the deposits have been identified as a mineral resource and the surface area or access area has been properly zoned to allow its exploitation; (3) acceptable environmental and economic impact studies had been made; and (4) all information contained in the three preceding steps be either published or on open file and readily available.

Glossary of Terms Used in Report

Anticline - An arch-shaped upwarping of one or more strata in the earth's crust.

Attitude - The dip and strike of a bed. "The coal strikes N 30° W and dips 24° NE."

B.t.u. - Abbreviation for British thermal unit. One B.t.u. is equivalent to the amount of energy required to raise one pound of water one degree Fahrenheit. One B.t.u. equals .000293 kilowatt hours.

Dip - The inclination of rock strata or a coal seam, measured in degrees from the horizontal. The direction of a dip is always at right angles to the strike.

Fault - A plane of slippage through rock formations. The amount of relative movement may range from a fraction of an inch to a hundred feet or more.

Gob - The space from which coal has been mined, also waste material stored in such space.

In situ - In place. As used in the report the term refers to the burning of coal in place in the seam without mining, but with some development work to provide ventilation and collection of combustion gases.

Parting - A layer of non-coal material, usually clay, shale or sandstone, separating a coal seam into two or more parts. Not all coal beds have partings.

Strike - The direction of a horizontal trace across a bedding plane or coal seam. See also dip.

Syncline - A downwarping of the earth's crust. The degree of folding for both anticlines and synclines varies widely.

Selected References on Coos Bay Coal

Allen, John E., and Baldwin, Ewart M., 1944, Geology and coal resources of the Coos Bay quadrangle, Oregon: State of Oregon Dept. of Geology and Mineral Industries Bull. 27.

Anderson, Webster S., 1962, Test operation of a pneumatic vibrating-blade planer in phosphate and coal: U.S. Bur. Mines Rept. of Inv. 6140.

Baldwin, Ewart M., 1966, Some revisions of the geology of the Coos Bay area, Oregon: State of Oregon Dept. of Geology and Mineral Industries, The Ore Bin, vol. 28, no. 11, p. 189-203.

Duncan, Donald C., 1953, Geology and coal deposits in part of the Coos Bay coal field, Oregon: U.S. Geol. Survey Bull. 982-B.

Katell, Sidney, and Hemingway, E. L., 1974, Basic estimated capital investment and operating costs for underground bituminous coal mines: U.S. Bur. of Mines Inf. Circ. 8632 and Inf. Circ. 8641.

Libbey, F. W., 1938, Progress report on Coos Bay coal field, Oregon: State of Oregon Dept. of Geology and Mineral Industries Bull. 2.

Mason, Ralph S., and Erwin, Margaret I., 1955, Coal resources of Oregon: U.S. Geol. Survey Circ. 362.

Nasiatka, Thomas M., and Badda, Frank, 1963, Hydraulic coal mining research: U.S. Bur. Mines Rept. of Inv. 6276.

Northern Great Plains Resources Program, 1975, Effects of coal development in the Northern Great Plains: Denver, Colorado, Federal Center, Northern Great Plains Resources Program.

Perry, Harry, 1974, The gasification of coal, Sci. American, vol. 230, no. 3, p. 19-25.

Smith, William H., and Stall, John B., 1975, Coal and water resources for coal conversion in Illinois: Illinois State Water Survey and Illinois State Geol. Survey, Cooperative Resources Report 4.

Toenges, Albert L., and others, 1949, Minable reserves, petrography, chemical characteristics, and washability tests of coal occurring in the Coos Bay field, Coos County, Oregon: U.S. Bur. Mines Tech. Paper 707.

U.S. Congress, Committee on Interior and Insular Affairs, 1975, Factors affecting coal substitution for other fossil fuels in electric power production and industrial uses: Washington, U.S. Govt. Print. Off. (94th Congress, 1st sess. Senate, Committee print).

APPENDIX

On the following pages the individual computations for the reserves of coal in the Coos Bay coalfield are shown for the "Minable," "Prospective," and "Remotely Possible" categories of the Beaver Hill bed, and for the "Minable" reserves of the "Upper Coals" and the "Coaledo Arch" coals. The tables also give the tonnages both by quadrangle and by mining area. The area numbers shown on the various sheets refer to the areas outlined on the quadrangle maps.

The tonnage factor shown at the bottom of each page represents 50 percent of the total geologic coal per acre that is felt to be recoverable in standard underground mining. If some form of longwall mining was undertaken, then the percentage of recoverable coal would be greater. The figure of 1700 tons of coal per acre-foot would be conservative for a coal bed without partings. The presence of the two partings in the Beaver Hill bed implies certain losses, either in physical separation at the face or in the washery, hence the figure used.

COOS BAY COAL STUDY

"Minable" and "Prospective" Coals of the Beaver Hill Bed

Coos Bay Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
1	22	26S	13W	90			
	23	"	"	180			
	26	"	"	5			
	27	"	"	90			Southport-Thomas
			TOTAL	365 (m)	(4250)	1,551,250	Minable coal
2	26	26S	13W	375			
	27	"	"	70			
	34	"	"	350			
	35	"	"	550			
	2	27S	"	365			
	3	"	"	570			
	9	"	"	20			
	10	"	"	95			Beaver Hill Area
			TOTAL	2395 (m)	(4080)	9,771,600	Minable coal
3	2	27S	13W	235			
	10	"	"	25			
	11	"	"	70			Beaver Hill Area
			TOTAL	330 (p)	(4080)	1,346,400	Prospective coal
4	2	27S	13W	45			
	11	"	"	45			
	12	"	"	70			Beaver Hill Area
			TOTAL	160 (m)	(4080)	652,800	Minable coal

	Acres	Beaver Hill Area	Southport-Thomas	Total
Total "Minable coal"	2920	10,424,400	1,551,250	11,975,650
Total "Prospective coal"	330	1,346,400	----	1,346,400
Total for quadrangle	3250	11,770,800	1,551,250	13,322,050

* Factor = 5' thicknes x $\frac{1700}{2}$ = 4250, or 4.8' thickness = 4080 tons per acre of recoverable coal.

COOS BAY COAL STUDY

"Minable" and "Prospective" Coals of the Beaver Hill Bed

Coquille Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
(1)	9	27S	13W	165			
	10	"	"	305			
	11	"	"	350			
	12	"	"	60			
	14	"	"	20			
	15	"	"	525			
	16	"	"	270			
	22	"	"	80			
	23	"	"	35			
			TOTAL	1810 (m)	(4080)	7,384,800	Minable coal
(2)	25	27S	13W	108			
	26	"	"	260			
	34	"	"	20			
	35	"	"	340			
	36	"	"	20			
			TOTAL	745 (p)	(4080)	3,039,600	Prospective coal
(3)	Listed under "Remotely Possible"						
(4)	" " "Upper Coals"						

	Acres	Beaver Hill Area	Riverton-Coquille Area	Total
Total "Minable coal"	1810	7,384,800	----	7,384,800
Total "Prospective coal"	745	----	3,039,600	3,039,600
Total for quadrangle	2555	7,384,800	3,039,600	10,424,400

* Factor $= 4.8' \text{ thickness} \times \frac{1700}{2} =$ tons per acre of recoverable coal.

COOS BAY COAL STUDY

"Minable" and "Prospective" Coals of the Beaver Hill Bed

Charleston Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
1	16	26S	14W	260			
	21	"	"	260			
	27	"	"	140			
	28	"	"	170			
			TOTAL	830 (p)	(4250)	3,527,500	Prospective coal
2	34	26S	14W	210 (p)	(4250)	892,500	Prospective coal
3	34	26S	14W	125			
	35	"	"	10			
	2	27S	14W	430			
	3	"	"	75			
			TOTAL	640 (m)	(4250)	2,720,000	Minable coal
4	5	26S	13W	45			
	6	"	"	5			
	7	"	"	120			
	8	"	"	125			
	18	"	"	200			
	19	"	"	40			
			TOTAL	535 (p)	(4250)	2,273,750	Prospective coal
5	3	26S	14W	-			
	4	"	"	25			
	9	"	"	170			
	10	"	"	5			
			TOTAL	200 (p)	(4250)	850,000	Prospective coal

		South Slough Area	Beaver Hill Area	Total
Total "Minable coal"	640	2,720,000	----	2,720,000
Total "Prospective coal"	1775	7,543,750	----	7,543,750
Total for quadrangle	2415	10,263,750	----	10,263,750

* Factor - 5' thickness x $\frac{1700}{2}$ = 4250 tons per acre of recoverable coal.

COOS BAY COAL STUDY

"Minable" and "Prospective" Coals of the Beaver Hill Bed

Riverton Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
(1)	8	27S	13W	-			Mined out
	9	"	"	60			
	16	"	"	220			
	17	"	"	210			
	18	"	"	40			
	19	"	"	10			
	20	"	"	155			
	21	"	"	-			
			TOTAL	695 (m)	(4080)	2,835,600	Minable coal
(2)	13	27S	14W	105			
	18	"	"	40			
	19	"	"	280			
	24	"	"	210			
	29	"	"	25			
	30	"	"	300			
			TOTAL	960 (p)	(4080)	3,916,800	Prospective coal
(3)	Listed under "Remotely Possible"						

	Acres	Beaver Hill Area
Total "Minable coal"	695	2,835,600
Total "Prospective coal"	960	3,916,800
Total for quadrangle	1655	6,752,400

* Factor = 4.8' thickness x $\frac{1700}{2}$ = 4080 tons per acre of recoverable coal.

COOS BAY COAL STUDY

"Remotely Possible" Coal, Beaver Hill Bed Only
Coos Bay Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
5	24	26S	13W	560			
	23/37	"	"	450			Southport-Thomas mine area
			TOTAL	1010	(4080)	4,120,800	
6	25	26S	13W	580			
	26	"	"	170			
	35	"	"	135			
	36	"	"	430			
	1	27S	"	370			Beaver Hill mine area
			TOTAL	1685	(4080)	6,874,800	

	Acres	Southport-Thomas Area	Beaver Hill Area	Total
Total "Remotely Possible"	2695	4,120,800	6,874,800	10,995,600

* Factor = 4.8' Thickness x $\frac{1700}{2}$ = 4080 tons per acre of recoverable coal.

COOS BAY COAL STUDY

"Remotely Possible" Coal, Beaver Hill Bed Only
Coquille Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
6	27	27S	13W	320			
	28	"	"	370			
	33	"	"	130			
			TOTAL	820	(4080)	3,345,600	Beaver Hill area
7	26	27S	13W	330			
	27	"	"	320			
	33	"	"	240			
	34	"	"	640			
	3	28S	"	445			
	4	"	"	350			Riverton-Coquille
			TOTAL	2325	(4080)	9,486,000	area
8	9	28S	13W	270			
	10	"	"	30			"Dirty" coal
	16	"	"	20			Riverton-Coquille
			TOTAL	320	(4080)	1,305,600	area

	Acres	Beaver Hill Area	Riverton-Coquille Area	Total
Total "clean" coal	3145	3,345,600	9,486,000	12,831,600
Total "Dirty" coal	320	----	1,305,600	1,305,600
Total for quadrangle	3465	3,345,600	10,791,600	14,137,200

* Factor = 4.8' thickness x $\frac{1700}{2}$ = 4080 tons per acre of recoverable coal.

COOS BAY COAL STUDY

"Remotely Possible" Coal, Beaver Hill Bed Only
Riverton Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
6	28	27S	13W	270			
	29	"	"	640			
	30	"	"	125			
	31	"	"	225			
	32	"	"	640			
	33	"	"	215			
	5	28S	"	320			
	6	"		150			
			TOTAL	2585	(4080)	10,546,800	Beaver Hill area
7	33	27S	13W	55			
	4	28S	"	210			
	5	"	"	320			
			TOTAL	585	(4080)	2,386,800	Riverton-Coquille area
8	7	28S	13W	20			
	8	"	"	640			
	9	"	"	275			
	16	"	"	125			
	17	"	"	600			
	18	"	"	25			
	19	"	"	75			
	20	"	"	230			
			TOTAL	1990	(4080)	8,119,200	"Dirty" coal Riverton-Coquille area

	Acres	Beaver Hill Area	Riverton-Coquille Area	Total
Total "clean" coal	3170	10,546,800	2,386,800	12,933,600
Total "Dirty" coal	1970	----	8,119,200	8,119,200
Total for quadrangle	5140	10,546,800	10,506,000	21,052,800

* Factor = 4.8' thickness x $\frac{1700}{2}$ = 4080 tons per acre recoverable coal.

COOS BAY COAL STUDY

"Remotely Possible" Coals of the Beaver Hill Bed (Dirty" coal only)

Riverton and Coquille Quadrangles, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
Riverton Quadrangle							
	7	28S	13W	20			
	8	"	"	640			
	9	"	"	275			
	16	"	"	125			
	17	"	"	600			
	18	"	"	25			
	19	"	"	75			
	20	"	"	230			
			TOTAL	1990	(4080)	8,119,200	
Coquille Quadrangle							
	9	28S	13W	270			
	10	"	"	30			
	16	"	"	20			
			TOTAL	320	(4080)	1,305,600	
		TOTALS		2310	(4080)	9,424,800	Tons "Dirty" coal Beaver Hill bed

Note:-The northern boundary of the "Dirty Beaver Hill Coal" area has been arbitrarily placed along the southern edge of secs. 7, 8, 9, T. 28 S., R. 13 W. The southern boundary conforms to the approximate trace of the Beaver Hill outcrop as determined by Allen and Baldwin.

* Factor = 4.8' thickness x $\frac{1700}{2}$ = 4080 tons per acre of recoverable coal.

COOS BAY COAL STUDY

"Upper Coals" (above the Beaver Hill bed)

Coos Bay Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
1	26	26S	13W	90			
	27	"	"	50			
	34	"	"	220			
	35	"	"	500			
	2	27S	"	330			
	3	"	"	470			
	10	"	"	80			
	11	"	"	10			
			TOTAL	1750	(3400)	5,950,000	Beaver Hill mine area

	Acres	Beaver Hill Area	Riverton-Coquille Area	Total
Total	1750	5,950,000	----	5,950,000

* Factor $= 4'$ thickness $\times \frac{1700}{2} =$ 3400 tons per acre recoverable coal.

COOS BAY COAL STUDY

"Upper Coals" (above the Beaver Hill bed)

Coquille Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
1	26	27S	13W	620			
	27	"	"	460			
	34	"	"	40			
	35	"	"	115			Riverton-Coquille
			TOTAL	1235	(3400)	4,199,000	area
2	3	28S	13W	175			
	4	"	"	320			
	9	"	"	75			
	10	"	"	---			
	16	"	"	---			Riverton-Coquille
			TOTAL	480	(3400)	1,632,000	area
3	9	27S	13W	100			
	10	"	"	270			
	15	"	"	100			
	16	"	"	350			Beaver Hill mine
			TOTAL	820	(3400)	2,788,000	area

	Acres	Riverton-Coquille Area	Beaver Hill Area	Total
Total	2535	5,831,000	2,788,000	8,619,000

* Factor = 4' thickness x $\frac{1700}{2}$ = 3400 tons per acre recoverable coal.

COOS BAY COAL STUDY

"Upper Coals" (above the Beaver Hill bed)
Riverton Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons	Remarks
△1	4	28S	13W	310			
	5	"	"	195			
	8	"	"	200 (est.)			
	9	"	"	95			
	17	"	"	100 (est.)			
	18	"	"	10			
			TOTAL	910	(3400)	3,094,000	Riverton-Coquille area
△2	19	27S	13W	450			
	24	"	14W	65			
	29	"	13W	125			
	30	"	"	350			
	31	"	"	220			
	32	"	"	230			
			TOTAL	1440	(4250)	6,120,000	Riverton-Coquille area
△3	16	27S	13W	160			
	17	"	"	200			
	19	"	"	10			
	20	"	"	140			
			TOTAL	510	(3400)	1,734,000	Beaver Hill mine area

	Acres	Riverton-Coquille Area	Beaver Hill Area	Total
Total	2860	9,214,000	1,734,000	10,948,000

* Factors

4' thickness x $\frac{1700}{2}$ = 3400 tons per acre recoverable coal.

5' thickness x $\frac{1700}{2}$ = 4250 tons per acre recoverable coal.

COOS BAY COAL STUDY

"Minable" Coaledo Arch Coals

Coquille Quadrangle, Oregon

Area	Sec.	Twp.	Rge.	Acres	Factor*	Tons		Remarks
1	7	27S	12W	160				
	12	"	13W	200				
	13	"	"	390				
	14	"	"	35				
	23	"	"	300				
	24	"	"	85				
			TOTAL	1170	(3400)	3,978,000	Tons	
2	10	27S	13W	135				
	11	"	"	230				
	12	"	"	10				
	13	"	"	---				
	15	"	"	330				
	22	"	"	160				
			TOTAL	865	(3400)	2,941,000		
	TOTALS			2035		6,919,000	Tons	

Note:-Area arbitrarily limited to Coquille quadrangle although this coal probably continues to NE somewhat farther. Faulting and overturned beds reported by Allen and Baldwin in sec. 31, T. 26 S., R. 12 W. probably extend southward into sec. 6, T. 27 S., R. 12 W.

* Factor = 4' thickness x $\frac{1700}{2}$ = 3400 tons per acre of recoverable coal.

Table 5. Summary of the Coos Bay Coal Reserves (Beaver Hill Bed only).

By Quadrangle

Quadrangle	Minable	Prospective	Remotely Possible "Clean"	Remotely Possible "Dirty"	Total
Charleston	2,720,000	7,543,750	-----	-----	10,263,750
Coos Bay	11,975,650	1,346,400	10,995,600	-----	24,317,650
Coquille	7,384,800	3,039,600	12,831,600	1,305,600	24,561,600
Riverton	2,835,600	3,916,800	12,933,600	8,119,200	27,805,200
TOTALS	24,916,050	15,846,550	36,760,800	9,424,800	86,948,200

By Mine Area

Mine Area	Minable	Prospective	Remotely Possible "Clean"	Remotely Possible "Dirty"	Total
Southport-Thomas	1,551,250	-----	4,120,800	-----	5,672,050
Beaver Hill	20,644,800	5,263,200	20,767,200	-----	46,675,200
Riverton-Couqille	-----	3,039,600	11,872,800	9,424,800	24,337,200
South Slough	2,720,000	7,543,750	-----	-----	10,263,750
TOTALS	24,916,050	15,846,550	36,760,800	9,424,800	86,948,200

Table 6. Summary of the Coos Bay Coal Reserves (other than the Beaver Hill bed)

By Quadrangle

Quadrangle	Other Coal Upper Coal	Other Coal Coaledo Arch	Total Other Coal	Total Beaver Hill*	Total Coos Coal
Charleston	-----	-----	-----	10,263,750	10,263,750
Coos Bay	5,950,000	-----	5,950,000	24,317,650	30,267,650
Coquille	8,619,000	6,919,000	15,538,000	24,561,600	40,099,600
Riverton	10,948,000	-----	10,948,000	27,805,200	38,753,200
TOTAL	25,517,000	6,919,000	32,436,000	86,948,200	119,384,200

By Mine Area

Mine Area	Other Coal Upper Coal	Other Coal Coaledo Arch	Total Other Coal	Total Beaver Hill*	Total Coos Coal
Southport-Thomas	-----	-----	-----	5,672,050	5,672,050
Beaver Hill	16,592,000	-----	16,592,000	46,675,200	63,267,200
Riverton-Coquille	8,925,000	-----	8,925,000	24,337,200	33,262,200
South Slough	-----	-----	-----	10,263,750	10,263,750
Coaledo Arch	-----	6,919,000	6,010,000	-----	6,919,000
TOTAL	25,517,000	6,919,000	32,436,000	86,948,200	119,384,200

* From Table 5.