CHAPTER II

DESCRIPTION OF THE EXISTING ENVIRONMENT

Climate

The description of general climate, temperature, and precipitation data in the Regional level report (Part I) adequately characterizes the climate on the Atlantic Richfield lease.

Data from the Rochelle 3E, Dull Center, and Reno weather stations, all of which are within 15 miles of the A.R.Co. lease, show the following ranges of climatic factors:

Temperature range	-40°F to 111°F
Mean monthly temperatures	21°F in January to 90°F in July
Average 28°F frost-free period, May 6 to September 30 - 147 days	
Chill factor in winter	-60°F to -70°F minimum
Relative humidity range	5 percent to 100 percent
Average relative humidity range	45 percent to 55 percent
Average wind speed	10 to 12 miles per hour
Average rainfall	12.72 inches per year
Average snowfall	33.6 inches per year

Tornadoes have occurred near the lease area.

In 1970 an unofficial precipitation gauge on a ranch three miles from the Atlantic lease measured six inches of precipitation (rain) in 12 hours. The accuracy of this measurement is unknown. No frequency can be assigned to the event.

Microclimate

Microclimatology is the study of slight differences in climate as between adjoining terrains due to slight differences in soil exposure, vegetation, etc. Studies conducted of microclimate are usually below the 4.5-foot level where standard weather stations are located. There are no known studies of microclimate on the Atlantic lease. The major effect on climate due to surface mining will occur in the microclimate. Changes in the microclimate may be the limiting factor in achieving revegetation success.

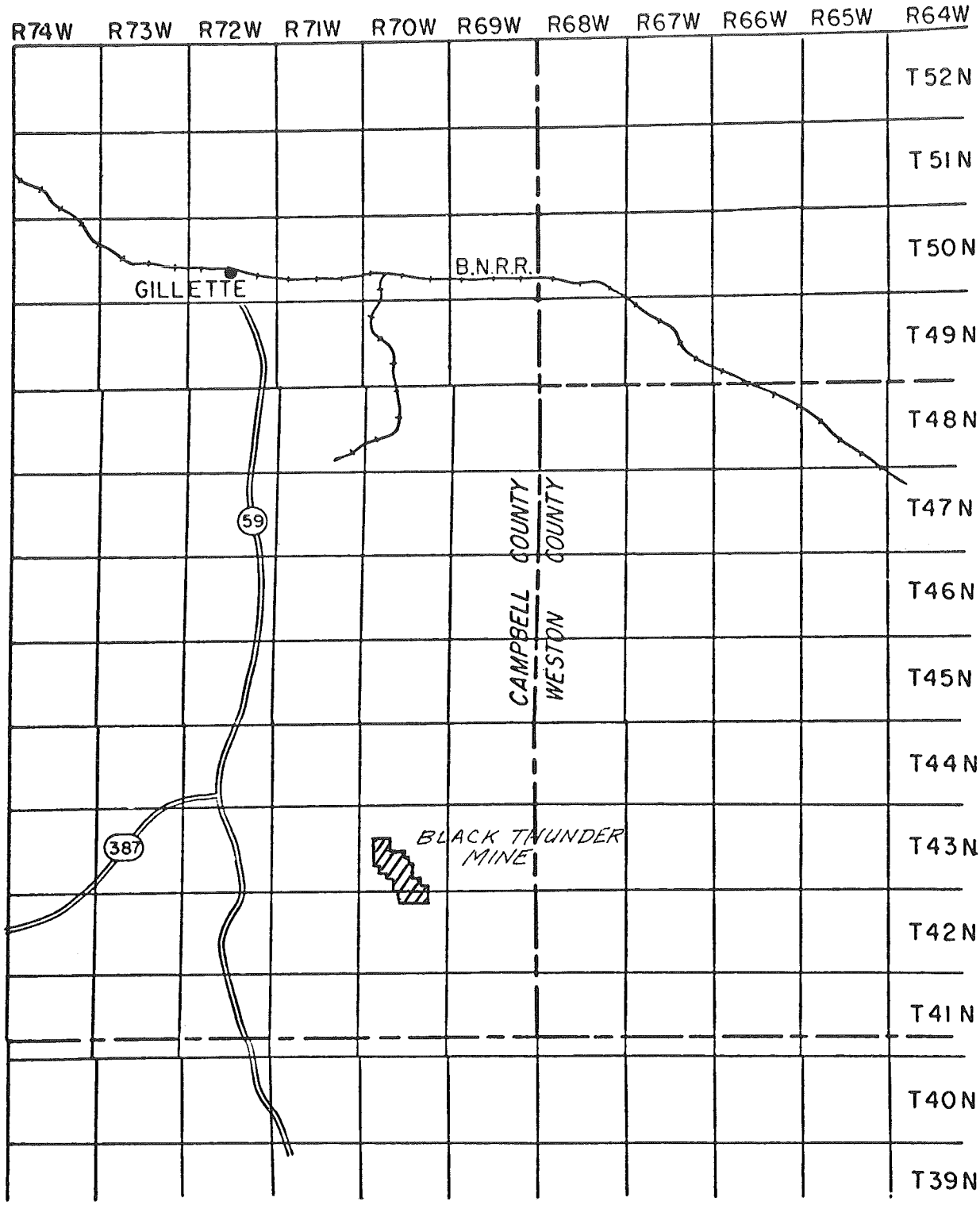


Figure 1

Location of the Black Thunder Coal Property, Atlantic Richfield Company, Campbell County, Wyoming.

Air Quality

Air quality over the lease is similar to the description given in the Regional level (Part I) report.

The lease is located in the Wyoming Intrastate Air Quality Region. Present air quality is estimated to be good. Emissions from the Cities of Douglas and Gillette and power plants at Glenrock and Wyodak probably do not affect the air quality over this lease. Data concerning mixing heights are contained in Table 6, Chapter IV, Part I.

Topography

The Black Thunder coal lease of the Atlantic Richfield Company is in the Northern Great Plains Province of Fenneman (1931) and on the eastern flank of the topographic and structural downwarp of the Eastern Powder River Coal Basin. The basin is a topographic depression between the Bighorn Mountains to the west and the Black Hills to the east. The Eastern Powder River Coal Basin is a plateau of low relief, interrupted by low rolling hills and grasslands, capped by sandstone and clinker deposits, and transected by steep-sided gulleys, washes, and broad, alluviated valleys. This part of the basin is typically rolling grasslands on a dissected plateau, local escarpments, and minor badland topography. Sparse vegetation, narrow ravines, sharp crests and pinnacles characterize the badlands.

In the vicinity of the lease site, the terrain is characterized by dissected plains having small, shallow intermittent ponds and lakes. These playa-like ponds form in depressions which probably result from a small structural warp and the differential settling of underlying deposits. To the east, steep bluffs, irregular, steep-sided ridges, and isolated hills typically form on interbedded sandstone lens and claystone and are capped by resistant clinker. These ridges and bluffs comprise breaks at the eastern edge of the plateau. Further east, a rugged, indented eastward-facing escarpment separates the upland from the smooth, low relief of the shale to the east (Figure 3). This striking and persistent feature, fringed by ponderosa pine trees, is locally known as the Rochelle Hills. The claystone forming the escarpment, the narrow ridges, and isolated buttes is protected and preserved by cappings of broken, porous red clinker. Slopes are steep or cliff-like in these areas.

The Black Thunder lease lies entirely within the drainage basin of Little Thunder Creek which flows eastward into the Cheyenne River. The creek has a narrow, meandering, steep-sided channel on the uplands that bisects the

Figure 3

Topography of the Proposed Black Thunder Mine Area.

lease and opens eastward into a wide, smooth-floored valley. Little Thunder Creek and its tributaries, North Prong and Trussler Creeks, flow intermittently.

Altitudes range from 4,847 feet in section 2 on the southeast side of the lease to about 4,630 feet where the creek enters the wide valley. The local relief averages about 250 feet. Slopes are less than 10 percent on the lease area but locally exceed 20 percent east of the burnline. The steepest topography on the lease site occurs on the southeast rim of North Prong Valley, near the northeast corner of Section 21.

Soils

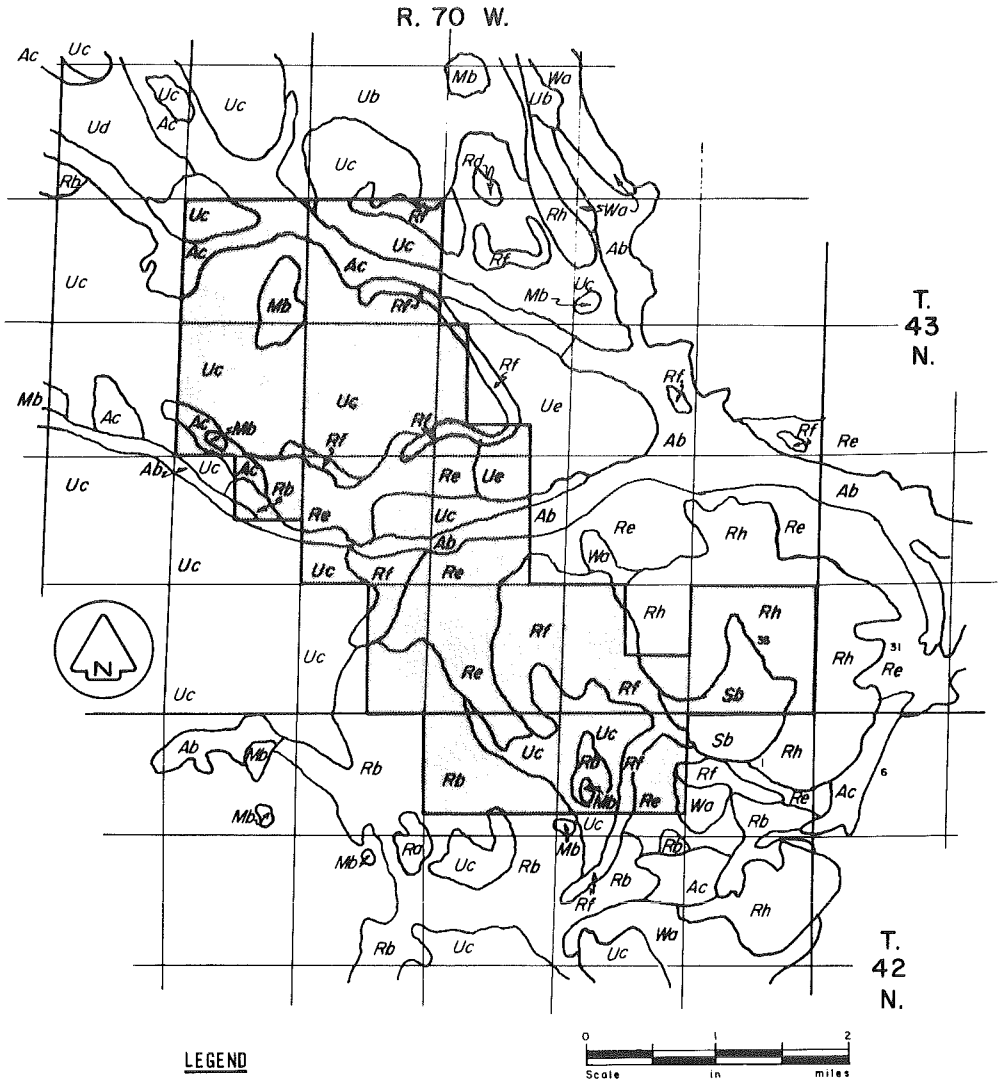
This presentation of soil data for the A.R.Co. lease was taken from the Campbell County Reconnaissance Soil Survey. The field work was completed in 1939 and published by the USDA Soil Conservation Service in 1955. It must be realized that this survey is very general (Reconnaissance) although a number of series was identified. Each delineation also includes several other soil series or variations not mapped or mentioned due to minor amounts or the failure of identification according to modern concepts. Since the end of field work on this survey, major classification methods have passed through the Great Soil Group system (1938), the 7th Approximation (1964), and currently the New Soil Taxonomy (1971). Soils indentified and classified in 1939 bearing the same series name of today may not approach similarity. Interpretations are based on the modern concepts of the series identified offsite; therefore, the implied interpretations may be somewhat less desirable than the basic interpretation of 1939. Soils of the area have not changed significantly since 1939, but technology in the field of soil science has; therefore, soil inventories must be conducted on the lease area and adjacent lands in order to properly evaluate impacts on the land and the relationships to the existing environment.

A soil map showing the distribution of soil units within the lease is illustrated in Figure 4. Interpretations of the soil units are summarized in Table 1. Detailed interpretations of each soil unit are in Tables 10 through 28, Appendix C.

The following soil unit descriptions provide definition to the generalized distribution of soil on the included map for the lease area.

<u>Ab-Arvada Clay loam</u>

Arvada clay loam occupies sloping terraces and alluvial fans that have been formed by local alluvium from upland soils. The soil has alkaline



LEGEND

Ab	Arvada Clay Loam
Ac	Arvada Loam
Mb	McKenzie Clay
Rb	Renohill Clay Loam
Re	Renohill Loam, Rolling Phase
Rf	Rough Broken Land
Rh	Rough Broken Land (Searing Soil Material)
Ub	Ulm Clay Loam, Shallow Phase
Uc	Ulm Loam
Ue	Ulm Loam, Rolling Phase
Wa	Wibaux-Searing Complex
Sb	Searing Gravelly Loam
	Boundary of Arco Coal Property

Figure 4
General soils map (Arco Coal Property)

Soil Unit		Erosion Hazard Potential		Revegetation Potential	Suitability for Sprinkler Irrigation	Suitability for Final Cover for Mined Land		Suitability for Transportation Routes	Suitability for Roadfill	Suitability for Sanitary Facilities: Septic-tank Absorption Fields	Suitability for Sanitary Facilities: Sewage Lagoons	Suitability for Sanitary Facilities: Sanitary Landfills (Trench)	Suitability for Small Commercial Buildings
Symbol	%Slope	** Water	Wind			In. Available	Suitability						
Ab	0-5	M	M	L	L	0	L	L	L	L	L	L	L
	5-10	H	M	L	L	0	L	L	L	L	M	L	L
Ac	0-5	M	M	L	L	0	L	L	L	L	H	L	L
	5-10	H	M	L	L	0	L	L	L	L	M	L	L
Mb	0-5	M	M	L	L	0	L	L	L	L	L	L	L
Rb	0-5	M	M	M	L	6	M	L	L	L	L	L	L
	5-19	H	M	M	L	6	M	L	L	L	L	L	L
Re	10-20	H	L	M	M	8	H	L	L	L	L	L	L
	20-30	H	L	M	L	8	H	L	L	L	L	L	L
	30-40	H	L	M	L	8	H	L	L	L	L	L	L
Rf	20-30	H	L	L	L	0	L	L	M	L	L	L	L
	30-40	H	L	L	L	0	L	L	L	L	L	L	L
	40-50	H	L	L	L	0	L	L	L	L	L	L	L
Rh	20-30	H	L	L	L	0	L	L	M	L	L	L	L
	30-40	H	L	L	L	0	L	L	L	L	L	L	L
	40-50	H	L	L	L	0	L	L	L	L	L	L	L
Ub	0-5	M	M	L	L	6	M	L	L	L	L	L	M
	5-10	H	M	L	L	6	M	L	L	L	L	L	M
Uc	0-5	M	M	M	M	16	M	M	M	L	L	L	M
	5-10	H	M	M	M	16	M	M	M	L	L	L	M
Ue	10-20	H	L	L	L	10	M	L	M	L	L	L	M
	20-30	H	L	L	L	10	M	L	M	L	L	L	L
	30-40	H	L	L	L	10	M	L	L	L	L	L	L
Wa	5-10	H	L	L	L	8	L	M	H	L	L	L	H
	10-20	H	L	L	L	8	L	L	H	L	L	L	M
	20-30	H	L	L	L	8	L	L	M	L	L	L	L
Sb	5-10	M	L	L	M	15	M	M	M	L	L	L	M
	10-20	H	L	L	M	15	M	M	M	L	L	L	M

*3 Classes: L = low, M = moderate, H = high.
**Estimated onsite erosion, bare soil conditions, L = 3.T./ac, M = 3-8T./ac., H = 8T./ac.
Source of interpretations: 1. Descriptions from Campbell County. 2. Soil Conservation Service soil profile descriptions. 3. SCS Form 5, Interpretation sheet. 4. Region 2, Forest Service Guidelines for Soil Interpretations, 5. SCS Guide for Interpreting Eng. Uses of soils.

Table 1

Soil Interpretation Summary*

or saline areas and bare spots where wind erosion has removed the surface and exposed the clay subsoil.

The surface horizon is light brownish gray friable clay loam about four inches thick. The soil reaction (pH) ranges from slightly to strongly alkaline. The subsoil is brown to gray clay to clay loam about 20 inches thick and has columnar to prismatic structure. The substratum is clay loam to clay to 60 inches or more. The soil reaction of the subsoil and substratum ranges from strongly to very strongly alkaline. The internal drainage is very slow. The exchangeable sodium percentage of the subsoil and substratum is high, more than 15 percent. There are an estimated 110 acres of these soils on the lease.

Ac-Arvada loam

Arvada loam occupies sloping terraces that have been formed by local alluvium. The soil has alkaline or saline areas and bare spots where wind erosion has removed the surface and exposed the clay subsoil. The surface horizon is 5 to 10 inches thick and ranges from sandy loam to loam. The subsoil is clay loam to clay and has columnar to prismatic structure. The substratum is clay to silty clay loam to 60 inches or more. The soil reaction of the subsoil and substratum ranges from strongly to very strongly alkaline. The internal drainage is very slow. The exchangeable sodium percentage of the subsoil and substratum is high, more than 15 percent. There are an estimated 380 acres of these soils on the lease.

Mb-McKenzie clay

McKenzie clay occurs in shallow, intermittent lakes on upland landforms. The soil consists of gray or dark gray clay materials which have eroded from upland soils. McKenzie clay varies in stage of development with carbonate bearing layers occurring from a few inches to several feet below the surface.

The surface layer is 2 to 5 inches thick and ranges from sandy loam to clay. The substratum is dominantly a massive, gray clay and may be more than 60 inches deep. Soil reaction is normally strongly to very strongly alkaline. Carbonate content is variable but usually increases with depth. Internal drainage is very slow. Saline and sodic salts are present in some locations. There are an estimated 140 acres of these soils on the lease.

Rb-Renohill clay loam

Renohill clay loam occupies gently sloping to rolling uplands. The parent material is weathered shale of the Wasatch, Lance, and Fort Union Formations. The clay loam surface horizon is 3 to 6 inches thick and has granular structure. The upper subsoil is clay to clay loam with prismatic and blocky structure. It normally contains no free calcium carbonate. The lower subsoil is clay loam and contains calcium carbonate. The clay loam substratum is calcareous extending to bedrock which occurs at depths of 20 to 40 inches. Soil reaction is normally neutral to moderately alkaline. The depth to calcareous material ranges from 6 to 20 inches. Internal drainage is slow. There are an estimated 510 acres of these soils on the lease.

Re-Renohill loam, rolling phase

This rolling phase differs from Renohill loam in topography, depth of soil, and degree of erosion. The topography is rolling to steep. The depth to bedrock ranges from less than 10 inches to 40 inches. Bedrock is exposed on some of the steeper slopes. Natural erosion has formed gullies in some areas. The parent material is weathered shale of the Wasatch, Lance, and Fort Union Formations. The loam to sandy loam surface layer is usually 3 to 6 inches thick. The upper subsoil is clay loam to clay with blocky and prismatic structure. It normally contains no free calcium carbonate. The lower subsoil is

clay loam and contains calcium carbonate. The clay loam substratum is calcareous. Soil reaction is normally neutral to moderately alkaline. The depth to calcareous material ranges from 6 to 20 inches. Internal drainage is slow. There are an estimated 930 acres of these soils on the lease.

Rf-Rough broken land

Rough broken land consists of steep, eroded, strongly dissected areas along escarpments, steep-walled drainage channels, and rock outcrops. The parent material is interbedded shale, sandstone, and limestone. Small areas of shallow to deep soils are intermingled in rough broken land. The density of vegetation is quite variable, ranging from bare areas or sparse vegetation on rock outcrops to dense stands on the deeper soils. The physical and chemical properties of the unit are very variable. There are an estimated 750 acres of this land type on the lease.

Rh-Rough broken land, searing soil material

This unit is a complex of rough broken land and eroded areas of scoria. Rough broken land includes steep, eroded, strongly dissected areas along escarpments, steep-walled drainage channels, and rock outcrops. Scoria is a red or reddish colored shaly material and clinker produced by the heating and partial fusing of clays during burning of underlying coalbeds. Searing soil is characterized by a reddish brown gravelly loam surface horizon about five inches thick. The subsoil is a gravelly clay loam to loam which has blocky structure. The substratum is a friable, calcareous gravelly loam. Bedrock generally occurs at an average depth of two feet. This unit has fragments and blocks of red shale, stone, and clinker scattered on the surface. Internal drainage is good. There are an estimated 480 acres of this land type on the lease.

Sb-Searing gravelly loam

Searing gravelly loam is developing in scoria, the beds of burned shale and clinker that have been formed by the burning of underlying coalbeds. The scoria beds consist of red, hardened shales and red to nearly black clinkers. This soil occurs on undulating to rolling areas and includes scattered outcrops of scoria. The surface horizon is reddish brown gravelly loam about five inches thick. The subsoil is a reddish brown gravelly clay loam which has blocky structure. The substratum is friable, calcareous gravelly loam. Bedrock generally occurs at an average depth of two feet. Internal drainage is good. There are an estimated 250 acres of these soils on the lease.

Ub-Ulm clay loam, shallow phase

This phase differs from Ulm loam in topography, texture, and depth of soil. The topography is rolling and the depth to interbedded sedimentary bedrock ranges from 10 to 20 inches. The steeper slopes have some rock outcrops. The surface horizon is granular clay loam about six inches thick. The subsoil is calcareous silty clay loam with prismatic structure. The subsoil normally becomes more loamy and friable with depth. Internal drainage is moderate to slow. Soil reaction normally ranges from neutral to moderately alkaline. There are an estimated 10 acres of these soils on the lease.

Uc-Ulm loam

Ulm loam occupies gently sloping to rolling uplands. The parent material is interbedded sandstone, shale, and loamstone. The surface horizon is friable loam 3 to 7 inches thick. The subsoil ranges from sandy clay loam to clay loam and has prismatic structure. The calcareous substratum ranges from sandy loam to clay loam and extends to weathered bedrock at depths of 20 to 40 inches. Soil reaction normally ranges from neutral to moderately alkaline.

Internal drainage is good. There are an estimated 2,374 acres of these soils on the lease.

Ue-Ulm loam, rolling phase

This phase differs from Ulm loam in topography, texture, and depth to bedrock. The topography is rolling to steep and often strongly dissected. The depth to bedrock is usually less than 20 inches. Bedrock is exposed on some of the steeper slopes. The parent material is interbedded sandstone, shale, and loamstone. Gullies have formed in some areas. The soil is more friable and sandy than Ulm loam. Soil reaction normally ranges from neutral to moderately alkaline. Internal drainage is good. There are an estimated 330 acres of these soils on the lease.

Wa-Wibaux - Searing complex

This complex occupies rolling to hilly topography. It is characterized by numerous outcroppings or knolls of scoria which rise above the general surface of the land. Scoria is a reddish colored shaly material and clinker produced by the burning of underlying coalbeds. The very shallow to shallow Wibaux soils occur on the knolls and steep slopes. It includes knolls, mounds, and steep slopes where unweathered scoria is exposed. The texture is gravelly to very gravelly loam and sandy loam. The depth to bedrock is less than 10 inches to 20 inches.

Searing soil normally occurs between the knolls. The surface horizon is reddish-brown gravelly loam about five inches thick. The subsoil is a reddish-brown gravelly clay loam and has blocky structure. The substratum is friable, calcareous gravelly loam. Bedrock generally occurs at an average depth of two feet. There are an estimated 100 acres of these soils on the lease.

Mineral Resources

Stratigraphic and structural relations

The Atlantic Richfield Company's federal coal lease in T42 and 43N, R70W is on the gently dipping eastern flank of the Powder River Basin (Figure 12, Chapter IV of Part I). This broad regional downwarp contains nearly flat-lying rocks of Tertiary age in the center surrounded by Cretaceous and progressively older rocks that are upturned on the flanks of the bordering Precambrian-cored mountains--the Black Hills to the east, the Bighorn Mountains to the west, and the Laramie Range to the south (Figure 8, Chapter IV, Part I) Northward, the basin indistinctly blends into the Great Plains.

The lease is in the Gillette coal field. The following descriptions of the local geology and coal are summarized from the report of Dobbin and Barnett (U.S. Geological Survey 1927), from reports referred to in Part I of this report, and from material in the proposed mining and reclamation plans submitted by the Atlantic Richfield Company. The lease area is on the Wasatch Formation of Eocene age just west of its boundary with the underlying Fort Union Formation of Paleocene age (Figure 10, Chapter IV, Part I). The contact between the two formations is drawn at the top of the Wyodak coalbed. The coal is not exposed in the lease area; its subcrop is masked by alluvium or by the red, baked and fused rock, commonly called clinker, scoria, or porcellanite, that was formed when the coalbed burned sometime in the past. The Tongue River Member of the Fort Union Formation (U.S. Geological Survey 1927) is exposed just to the east of the lease area. It is underlain in turn by the Lebo and Tullock Members and then by the Cretaceous Lance Formation and Fox Hills Sandstone to a depth of about 3,000 feet. Increasingly older, sedimentary formations representing Mesozoic and Paleozoic ages lie below the Fox Hills Sandstone to a depth of about 14,500 feet below the surface where the top of

the Pre-Cambrian igneous and metamorphic rock complex is located. Recent alluvium composed of unconsolidated sand and clay with thin gravel lenses occurs in the valleys of Little Thunder Creek and North Prong of Little Thunder Creek.

The Tongue River Member of Fort Union Formation is partially exposed on the low, east-facing escarpment east of the lease area. The Wyodak (Roland) coalbed at the top of the formation is as much as 73 feet thick in the lease area. Below the coalbed, the rocks are predominatly drab gray, brown, and dark gray to black carbonaceous clay shale and siltstone interbedded with light gray to yellowish gray, fine-grained, friable sandstone lenses and coalbeds of variable thickness. Nonpersistent beds of reddish-brown, coarse-grained, highly ferruginous sandstone and hard brown sandstone concretions form resistant ledges that are distinctive of the member. The following stratigraphic section was measured by Dobbin and Barnett (U.S. Geological Survey 1927, p. 10) about four miles east of the lease area:

Section of part of the Tongue River Member of the Fort Union Formation, between sec 21, T43N, R69W, and Little Thunder Creek in sec 34:

	Ft.	In.
Clinker of Wyodak (Roland) coalbed (top of Tongue River Member). (Bed is as much as 75 feet thick on the Atlantic Richfield lease area.)		
Shale, blue-gray, sandy	10	
Shale, carbonaceous, containing fossil leaves	6	
Coal		5
Shale, carbonaceous, and bone	1	9
Shale, blue-gray, carbonaceous	10	
Sandstone, gray, friable, with hard brown sandstone concretions containing fossil leaves	5	
Shale, carbonaceous	1	4
Shale, sandy, and sandstone, friable, with hard sandstone concretions	33	
Shale, dark, carbonaceous	9	
Shale, gray, sandy	7	

(Continued)

	Ft.	In.
Sandstone, gray, friable, with 1-inch concretionary band at top	15	
Shale, dark bluish gray, sandy, with a few hard brown sandstone concretions	16	
Sandstone, yellowish gray, friable, with a few bands of carbonaceous shale	38	
Shale, dark blue, with fossil leaves and with selenite crystals in upper part	7	
Shale, brown, carbonaceous, with fossil leaves and fragments of conifers		10
Shale, dark blue	1	2
Shale, bluish gray, with brown sandstone concretions	12	6
Sandstone, yellowish gray, friable		11
Shale, bluish gray		8
Shale, brown to black, with lenses of bright coal in upper part		2
Sandstone, yellowish, friable	6	
Shale, blue, with 1-foot lens of black carbonaceous shale near the middle	11	
Clay, yellow, sandy, with brown sandstone concretions near the base	5	
Shale, bluish gray	11	
Shale, brown, carbonaceous	10	
Concealed	6	
Sandstone, gray, friable, with 1-foot brown concretionary band at top	8	10
Largely covered but sandstone and shale exposed in places	108	
	341	7

The Wasatch Formation (the overburden to be stripped at the proposed Black Thunder mine) ranges from 15 feet thick along the eastern boundary of the lease block to 240 feet thick at the southwestern corner in sec. 3, T42N, R70W (Figure 5). Where it is not clinker in the lease area, the formation is about 80 percent drab gray clay shale and 20 percent yellowish-gray, fine-grained, poorly consolidated lenticular sandstone. Discontinuous impure coal-beds generally less than five feet thick and thinner and concretionary calcareous sandstone beds make up less than one percent. The general lithologic character of the Wasatch Formation is shown by the following logs of two core drill holes furnished by the Atlantic Richfield Company:

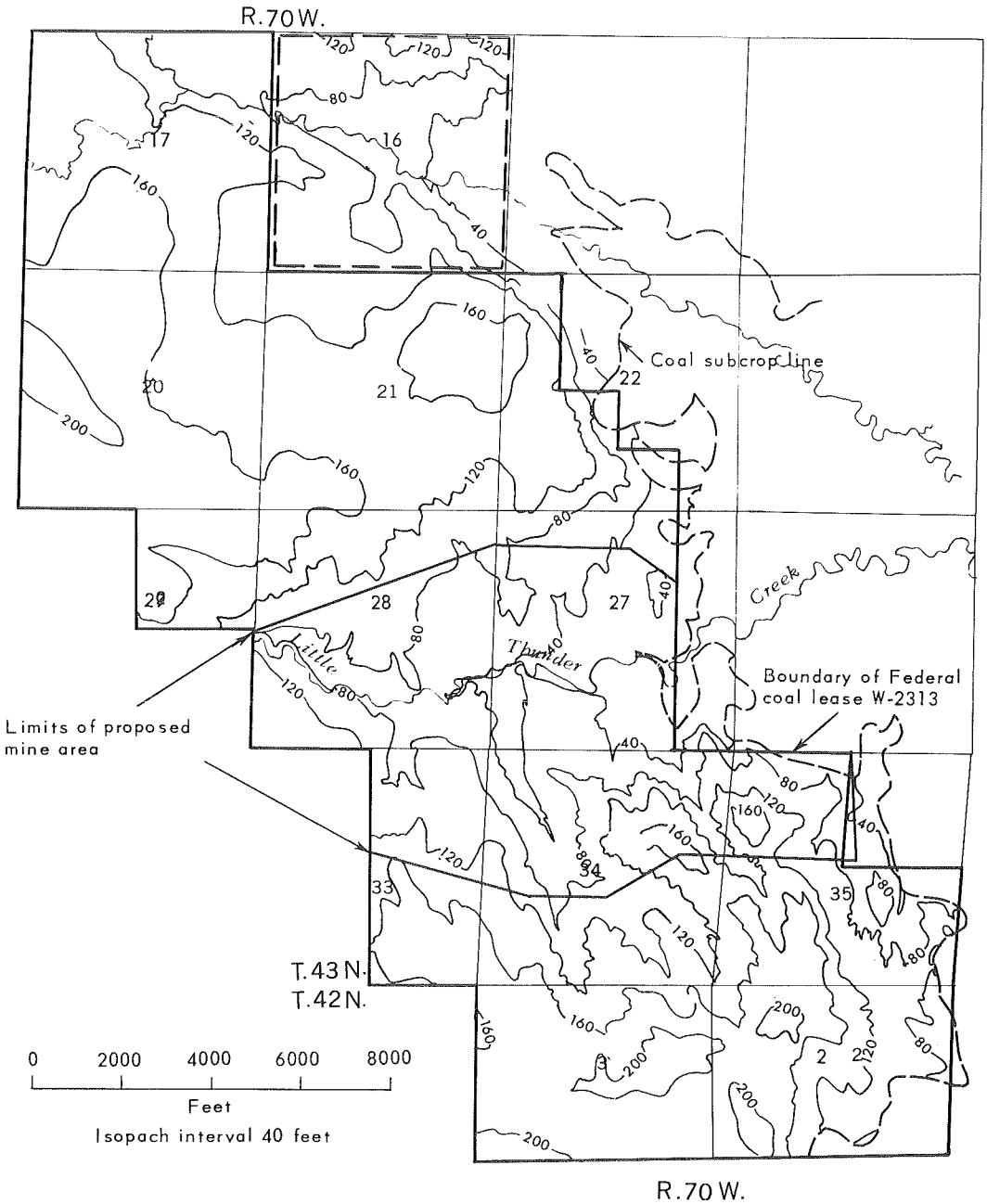


Figure 5

Thickness Map of Overburden at the Proposed Black Thunder Mine

Sample No. *	Depth From	Depth To	Description
Drill Hole BT-82A			(Center Sec. 34, T43N, R70W)
1	14'0"	31'7"	Clays, carbonaceous, dark gray-black, some sand and silt layers; 7' to 8' and 26'8" to 28' lost.
2	31'7"	33'9"	Sandstone, light gray, hard, calcerous.
3	33'9"	53'6"	Sands, silts, and clays, light gray, soft, 33'6" to 34' and 49' to 50' lost.
4	53'6"	56'3"	Limestone, light gray, hard, 53'8" to 56'3" lost.
5	56'3"	69'9"	Sands and silts, gray, 59'3" to 60' and 66'4" to 68' lost.
6	69'9"	82'1"	Sands, silts, and clays, gray.
7	82'1"	90'0"	Clays, gray.
8	90'0"	99'0"	Clays, carbonaceous, brownish-gray, 92' to 93'7" removed.
9	99'0"	106'2"	Clays, carbonaceous, brownish-gray, 102'7" to 104' removed.
Drill Hole BT-110	(near the northwest corner of Sec. 27, T43N, R70W).		
10	11'0"	26'8"	Clays, light to medium-gray, soft to medium hard.
11	26'8"	29'2"	Siltstone, calcareous, very hard, light gray.
12	29'2"	41'4"	Clays, light gray, some slightly carbonaceous, soft to hard.
13	41'4"	43'0"	Sandstone, very fine, very hard, light gray.
14	43'0"	46'2"	Clays, some silt, light gray, medium soft to hard.
15	46'2"	49'6"	Siltstone, moderate clay, light gray, medium soft to medium hard.

Drill Hole BT-110 (cont)

16	49'6"	52'9"	Clays, silty, some highly carbonaceous, light gray to dark gray, medium soft to medium hard.
17	52'9"	54'1"	Siltstone, very hard, slightly carbonaceous, light gray.
18	54'1"	77'11"	Clays, some silt, light gray to dark gray, soft to hard.
19	77'11"	82'11"	Clays, trending from silty to carbonaceous, soft to medium hard

* Numbers refer to analyses listed in Tables 2-5.

The cores were submitted to the Colorado School of Mines Research Institute for analyses to provide information on potential toxicity to plant growth and other revegetation problems that might be encountered if the material was placed at the top of the graded spoil piles in post-mining reclamation. The analyses by semiquantitative x-ray fluorescence spectrography are shown in Table 2; chemical analyses are reported in Tables 3 and 4. Water-holding capacities and settling characteristics are shown in Table 5. The analyses are in general normal for these types of sedimentary rocks (see section on trace elements in Chapter IV, Part I). However, the analyses indicate that the following potential problems to plant establishment and growth might arise if certain layers of the material became the soil zone:

Interval	Indicated Potential Problem
Drill Core BT-82A	
11'6" to 106'2"	deficiency of available phosphorous and nitrate
31'7" to 33'9"	extractable lead
53'6" to 106'2"	plant-available boron
99'0" to 106'2"	high exchangeable sodium percentage, i.e., poor physical properties in regard to water infiltration and erosion

Interval	Indicated Potential Problem
Drill Core BT-110	
11'0" to 82'11"	deficiency of available phosphorus and nitrate
11'0" to 26'8"	plant-available boron
26'8" to 29'2"	deficiency of available potassium and high ratio of chelatable iron to chelatable copper and zinc
41'4" to 43'0"	plant-available boron
46'2" to 49'6"	deficiency of available potassium
49'6" to 52'9"	plant-available boron
52'0" to 54'11"	high ratio of chelatable iron to chelatable copper and zinc
77'11" to 82'11"	plant-available boron and relatively poor physical properties

These problems are not of major consequence because the mining, reclamation, and rehabilitation plans as outlined by the Atlantic Richfield Company include methods of correction and control. The proposed truck and power shovel mining method facilitates selective removal, special handling and burial of any toxic material found in the overburden. Application of specially formulated fertilizers will correct the deficiencies of phosphorous, nitrate and potassium.

Table 2

Semiquantitative Spectrographic Analyses in Parts Per Million of Core Samples of Overburden in Drill Holes BT-82A and BT-110 at the Proposed Black Thunder Mine, Campbell County, Wyoming

Sample No.*	Cu	Zn	Pb	Fe	Ni	Rb	Ba	Sr	Ti	Zr	V	Nb	Cr	Mo	U	Mn	Y
Drill Hole BT-82A																	
1	80	220	400	44,000	30	160	1,500	260	2,500	430	-	-	-	-	50	410	90
2	60	150	80	17,000	-	220	1,500	240	1,500	170	-	-	-	-	-	210	70
3	30	90	90	11,000	60	140	930	180	1,800	620	-	-	70	-	70	220	90
4	70	120	280	20,000	90	50	1,100	180	1,800	630	-	-	-	-	-	300	40
5	90	120	60	23,000	30	170	990	120	2,100	580	310	50	-	30	80	200	100
6	20	140	-	38,000	60	140	1,300	110	2,500	230	-	-	-	-	-	280	40
7	20	200	220	33,000	100	230	1,200	160	2,600	310	230	30	-	-	80	110	20
8	110	180	350	15,000	120	290	770	160	3,300	270	-	-	80	-	-	-	40
9	120	120	60	16,000	40	210	880	150	3,500	320	-	30	-	-	-	160	100
Drill Hole BT-110																	
10	90	160	-	16,000	80	220	720	170	2,100	1,200	-	-	-	-	-	110	50
11	60	170	200	180,000	-	80	1,300	140	1,100	290	-	-	290	-	-	1,600	-
12	110	170	250	27,000	90	160	1,500	300	2,500	370	-	30	80	40	-	500	20
13	130	170	-	180,000	80	190	1,400	210	2,300	250	-	70	130	-	130	1,700	-
14	80	100	280	38,000	30	200	1,600	370	3,100	520	-	40	-	30	-	380	100
15	50	170	140	7,100	70	140	1,500	270	1,800	620	-	20	-	110	-	40	110
16	130	240	230	19,000	80	260	880	210	2,700	470	-	30	10	30	40	250	120
17	140	180	240	350,000	320	320	140	170	2,300	280	-	-	250	-	-	2,200	110
18	30	170	-	22,000	60	270	1,700	250	2,000	380	150	30	80	50	-	390	220
19	140	180	200	21,000	80	190	700	160	3,000	290	300	-	120	-	-	90	60

*See log of core for sample description.

Sample No.	depth From	depth To	pH Water (1)	pH 0.01 M $CaCl_2$ Solution (2)	Soluble Salts Extract Conductivity millimhos/cm (1)	Soluble Salts Extract Conductivity millimhos/cm (3)	Sodium Water Soluble (milliequivalents/100 g)	Sodium NH_4 Acetate Soluble (milliequivalents/100 g)	Cation Exchange Capacity (milliequivalents/100 g)	Exchangeable Sodium Percentage (4)	Potassium Available ppm	Phosphorus $NaHCO_3$ Soluble ppm	Organic Matter %	Nitrate ppm	Sulfide ppm
	Drill Hole BT-82A														
1	14'0"	31'7"	8.62	7.89	0.46	2.0	0.47	1.30	13.3	6.2	316	0.2	1.2	<2	<10
2	31'7"	33'9"	9.07	7.92	0.26	3.0	0.32	0.57	6.7	3.7	203	0.2	0.1	<2	20
3	33'9"	53'6"	8.36	7.58	0.33	2.0	0.42	0.73	8.7	3.6	239	0.1	0.5	<2	30
4	53'6"	56'3"	8.66	7.85	0.37	2.4	0.32	0.67	7.2	4.9	202	<0.1	0.6	<2	10
5	56'3"	69'9"	8.26	7.52	0.36	1.5	0.46	0.65	12.0	1.6	200	0.1	1.1	<2	40
6	69'9"	82'1"	8.04	7.22	0.36	2.1	0.32	0.70	6.3	6.0	197	<0.1	1.0	<2	50
7	82'1"	90'0"	8.34	7.95	0.46	1.6	0.53	1.74	14.6	8.3	443	0.3	1.8	<2	50
8	90'0"	99'0"	7.70	7.39	0.34	1.1	0.50	1.52	23.0	4.4	317	0.3	6.5	<2	30
9	99'0"	106'2"	8.02	7.70	0.26	0.9	0.26	2.00	9.8	17.8	426	0.7	2.2	<2	30
	Drill Hole BT-110														
10	11'0"	26'8"	6.81	6.27	1.00	3.5	0.70	1.43	25.2	2.9	385	0.9	1.7	<2	10
11	26'8"	29'2"	9.01	7.57	0.22	3.9	0.15	0.26	4.8	2.3	113	0.2	2.7	<2	60
12	29'2"	41'4"	8.36	7.47	0.52	1.9	0.63	1.30	15.9	4.2	336	0.4	1.4	<2	20
13	41'4"	43'0"	8.60	7.50	0.30	2.1	0.35	0.75	11.3	3.5	283	0.2	2.4	<2	30
14	43'0"	46'2"	8.63	7.56	0.44	1.8	0.42	1.03	15.9	3.8	271	0.4	0.4	<2	20
15	46'2"	49'6"	8.59	7.44	0.35	1.8	0.37	0.60	7.2	3.2	169	0.1	0.2	<2	20
16	49'6"	52'9"	8.23	7.26	0.52	1.9	0.63	1.30	19.1	3.5	358	0.1	1.5	<2	10
17	52'0"	54'1"	8.73	7.27	0.18	2.0	0.19	0.57	9.4	4.1	254	0.4	2.8	<2	30
18	54'1"	77'11"	8.10	7.42	0.57	2.2	0.59	1.13	18.5	2.9	394	0.2	0.6	<2	10
19	77'11"	82'11"	6.89	6.35	0.89	3.0	0.80	1.35	16.3	3.4	393	0.2	6.0	<2	20

1/ Sample/Extract Ratio: 1 to 2
2/ Sample/Extract Ratio: 1 to 5
3/ Calculated conductivity for a saturation extract; basis, 1 to 2 ratio conductivity and 1/3-bar water holding capacity data.
4/ Calculated from the equation exchangeable sodium percentage = $\frac{(100)(\text{Na, ammonium acetate soluble} - \text{Na, water soluble})}{(\text{cation exchange capacity})}$

Table 3

Chemical Analyses for Available Nutrients in Core Samples of Overburden from Drill Holes BT-82A and BT-110 at the Proposed Black Thunder Mine, Campbell County, Wyoming

Table 4

Chemical Analyses for Toxic Elements in Core Samples of Overburden from Drill Holes BT-82A and BT-110 at the Proposed Black Thunder Mine, Campbell County, Wyoming

Sample No.	Depth From	Depth To	DTPA Extractable Cu ppm	DTPA Extractable Fe ppm	DTPA Extractable Mn ppm	DTPA Extractable Zn ppm	Arsenic Total ppm	Boron Water Soluble ppm	Copper Total ppm	Fluoride Total ppm	Lead Total ppm	Lead, 2.5% Acetic Acid Soluble ppm	Mercury Total ppm	Molybdenum Total ppm	Selenium Available ppm	Uranium Total ppm	Uranium Water Soluble ppm
	Drill Hole BT-82A																
1	14'0"	31'7"	2.0	220	5.6	10.6	6	1.9	62	200	35	<5	0.16	0.8	0.03	3	<0.02
2	31'7"	33'9"	1.6	296	6.8	14.8	3	0.4	20	200	40	24	0.10	0.8	0.03	2	<0.02
3	33'9"	53'6"	2.2	312	9.2	8.8	6	1.4	17	100	32	<5	0.10	0.3	0.02	3	<0.02
4	53'6"	56'3"	1.6	288	7.2	11.2	5	<0.2	17	100	32	6	0.09	0.6	0.03	2	<0.02
5	56'3"	69'9"	2.0	360	10.4	10.6	5	2.7	20	100	35	<5	0.11	0.3	0.02	2	0.06
6	69'9"	82'2"	1.4	464	9.0	7.2	7	2.6	18	100	27	<5	0.09	0.5	0.02	2	<0.02
7	82'1"	90'0"	2.2	88	2.0	4.4	5	2.4	27	100	37	<5	0.18	0.3	0.03	5	<0.02
8	90'0"	99'0"	4.4	88	0.8	8.0	6	3.9	32	200	32	<5	0.16	0.3	0.03	3	0.02
9	99'0"	106'2"	2.8	88	1.0	5.2	5	2.6	32	200	40	<5	0.18	0.2	0.03	5	<0.02
	Drill Hole BT-110																
10	11'0"	26'8"	2.0	76	8.0	6.8	10	2.2	35	200	30	<5	0.17	0.6	0.03	4	0.10
11	26'8"	29'2"	0.8	564	15.6	2.0	4	1.6	12	200	27	6	0.07	1.4	0.02	<1	<0.02
12	29'2"	41'4"	6.4	152	6.8	28.6	6	1.9	30	200	57	<5	0.15	0.2	0.02	5	<0.02
13	41'4"	43'0"	3.2	408	14.8	4.4	4	2.2	20	200	35	<5	0.14	0.7	0.02	4	<0.02
14	43'0"	46'2"	2.0	152	6.6	5.2	8	1.2	20	100	33	<5	0.12	0.9	0.04	4	<0.02
15	46'2"	49'6"	0.8	76	2.2	5.2	7	1.1	17	100	27	<5	0.08	0.4	0.04	2	<0.02
16	49'6"	52'9"	1.4	112	4.8	5.0	10	3.0	30	200	59	<5	0.17	0.4	0.03	5	<0.02
17	52'0"	54'11"	0.8	556	16.8	1.0	8	0.6	18	300	37	<5	0.09	0.1	0.03	3	<0.02
18	54'1"	77'11"	2.0	132	4.6	6.0	10	0.9	28	300	35	<5	0.17	0.3	0.03	4	<0.02
19	77'11"	82'11"	6.4	176	8.4	12.4	6	2.8	57	300	37	<5	0.30	1.1	0.03	5	0.08

Table 5

Water Holding Capacities and Settling Characteristics of Core Samples of Overburden (Wasatch Formation) in Drill Holes BA-82A and BT-110 at the Proposed Black Thunder Mine, Campbell County, Wyoming

Sample No.	Depth From	Depth To	Water Holding Capacity* 1/3-Bar Section %(dry sample wt. basis)	Settling Characteristic** Final Pulp Volume, ml
	Drill hole BT-82A			
1	14'0"	31'7"	22.7	48
2	31'7"	33'9"	8.7	30
3	33'9"	53'6"	16.9	37
4	53'6"	56'3"	15.7	30
5	56'3"	69'9"	24.1	60
6	69'9"	82'1"	17.5	47
7	82'1"	90'0"	28.8	45
8	90'0"	99'0"	30.8	68
9	90'0"	106'2"	31.4	83
	Drill Hole BT-110			
10	11'0"	26'8"	28.5	40
11	26'8"	29'2"	5.7	30
12	29'2"	41'4"	27.3	53
13	41'4"	43'4"	14.7	30
14	43'0"	46'2"	24.7	62
15	46'2"	49'6"	19.3	60
16	49'6"	52'9"	27.6	50
17	52'0"	54'1"	9.0	30
18	54'1"	77'11"	26.0	70
19	77'11"	82'11"	30.2	90

*Ceramic permeable pressure-plate method, 80°F, deionized water.
**15 g sample dispersed in 1,000 ml deionized water; 3 gpl $CaCL_2$ added to water; 30 min settling time in 1-liter graduate.

The Wyoming Highway Department encountered no difficult engineering or construction problems in cuts for an interstate highway through the Fort Union and Wasatch Formations in Campbell County; however, all rocks were near surface and weathered and, thus, were rippable with standard road-building equipment, and blasting was not required (Sherman 1974). Unweathered bedrock commonly is found at depths less than 25 feet and has a bearing strength of 3 to 7 tons per square foot. Unweathered bedrock in surface mines probably will have to be blasted before removal. Landslides or other slope stability problems occur only locally in oversteepened cuts. Shale from the Fort Union and Wasatch Formations used in fills breaks down and deteriorates in less than one year. Consolidation and differential settling of the fill ranges from 10 to 20 percent; shale is unstable in slopes greater than 2:1; some clay is compressible, but no problems were encountered unless slope ratios exceeded 2:1 (Sherman 1974).

Strata on the lease area are essentially flat lying but do have imperceptable regional dip of about one degree to the west as shown by the structure contours on Figure 6. Minor local interruptions to the regional dip consist of shallow basins in the northern and southern parts of the lease separated by a high on the line between sections 21 and 28, T43N, R70W, just north of Little Thunder Creek (Figure 6).

Major faults are not known to offset the rocks in the lease area; faults with small displacement may be present, similar to those described by Osterwald and Dean (U.S. Geological Survey 1961, pl. 28). Detailed studies have not been made of the attitude and spacing of joints or fractures in rocks on the lease area; the joint system probably will be the same as regionally developed in the Great Plains; that is, two prominent sets, one striking northwest and the other northeast (U.S. Geological Survey 1961, pl. 28).

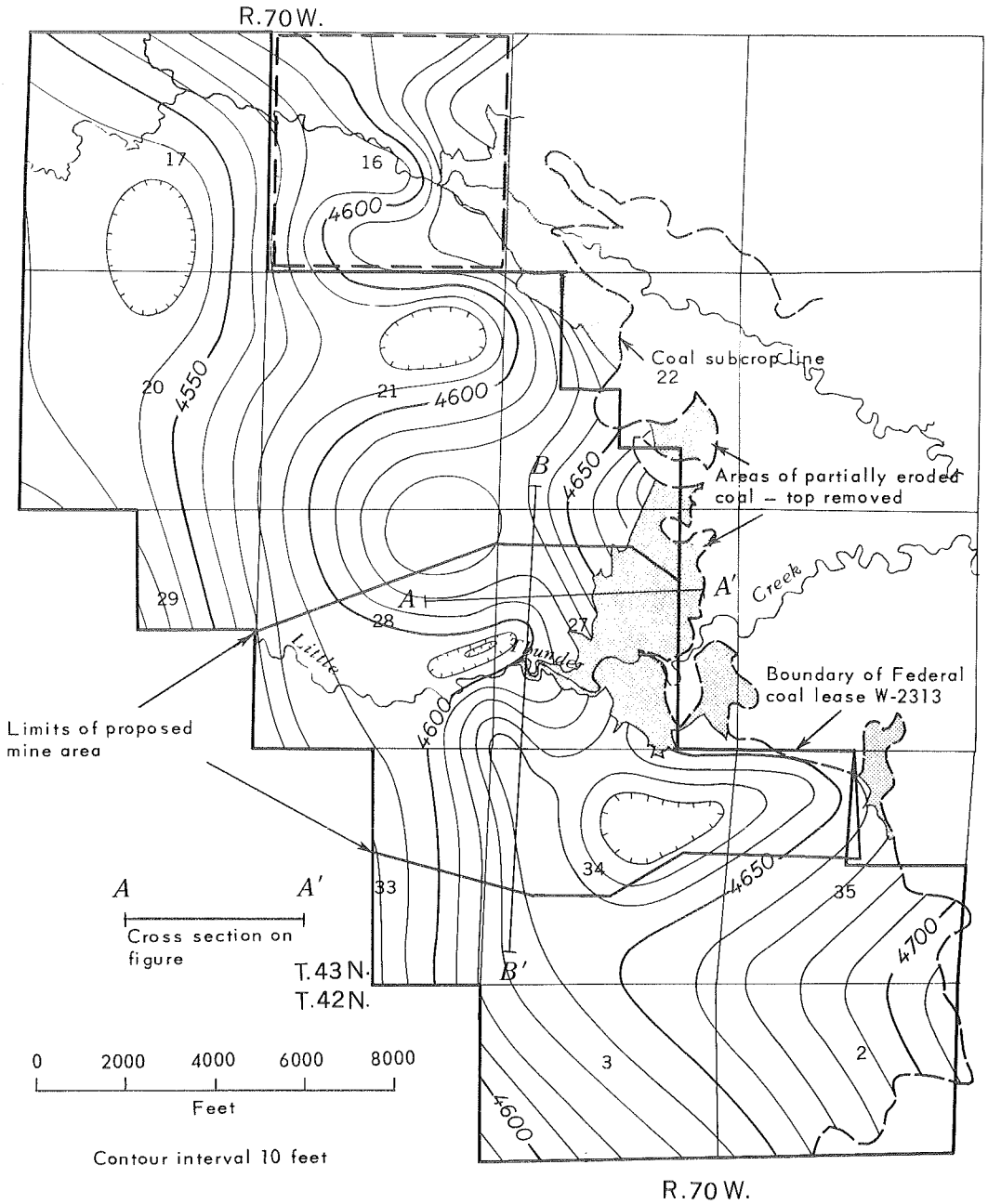


Figure 6
Structure Contour Map on Top of the Coalbed at the Black Thunder Coal Property

Coal

The Wyodak (Roland) coalbed underlying the proposed Black Thunder mine area is a single bed ranging from 60 to 73 feet in thickness (Figures 7 and 8). Areas of thickest coal are in sections 17, 21, 27, 34 and 35. Erosion and burning have destroyed all or part of the coalbed in a zone 500 to 1000 feet wide along its subcrop on the eastern edge of the proposed mine area. The remaining coal in these locales ranges from zero to 60 feet thick (Figures 7 and 8).

Quality of the coal

Coal from the Wyodak (Roland) bed that will be produced at the Black Thunder mine is subbituminous C in rank. The coal is low in ash and sulfur. The range and typical values of analyses of coal and ash of coal in 102 samples from the proposed Black Thunder mine are given in Tables 6 and 7. Proximate and ultimate analyses, sulfur forms, and oxides in ash for coal samples by interval in a selected core drill hole are listed in Table 8. Samples of coal were submitted for analyses of amounts of trace elements that might be emitted to the atmosphere or concentrated in ash when the coal is burned. The results of trace elements analyses of 29 coal samples, including those described in Table 8, are shown in Table 9. The analyses do not show anomalously high concentrations of trace elements.

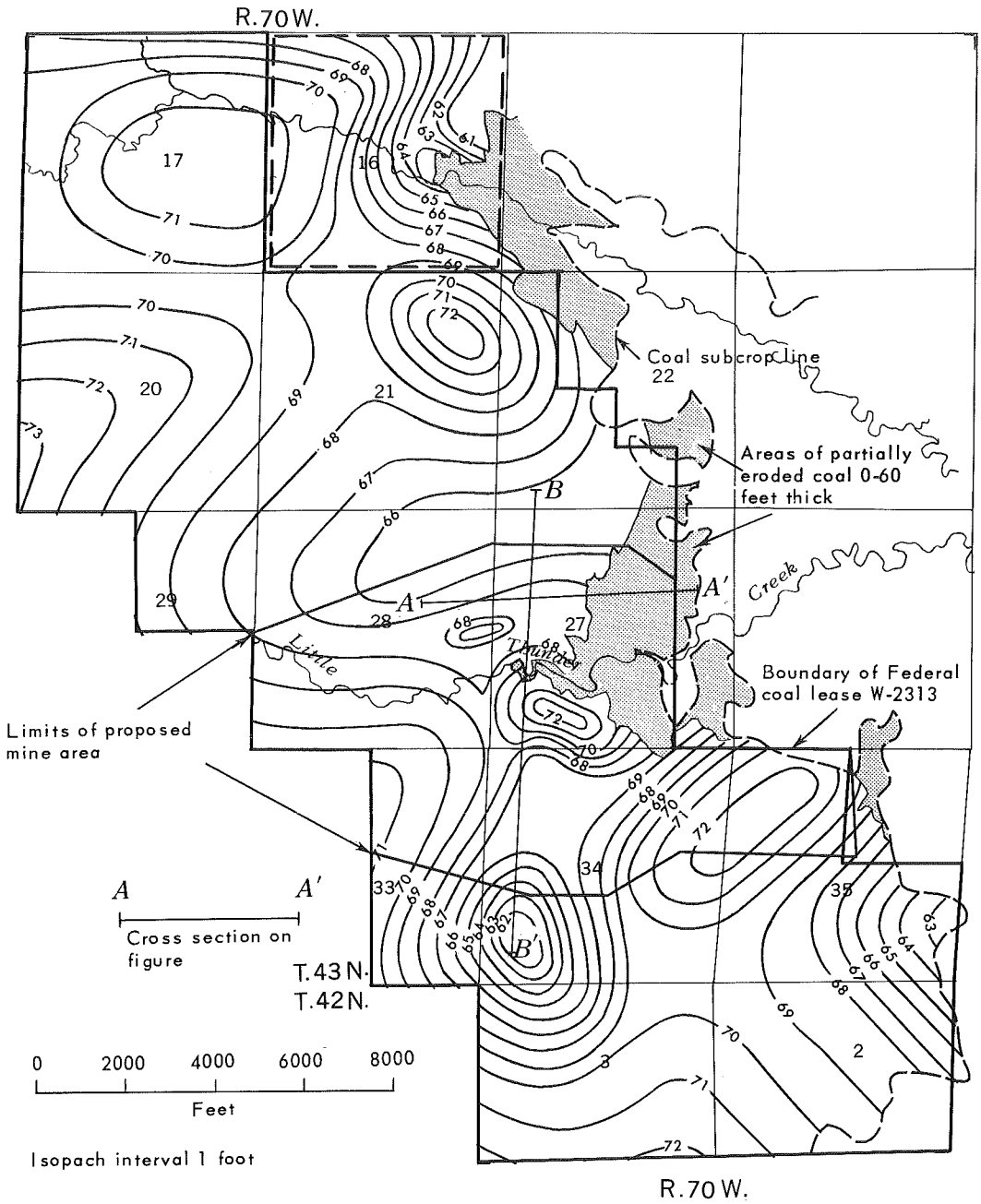


Figure 7

Thickness Map of Coalbed at the Black Thunder Property

Figure 8

Cross Sections Showing the Wyodak Coal Bed at the Proposed Black Thunder Mine, T.43N., R. 70W., Campbell County, Wyo.

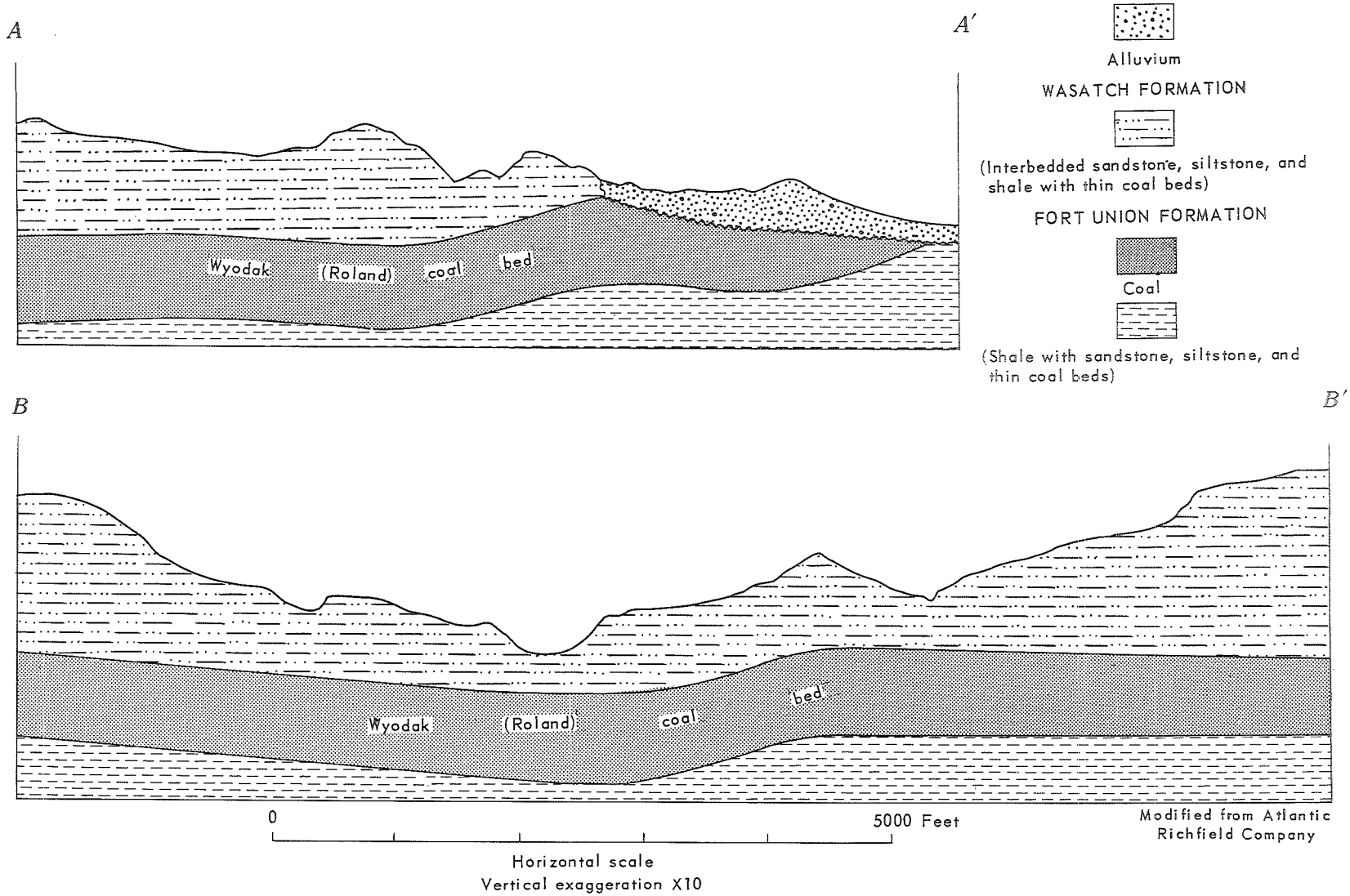


Table 6

Range and Typical Values of Analyses From 102 Samples of Coal From the Roland Bed at the Proposed Black Thunder Mine, Campbell County, Wyoming. (All analyses except Btu are in percent)

Proximate Analysis As Received	Typical	Range
Moisture	28.13	12.18 - 34.52
Ash	4.75	3.26 - 7.36
Volatile Matter	31.88 - 32.19	27.39 - 43.36
Fixed Carbon	34.93	30.96 - 40.02
Btu	8,622	7,765 - 10,590
Sulfur	0.33	0.09 - 0.59
Ultimate Analysis As Received		
Moisture	28.36	12.18 - 34.52
Carbon	50.19	45.76 - 61.19
Hydrogen	3.55	3.09 - 4.20
Nitrogen	0.71	0.49 - 1.02
Chlorine	0.01	0.00 - 0.04
Sulfur	0.33	0.09 - 0.59
Ash	4.75	3.26 - 7.36
Oxygen	12.31	10.25 - 16.44
Sulfur Forms (76 samples)		
Pyritic	0.05	0.00 - 0.17
Sulfate	0.02	0.00 - 0.11
Organic	0.25	0.01 - 0.45
Equilibrium Moisture	24.72	19.23 - 27.72
Btu at Equilibrium Moisture	9,031	8,539 - 9,740
Hardgrove Grindability Index	53.65	37.00 - 67.50

Source: Atlantic Richfield Company

Table 7

Range and Typical Values of Analyses of Ash From 90 Samples of Coal From the Roland Bed at the Proposed Black Thunder Mine, Campbell County, Wyoming

MINERAL ANALYSIS OF ASH
(Percent)

	Typical	Range
Phosphorous Pentoxide	0.94	0.07 - 2.80
Silica	29.51	19.64 - 43.31
Ferric Oxide	4.95	2.41 - 6.78
Alumina	15.49	10.57 - 19.73
Titania	1.19	0.11 - 1.59
Lime	23.93	14.70 - 34.40
Magnesia	4.85	3.22 - 7.43
Sulfur Trioxide	15.68	7.64 - 24.50
Potassium Oxide	0.33	0.05 - 1.67
Sodium Oxide	1.05	0.00 - 2.45
Undetermined	2.41	0.00 - 12.78
Alkalies as Na_2O, DCB	0.10	0.02 - 0.21
Silica Value	48.33	34.11 - 56.99

Fusion Temperature of Ash
(Degrees Fahrenheit)

	Reducing		Oxidizing	
	Typical	Range	Typical	Range
Initial Deformation	2160	1950 - 2610	2210	2020 - 2700
Softening (H=W)	2210	2045 - 2700	2258	2120 - 2700
Softening (H=1/2W)	2238	2080 - 2700	2289	2130 - 2700
Fluid	2284	2090 - 2700	2339	2140 - 2700

Source: Atlantic Richfield Company

Analysis Report Number:	72-15420		72-15421		72-15422		72-15423		72-15424		72-15425		72-15426	
	As Received	Moisture Free	As Received	Moisture Free	As Received	Moisture Free	As Received	Moisture Free	As Received	Moisture Free	As Received	Moisture Free	As Received	Moisture Free
PROXIMATE ANALYSIS														
Moisture	31.84	xxxxx	27.83	xxxxx	28.47	xxxxx	29.33	xxxxx	29.44	xxxxx	29.96	xxxxx	28.14	xxxxx
Ash	5.48	8.04	4.44	6.15	3.84	5.37	3.45	4.88	3.32	4.70	4.68	6.68	3.13	4.36
Volatile Matter	32.34	47.44	33.93	47.01	35.60	49.77	33.62	47.58	31.62	44.81	30.08	42.94	32.92	45.81
Fixed Carbon	30.34	44.52	33.80	46.84	32.09	44.86	33.60	47.54	35.62	50.49	35.28	50.38	35.81	49.83
Btu	8099	11882	8552	11850	8556	11962	8420	11915	8495	12040	8187	11689	8708	12118
Sulfur	0.60	0.88	0.38	0.53	0.16	0.23	0.08	0.11	0.04	0.06	0.13	0.18	0.13	0.18
ULTIMATE ANALYSIS														
Carbon	46.67	68.47	50.42	69.86	50.41	70.47	50.37	71.28	50.30	71.28	49.25	70.31	51.19	71.24
Hydrogen	3.42	5.02	3.51	4.86	3.58	5.01	3.43	4.86	3.44	4.88	3.31	4.73	3.38	4.71
Nitrogen	0.67	0.99	0.76	1.05	0.70	0.98	0.69	0.98	0.60	0.85	0.57	0.82	0.70	0.97
Chlorine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sulfur	0.60	0.88	0.38	0.53	0.16	0.23	0.08	0.11	0.04	0.06	0.13	0.18	0.13	0.18
Ash	5.48	8.04	4.44	6.15	3.84	5.37	3.45	4.88	3.32	4.70	4.68	6.68	3.13	4.35
Oxygen (diff.)	11.32	16.60	12.66	17.55	12.84	17.94	12.65	17.89	12.86	18.23	12.10	17.28	13.33	18.54
SULFUR FORMS														
Pyritic	0.01	0.01	0.04	0.06	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sulfate	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.03
Organic	0.58	0.85	0.33	0.45	0.14	0.20	0.06	0.09	0.03	0.05	0.12	0.17	0.10	0.14
FUSION TEMPERATURE OF ASH														
Degrees F.	Reducing	Oxidizing	Reducing	Oxidizing	Reducing	Oxidizing	Reducing	Oxidizing	Reducing	Oxidizing	Reducing	Oxidizing	Reducing	Oxidizing
Initial Deformation	2160	2225	2280	2370	2420	2445	2430	2455	2370	2415	2140	2220	2335	2345
Softening (H=W)	2180	2230	2320	2375	2425	2460	2435	2485	2405	2425	2160	2235	2350	2360
Softening (H=1/2W)	2190	2235	2340	2400	2435	2480	2440	2500	2440	2445	2180	2250	2375	2385
Fluid	2205	2495	2360	2440	2490	2500	2465	2520	2470	2480	2200	2410	2380	2390
OXIDE COMPOSITION OF ASH														
Phosphorous pentoxide, P_2O_5	1.79		1.47		0.54		0.83		0.68		1.80		1.75	
Silica, SiO_2	31.19		21.47		20.58		23.02		21.49		45.58		25.49	
Ferric oxide, Fe_2O_3	4.48		6.99		5.34		5.35		5.62		4.02		6.81	
Alumina, Al_2O_3	18.14		18.81		16.50		18.27		19.51		20.04		15.72	
Titania, TiO_2	1.20		0.65		1.92		1.35		1.30		1.86		0.60	
Lime, CaO	21.98		26.77		31.64		29.65		30.29		18.39		21.31	
Magnesia, MgO	3.81		5.56		6.39		6.94		5.82		4.69		7.26	
Sulfur trioxide, SO_3	14.45		14.68		13.30		11.14		11.15		1.21		17.17	
Potassium oxide, K_2O	0.72		0.72		0.73		0.80		0.85		0.47		1.11	
Sodium oxide, Na_2O	1.35		1.95		2.17		2.29		2.37		1.42		2.56	
Undetermined	0.89		0.93		0.89		0.36		0.92		0.52		0.22	
Alkalies as Na_2O, DCB	0.15		0.15		0.14		0.14		0.14		0.12		0.14	
THICKNESS OF COAL SAMPLED	Hole No. BT-82 103' - 110'		Hole No. BT-82 111' - 121'		Hole No. BT-82 121' - 131'		Hole No. BT-82 131' - 141'		Hole No. BT-82 141' - 151'		Hole No. BT-82 151' - 161'		Hole No. BT-82 161' - 173'	

SOURCE: Atlantic Richfield Company.

Table 8

Analyses of Coal and Ash of the Coal Sample by Interval in a Selected Core Hole from the Proposed Black Thunder Mine, Campbell County, Wyoming
(All values except Btu and fusion temperature are in percent. Analyses by Commercial Testing and Engineering Company.)

Table 9

Semiquantitative Spectrographic Analyses (in parts per million) of Core Samples from the Roland Coal Bed at the Proposed Black Thunder Mine, Campbell County, Wyoming

Hole Number:	BT-37	BT-34	BT-38	BT-56	BT-58	BT-61	BT-63	BT-64	BT-66	BT-68	BT-69	BT-71	BT-73	BT-75	BT-77
Interval Sampled: (Depth in feet)	181-251	111-180	132-202	47-116	59-129	60-132	36-58	78-146	24-91	40-85	85-152	22-72	21-76	65-132	24-84
Uranium	<0.13	<0.13	<0.13	--	0.3	.30	--	--	0.4	0.7	0.50	0.30	--	0.7	--
Thorium	0.72	<0.1	<0.1	--	0.6	0.63	0.72	0.70	1.0	1.7	1.2	0.72	--	2.5	--
Bismuth	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lead	1.3	0.26	2.6	1.0	0.86	2.6	1.0	1.3	1.0	1.0	0.64	0.65	1.0	1.7	0.37
Thallium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mercury	0.08	0.16	0.30	0.10	0.11	0.08	0.06	0.08	0.07	0.09	0.08	0.07	0.09	0.08	0.11
Tungsten	0.40	<0.1	0.27	0.27	0.4	0.40	0.40	0.27	--	0.4	0.4	0.4	0.4	0.30	0.8
Tantalum	0.76	1.8	0.76	--	--	--	--	--	--	0.3	0.5	--	--	--	0.2
Hafnium	0.23	1.5	<0.1	--	--	--	--	--	--	0.3	0.56	--	0.64	0.30	--
Lutecium	<0.1	<0.1	<0.1	--	--	--	--	--	--	--	--	--	--	--	--
Ytterbium	<0.1	<0.1	<0.1	--	--	--	--	--	--	--	--	<0.15	--	--	--
Thulium	<0.1	<0.1	<0.1	--	--	--	--	--	--	--	--	--	--	--	--
Erbium	<0.1	<0.1	<0.1	--	--	--	--	--	--	--	--	--	--	--	--
Holmium	<0.1	<0.1	<0.1	--	--	--	--	--	--	--	--	--	--	--	--
Dysprosium	0.1	0.1	0.1	--	--	--	--	--	--	--	--	--	--	--	--
Terbium	<0.1	<0.1	<0.1	0.02	0.04	0.02	0.08	0.12	0.05	0.12	0.02	0.04	0.04	0.04	0.05
Gadolinium	<0.1	<0.1	<0.1	0.12	0.12	0.06	0.12	0.10	0.06	0.17	0.12	0.17	0.12	0.06	0.04
Europium	<0.1	<0.1	<0.1	0.02	0.06	0.02	0.02	0.02	0.06	0.02	0.02	0.02	0.02	0.02	0.02
Samarium	<0.1	<0.1	0.11	0.24	0.33	0.24	0.24	0.66	0.42	0.24	0.17	0.24	0.24	0.55	0.24
Neodymium	0.90	0.90	1.8	1.1	0.38	0.38	0.53	1.1	0.53	0.38	0.38	0.38	0.89	0.66	0.24
Praseodymium	0.20	0.15	0.30	1.0	0.2	0.15	0.24	0.24	0.86	0.24	0.24	0.24	0.24	0.67	0.30
Cerium	0.62	0.50	0.83	0.83	0.25	0.83	0.62	2.5	2.0	2.5	1.2	0.55	0.83	2.0	0.83
Lanthanum	0.78	0.39	0.87	0.87	0.39	0.39	0.87	3.1	1.3	1.3	1.3	0.78	0.78	2.6	0.31
Barium	27.0	27.0	4.6	11.0	11.0	20.0	30.0	100.0	30.0	68.0	30.0	25.0	44.0	40.0	30.0
Cesium	0.03	0.03	1.5	<0.1	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.12	0.1	<0.1	<0.1
Iodine	0.15	0.15	0.15	0.38	0.14	0.05	0.38	0.03	0.26	0.02	0.05	0.14	0.06	0.26	0.23
Tellurium	<0.1	<0.1	<0.1	0.17	0.26	0.18	<0.1	<0.1	0.18	<0.1	<0.1	0.76	0.1	0.50	0.14
Antimony	1.8	0.27	0.05	0.07	<0.1	<0.1	<0.1	0.07	<0.1	0.07	<0.1	0.07	0.07	0.20	<0.1
Tin	0.20	0.04	0.04	0.32	0.20	0.2	0.32	2.0	0.32	3.2	0.40	0.89	0.89	0.89	0.32
Cadmium	0.01	0.01	0.02	0.43	0.44	0.44	1.2	0.41	0.34	0.41	0.43	1.2	0.18	2.3	4.3
Silver	0.01	0.02	0.06	0.21	0.08	0.09	0.85	0.20	0.08	0.56	0.24	0.25	0.24	0.06	0.23
Molybdenum	0.86	0.75	0.60	1.0	0.86	0.86	0.86	2.0	0.86	0.86	0.86	0.86	1.5	2.4	0.86
Niobium	0.48	0.60	0.81	0.60	0.24	0.53	0.32	1.9	0.80	1.6	0.8	0.53	0.81	1.9	0.54
Zirconium	3.2	3.2	3.2	6.3	3.2	2.5	2.5	2.5	7.0	7.0	7.0	3.5	5.0	7.0	25.0
Yttrium	0.61	0.41	1.2	0.61	0.61	0.61	0.41	1.5	1.5	1.8	0.61	0.61	0.61	1.8	0.61
Strontium	46.0	40.0	46.0	46.0	31.0	31.0	31.0	110.0	110.0	110.0	46.0	30.0	46.0	35.0	45.0
Rubidium	0.31	0.31	0.62	0.21	0.05	0.07	0.21	0.31	0.19	0.07	0.31	2.1	2.1	0.75	0.75
Bromine	1.3	1.3	2.9	0.09	0.04	0.04	0.04	0.10	0.10	0.10	0.10	0.10	0.10	0.32	0.10
Selenium	<0.1	<0.1	<0.1	0.84	1.3	0.37	0.36	0.29	0.29	0.29	0.65	0.37	0.42	4.3	0.65
Arsenic	1.5	0.3	1.0	0.50	2.3	0.73	0.98	3.0	2.3	1.0	1.4	0.65	2.0	5.0	1.5
Germanium	0.06	0.02	0.06	<0.1	<0.1	<0.1	0.04	0.02	0.02	0.06	0.24	<0.1	0.06	0.17	0.06
Gallium	0.45	<0.1	<0.1	1.8	0.65	0.81	1.6	1.8	2.7	1.8	2.7	1.6	2.7	6.5	1.6
Zinc	11.0	220.0	11.0	37.0	9.0	9.0	22.0	9.0	11.0	9.0	9.0	2.5	11.0	11.0	0.42
Copper	9.5	4.3	14.0	15.0	6.4	15.0	7.6	15.0	6.4	15.0	15.0	6.4	15.0	6.4	12.0
Nickel	2.6	0.21	7.1	0.71	0.71	1.1	0.71	2.6	1.1	2.6	2.6	0.25	3.2	6.4	1.1
Cobalt	1.6	2.5	0.82	2.0	4.9	2.0	1.6	5.4	5.4	2.0	5.4	2.0	2.5	5.4	2.0
Manganese	2.7	2.3	2.7	6.4	4.0	6.4	6.4	6.4	64.0	64.0	6.4	6.4	18.0	26.0	6.4
Chromium	12.0	7.2	9.0	12.0	8.0	8.0	3.6	9.0	8.0	12.0	12.0	8.0	7.2	9.0	2.9
Vanadium	5.6	5.6	5.6	5.6	4.4	4.4	2.2	12.0	4.4	12.0	4.4	4.4	12.0	5.5	4.5
Titanium	190.0	190.0	320.0	770.0	210.0	240.0	190.0	320.0	320.0	640.0	240.0	240.0	480.0	210.0	220.0
Scandium	0.26	0.52	2.6	0.62	0.62	0.62	0.17	1.7	0.62	0.62	0.62	0.62	0.78	1.7	0.63
Fluorine	36.0	36.0	180.0	72.0	70.0	140.0	140.0	140.0	70.0	70.0	60.0	150.0	60.0	40.0	60.0
Boron	33.0	22.0	33.0	25.0	80.0	20.0	10.0	15.0	20.0	20.0	20.0	20.0	13.0	15.0	22.0
Beryllium	0.96	3.2	2.1	0.48	0.27	0.77	0.24	0.27	0.48	0.27	0.27	0.38	0.27	0.27	0.83
Lithium	13.0	13.0	8.5	1.3	4.3	4.3	2.8	4.2	4.3	3.2	4.3	4.3	1.0	2.6	2.8

Other elements looked for but not detected: Gold, Platinum, Iridium, Osmium, Rhenium, Palladium, Rhodium, and Ruthenium.

-- Element less than detection limit.

Table 9 (Cont'd)

Semiquantitative Spectrographic Analyses (in parts per million) of Core Samples from the Roland Coal Bed at the Proposed Black Thunder Mine, Campbell County, Wyoming

Hole Number:	BT-80	BT-82	BT-82	BT-82	BT-82	BT-82	BT-82	BT-82	BT-92	BT-98	BT-100	BT-107	BT-109	BT-115
Interval Sampled: (Depth in feet)	130-198	103-110	111-121	121-131	131-141	141-151	151-161	161-173	64-134	127-197	86-144	149-218	102-175	130-197
Uranium	0.35	0.53	0.26	0.35	0.38	0.14	0.19	0.24	0.53	0.44	0.44	0.58	0.53	0.23
Thorium	1.8	1.5	0.72	1.5	1.3	0.48	1.4	0.96	1.8	0.8	2.1	1.5	1.1	1.9
Bismuth	<0.47	0.35	<0.35	<0.35	0.30	<0.23	0.19	<0.35	<0.35	<0.11	<0.23	<0.35	<0.35	<0.23
Lead	7.3	1.7	0.55	0.83	0.95	1.1	1.3	2.8	1.1	0.73	0.73	2.4	1.1	1.6
Thallium	0.8	2.6	<0.15	<0.15	--	--	--	<0.2	<0.15	--	<0.1	0.15	<0.15	<0.1
Mercury	0.07	<0.03	<0.03	0.07	<0.03	<0.03	<0.03	0.04	<0.03	0.12	0.13	<0.03	<0.03	0.07
Tungsten	2.2	1.4	0.93	1.4	0.66	1.9	1.5	1.2	0.7	1.9	<0.47	2.1	14.0	1.9
Tantalum	--	5.9	--	0.39	0.14	0.08	0.16	0.4	8.4	0.26	4.9	0.39	0.39	0.56
Hafnium	0.35	0.87	<0.22	0.87	0.38	<0.15	0.23	0.34	0.65	0.58	0.35	0.44	1.7	0.58
Lutecium	<0.47	<0.35	<0.35	<0.35	<0.3	<0.23	<0.18	<0.23	<0.35	0.23	<0.23	<0.35	<0.35	<0.23
Ytterbium	<1.5	<1.1	<1.1	<1.1	<1.0	<0.3	<0.6	<0.3	<1.1	0.75	0.75	<1.1	<1.1	<0.3
Thulium	<0.15	<0.11	<0.11	<0.11	<0.10	<0.08	<0.06	<0.08	<0.11	0.08	<0.08	<0.11	<0.11	<0.08
Erbium	<0.32	<0.24	<0.24	<0.24	0.28	<0.16	<0.13	<0.16	<0.24	0.16	0.27	<0.24	<0.21	<0.16
Holmium	<0.14	0.18	0.11	0.13	0.12	<0.07	<0.06	<0.07	0.11	0.11	0.09	0.13	<0.13	<0.07
Dysprosium	<0.9	1.2	<0.68	0.81	0.78	<0.45	<0.36	<0.45	0.68	0.9	<0.45	0.74	<0.68	<0.45
Terbium	<0.14	0.13	<0.11	<0.1	<0.1	<0.07	<0.06	<0.07	<0.11	0.11	0.09	<0.1	<0.1	<0.07
Gadolinium	<0.43	0.39	<0.33	<0.32	<0.28	<0.22	<0.17	<0.22	0.35	0.33	0.22	<0.32	<0.32	<0.22
Europium	<0.57	0.64	<0.43	0.46	0.40	<0.28	<0.23	<0.28	<0.43	<0.28	<0.28	<0.46	0.46	<0.28
Samarium	0.83	1.1	<0.63	0.63	<0.54	0.5	<0.33	<0.42	<0.63	0.5	<0.42	0.63	0.60	<0.42
Neodymium	21.0	13.0	9.5	3.8	6.6	4.2	15.0	8.2	24.0	8.5	18.0	24.0	27.0	5.1
Praseodymium	11.0	4.0	3.0	1.6	2.3	1.1	3.2	2.2	8.0	1.6	2.7	8.0	8.0	2.3
Cerium	8.0	10.0	6.0	4.3	0.43	3.3	5.3	5.0	3.8	2.9	6.7	10.0	20.0	6.7
Lanthanum	13.0	4.8	9.5	3.8	10.0	4.2	7.2	4.2	5.9	4.2	7.9	14.0	14.0	6.3
Barium	170.	96.	180.	220.	120.	100.	90.	180.	70.	21.	60.	140.	280.	45.
Cesium	0.3	0.11	0.02	0.15	0.02	0.01	0.008	0.04	0.004	0.005	<0.003	0.01	0.15	0.08
Iodine	0.8	0.9	0.68	1.4	0.43	0.3	0.48	0.90	0.9	0.6	1.0	0.9	0.54	0.36
Tellurium	0.07	0.05	<0.05	0.1	0.05	<0.03	0.05	0.08	<0.05	0.07	<0.03	0.1	0.05	0.07
Antimony	0.24	0.16	<0.11	0.16	<0.1	0.76	0.07	0.22	<0.11	0.14	<0.07	0.13	0.11	0.08
Tin	0.29	0.44	1.0	2.6	2.6	1.0	1.8	14.0	1.3	1.0	0.86	6.9	5.2	2.3
Cadmium	0.44	0.55	0.44	0.66	0.64	0.29	0.23	0.44	0.66	0.49	0.63	0.66	0.94	0.29
Silver	0.03	0.03	<0.02	0.03	<0.02	0.03	0.01	0.12	0.04	0.02	0.02	0.03	0.03	0.03
Molybdenum	35.0	20.0	5.6	13.0	11.0	3.7	2.6	7.0	13.0	8.7	4.3	13.0	13.0	8.7
Niobium	7.4	2.6	1.3	13.0	4.2	0.87	3.0	3.1	5.6	3.7	5.2	5.6	13.0	6.5
Zirconium	70.	70.	84.	140.	61.	47.	75.	52.	70.	160.	93.	140.	140.	47.
Yttrium	5.3	8.0	6.0	4.0	2.6	2.3	3.2	2.2	3.0	5.3	4.6	8.0	8.0	3.2
Strontium	350.	130.	110.	94.	98.	96.	280.	290.	200.	62.	180.	270.	530.	96.
Rubidium	0.52	0.14	0.26	0.39	1.0	0.03	0.07	0.26	0.11	0.17	0.07	1.3	1.3	0.26
Bromine	7.3	8.3	1.7	1.1	3.6	1.4	2.9	1.6	5.5	1.6	18.0	11.0	5.5	1.4
Selenium	0.74	0.28	0.37	0.37	0.27	0.15	0.20	<0.20	0.28	0.49	2.5	0.56	0.37	0.49
Arsenic	2.5	1.9	1.4	1.2	1.0	0.4	0.64	0.6	1.5	0.8	0.8	2.6	1.2	0.8
Germanium	0.45	0.27	0.14	0.27	0.39	0.09	0.10	0.12	0.27	0.26	0.6	0.39	0.09	0.18
Gallium	2.4	1.2	2.3	2.6	2.6	0.8	4.8	0.8	2.3	0.8	0.8	2.6	2.6	2.0
Zinc	4.8	1.2	0.58	0.36	1.5	0.4	1.6	1.6	0.43	0.46	0.23	2.0	0.95	0.8
Copper	32.0	2.4	16.0	34.0	59.0	19.0	14.0	5.4	40.0	19.0	23.0	40.0	16.0	23.0
Nickel	7.8	17.0	15.0	29.0	5.6	6.5	7.8	6.2	5.9	2.6	2.6	20.0	3.9	2.6
Cobalt	8.0	11.0	1.5	7.5	3.8	1.1	2.0	1.0	2.5	2.5	1.8	3.8	3.8	1.9
Manganese	32.0	11.0	15.0	23.0	19.0	12.0	11.0	8.4	34.0	13.0	28.0	27.0	19.0	13.0
Chromium	7.1	5.3	12.0	10.0	10.0	2.7	10.0	3.0	11.0	6.6	18.0	22.0	11.0	7.6
Vanadium	56.0	19.0	18.0	25.0	26.0	6.6	32.0	8.6	25.0	11.0	21.0	48.0	34.0	17.0
Titanium	1500.	490.	400.	1100.	840.	280.	670.	280.	770.	650.	1300.	1300.	2100.	830.
Scandium	5.9	3.8	2.9	4.5	2.5	0.9	1.6	2.1	3.3	2.0	1.9	5.3	5.0	2.0
Fluorine	240.	180.	180.	180.	160.	210.	96.	120.	210.	180.	110.	90.	140.	120.
Boron	75.	75.	45.	38.	39.	18.	24.	100.	38.	27.	30.	41.	150.	30.
Beryllium	0.84	0.32	0.84	0.25	0.73	0.30	0.22	1.0	0.32	0.17	0.56	0.63	0.84	0.56
Lithium	8.5	3.2	4.3	1.7	32.0	2.4	4.5	1.4	8.5	5.7	11.0	3.6	8.5	5.7

Other elements looked for but not detected: Gold, Platinum, Iridium, Osmium, Rhenium, Palladium, Rhodium and Ruthenium.

-- Element less than detection limit.

Quantity of Coal

Estimates of coal in the Wyodak (Roland) bed in the lease area of the Atlantic Richfield Company's Black Thunder mine are shown in Table 10. The recoverable coal of 724 million tons is more than adequate to fulfill projected production schedules. Overburden averages less than 150 feet thick over 414 million tons of recoverable coal and less than 100 feet thick over 262.5 million tons. Coal is under more than 200 feet of overburden only in small areas in sections 2 and 3, T42N, R70W, and section 20, T43N, R70W (Figure 5).

Table 10

Available Coal, in Thousands of Short Tons, at the Proposed Black Thunder Mine, T42 and 43N, R70W, Campbell County, Wyoming

Location	Area Acres	Average Coal Thickness (feet)	Coal in Place*	Recoverable Coal**	Average Overburden Thickness (feet)
T42N, R70W					
Section 2	400	70	49,560	47,082	148
Section 3	480	70	59,472	56,498	189
T43N, R70W					
Section 16	640	67	75,898	72,103	78
Section 17	640	70	79,296	75,331	133
Section 20	640	71	80,429	76,408	174
Section 21	640	69	78,163	74,255	143
Section 22	240	68	28,886	27,442	128
Section 27	470	57	47,418	45,047	47
Section 28	640	68	77,030	73,178	98
Section 29	160	69	19,541	18,564	163
Section 33	320	69	39,082	37,128	133
Section 34	640	67	75,898	72,103	97
Section 35	430	68	51,755	49,167	108
Total	6,340	68	762,428	724,306	123

*Assuming 1,770 short tons of coal per acre-foot.

** Assuming 95 percent recovery of coal in place.

Other minerals

Occurrences of uranium or minerals other than coal are not known in the lease area.

Sand and gravel lenses, potentially useful for aggregate, occur locally on the lease area in alluvial fill along Little Thunder Creek and North Prong of Little Thunder Creek. Areas of clinker are sufficiently thick and widespread along the eastern edge of the lease to provide road material and ballast.

Oil and gas

The Atlantic Richfield Company's federal coal lease in T42 and 43N, R70W, presently has five producing oil wells in the Payne Oil field and two plugged and abandoned oil and gas test holes. The company's surface mining plan indicates that an area with existing oil wells will not be mined before the year 1991. By 1983 all wells on production in 1974 will be properly plugged and abandoned and conditioned for the eventual surface mining of the area. A competitive oil and gas lease is being offered for the SE¼ sec. 3, T42N, R70W, in early 1974. If such a lease is issued an application for approval to drill a new well on this acreage could be submitted within six months or so after lease issuance. State spacing rules would require a well on this competitive lease to be drilled in the center of SW¼SE¼ sec. 3, T42N, R70W, with 200 feet of surface tolerance. This location would be no less than 440 feet from the southern boundary of the lease. No other wells are known within the coal lease area but tests for oil and gas from other producing zones could be applied for within the area at any time. Data on the existing wells in the Atlantic Richfield Company's federal coal lease follow:

During November 1971, a well was drilled 1,960 feet from north line and 660 feet from west line (C SW¼NW¼) sec. 2, T42N, R70W, on a private oil and gas lease, ground elevation at 4,847 feet; 9 5/8-inch surface casing was set at 627 feet; 5½-inch production casing is cemented at 7,163 feet; total depth is 7,180 feet. Sussex Sandstone Member of the Steele Shale from 7,073 to 7,075 feet is the producing zone at an initial potential of 163 barrels of oil per day. Present rate of production is 24 barrels of oil per day.

During April and May 1970, a well was drilled 1,980 feet from north line and 1,980 feet from east line (C SW¼NE¼) sec. 3, T42N, R70W, on public oil and gas lease W-23778-A; ground elevation, 4,834 feet; 9 5/8-inch surface casing was set at 750 feet; 5½-inch production casing is cemented at 7,200 feet; total depth is 7,208 feet. Sussex Sandstone Member of the Steele Shale from 7,090 to 7,100 feet is the producing zone at an initial potential of 102 barrels of oil per day. Present rate of production is 11 barrels of oil per day.

During August 1971, a well was drilled and abandoned 677 feet from south line and 2,002 feet from east line (C SW¼SE¼) sec. 27, T43N, R70W, on public oil and gas lease W-9354: ground elevation is 4,664 feet; 8 5/8-inch surface casing was set by 797 feet; total depth is 6,921 feet in Steele Shale.

During May 1957, a well was drilled and abandoned 1,980 feet from north line and 1,980 feet from east line (C SW¼NE¼) sec. 34, T43N, R70W, on public oil and gas lease W-04564-B; ground elevation is 4,770 feet; 8 5/8-inch surface casing was set at 147 feet and total depth is 6,363 feet in Parkman Sandstone Member of the Mesaverde Formation.

During May and June 1969, a well was drilled 1,970 feet from north line and 2,135 feet from east line (NW¼SW¼NE¼) sec 34, T43N, R70W, on public oil and gas lease W-10413; ground elevation is 4,745 feet; 8 5/8-inch

surface casing was set at 709 feet; 4½-inch production casing is cemented at 7,364 feet; total depth is 7,373 feet. Sussex Sandstone Member of the Steele Shale from 6,968 feet to 6,974 feet is the producing zone at an initial potential of 185 barrels of oil per day. Present rate of production is 42 barrels of oil per day.

During May through August 1969, a well was drilled 1,985 feet from north line and 680 feet from west line (C SW¼NW¼) sec. 34, T43N, R70W, on public oil and gas lease W-9354; ground elevation is 4,717 feet; 8 5/8-inch surface casing was set at 715 feet; 4½-inch production casing is cemented at 7,023 feet; total depth is 9,743 feet and plugged back to 6,984 feet. Sussex Sandstone Member of the Steele Shale from 6,963 to 6,971 feet is the producing zone at an initial potential of 28 barrels of oil per day. Present rate of production is 7 barrels of oil per day.

During August and September 1969, a well was drilled 1,680 feet from south line and 2,100 feet from east line (SW¼SW¼SE¼) sec. 34, T43N, R70W, on a state oil and gas lease; ground elevation is 4,773 feet; 8 5/8-inch surface casing was set at 734 feet; 4½-inch production casing is cemented at 7,048 feet; total depth is 7,055 feet. Sussex Sandstone Member of the Steele Shale from 7,010 feet to 7,020 feet is the producing zone at an initial potential of 75 barrels of oil per day.

Water Resources

Ground water

Aquifers

Formations within about 5,000 feet of land surface in the vicinity of the A.R.Co. coal lease that contain aquifers are, in order of increasing depth below land surface, the Wasatch, Fort Union, Lance, and Fox Hills. The only aquifers that are expected to be affected by mining operations by A.R.Co. are the coal beds and the overlying aquifers in the Wasatch which is the overburden to be removed during mining operations.

In the southern half of Campbell County, the land surface slopes eastward. The beds within these formations, however, dip very gently westward toward the axis of the Powder River structural basin. Many separate water levels are present in the thick sequence of Tertiary and Upper Cretaceous rocks that underlie the land surface. The water levels in these rocks are at higher altitudes than are the altitudes of the rock outcrops farther to the east.

Water movement

The higher water levels in the center of the basin preclude water movement basinward from the outcrop areas. Recharge in southern Campbell County occurs from infiltration of local precipitation on the topographic higher areas in the central and southern parts of Campbell County, east of the A.R.Co. coal lease.

Surface water

Drainage and streamflow

The surface of the area leased by the Atlantic Richfield Company is drained by Little Thunder Creek and its tributaries. North Prong Little Thunder Creek flows southeast across the northern part of the leased area. This stream has a contributing drainage area of about 43 square miles upstream from the leased area. About 2.5 miles of its main channel and 7.9 miles of its minor tributaries lie within the leased area. About 21 percent (2.0 sq. mi.) of the leased area is drained by North Prong Little Thunder Creek.

Little Thunder Creek flows east across the middle of the leased area. This stream has a drainage area of about 58 sq. mi. upstream from the lease area. About 61 percent (5.6 sq. mi.) of the leased area is drained by Little Thunder Creek.

A total of about 1.6 sq. mi. of the area is made up of shallow closed basins which have no apparent outflow. The formation of these depressions may be due to the burning of underlying coalbeds or to the differential settling of underlying deposits.

The main channels of Little Thunder and North Prong Little Thunder Creeks are intermittent streams, whereas, the intervening tributaries are ephemeral. The major part (75 percent) of annual runoff occurs during the spring and summer months, generally as a result of convective storms. Culler (U.S. Geological Survey 1961a, p. 37) determined average summer runoff during 1951-54 to a stockpond located in the NE¼NE¼ Section 10, T42N, R70W, to be 5.2 acre-feet per year. Drainage area to the stockpond is 0.66 sq. mi. Minor tributaries of the area commonly have periods of several years with no flow.

Based on basin characteristics and channel-geometry features, North Prong Little Thunder is estimated to have a mean annual runoff of 1,100 acre-feet per year and a mean annual flood peak of 700 cfs (cubic feet per second) at the site of its intersection with the lease boundary.

Little Thunder Creek is estimated to have a mean annual runoff of 1,400 acre-feet per year and a mean annual flood peak of 900 cfs at the site of its intersection with the lease boundary.

The average slopes of the streambeds of Little Thunder and North Prong Little Thunder Creeks are 10.8- and 17.4-feet drop per mile, respectively. Average slopes of minor tributaries range from 92.8-feet drop per mile in the northwest part of the area to 148-feet drop per mile in the southeast part of the area.

Water uses

The major use of surface water is for consumption by domestic and wild animals. Numerous stockponds are constructed on minor tributaries, and detention and retention of flows is afforded by these man-made structures. Several water wells provide water that is stored in small reservoirs for use by livestock. Spreader systems are used for irrigation of hay meadows and pastures along the downstream reaches of Little Thunder and Black Thunder Creeks, but due to the large variation in annual runoff, water supplies are not dependable for irrigation.

Erosion and sedimentation

The highest rates of erosion are occurring in the minor tributaries that have steep slopes. A reservoir in the leased area on Little Thunder Creek causes many of the large sediment particles to deposit, but outflow

from the reservoir has the ability to erode and transport fresh sediments in the downstream channel. Little erosion is occurring in the closed basins.

Water quality

Water originating in or flowing through the lease area contributes to flow in the Cheyenne River. Since a major portion of the drainage area upstream from the water quality sampling site near Spencer on the Cheyenne River is similar to the lease area, water quality sampled near Spencer should generally represent surface water quality in the lease area.

Dissolved solids concentration in the Cheyenne River near Spencer ranges from 1000 mg/l to 4000 mg/l, but concentration outside this range may occur in the lease area. The increase in sodium and sulfate concentrations at low flows observed near Spencer should also occur in the lease area.

Vegetation

On better drained upland sites, the vegetation of the A.R.Co. lease is characterized by shrub steppe plant communities dominated by big sagebrush (Artemisia tridentata) (Table 11 and Figure 9). Domestic livestock have grazed these communities since the middle 1800's so all are in an intermediate stage of plant succession. Heavy grazing is thought to increase the density of big sagebrush or allow it to invade into grasslands. However, site conditions and degree of grazing intensity where this takes place have not been defined for northeastern Wyoming, nor is a historical record available for the lease area to indicate if big sagebrush should be considered an endemic part of the natural plant communities of this area.

The shrub overstory of these plant communities is composed almost entirely of big sagebrush. The height of this layer generally does not exceed 18 to 24 inches. Density (plants per unit area) will range from scattered to moderately closely spaced, but the crowns of individual plants rarely touch. Canopy coverage is in the 20 to 40 percent range. Beneath the sagebrush overstory and mixed with it are species common to the Northern Great Plains to the east. Grasses and sedges predominate, but forbs are evident in the early part of the growing season (April-May).

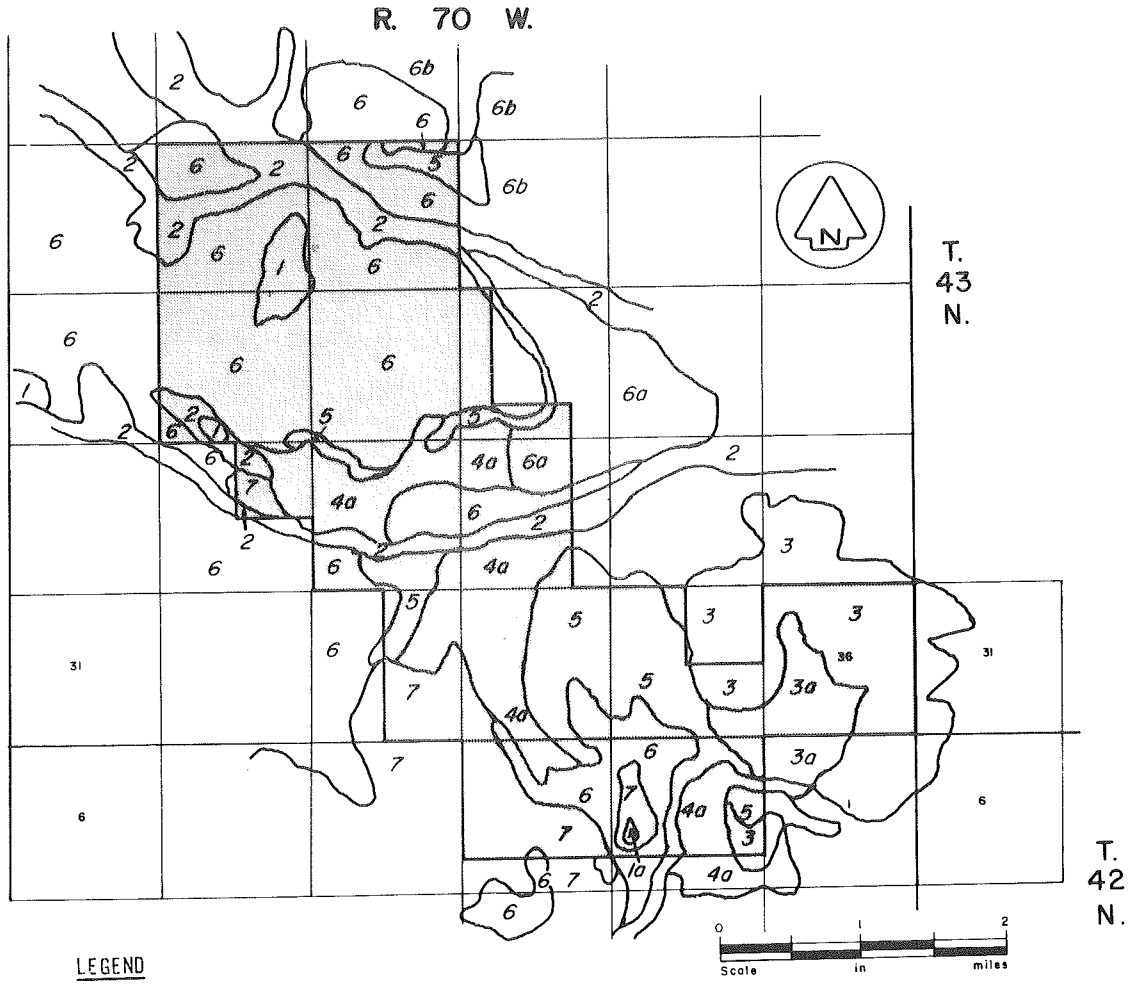
The greater amount of great plains species in the plant mixture is the most likely reason for the theory that big sagebrush is an invader into what should be grasslands similar to those of the Northern Great Plains. Areas of low sagebrush density certainly have the appearance similar to these grasslands. However, it is also possible that the communities dominated by big sagebrush represent the vegetational transition (ecotone) between the Northern Great Plains Grasslands to the east and the sagebrush shrubland more common to the west.

Ecological Relationships of the Atlantic Richfield Lease Area and Facility Site

No	Acres	Vegetation (Community type	Soil Series	Landform
1	130	Western wheatgrass-Foxtail barley	McKenzie clay	Playa (dry)
1a	10	Western wheatgrass-Slender Spikerush	McKenzie clay	Playa (wet)
2	520	Inland saltgrass-Western wheatgrass-Blue grama	Arvada clay loam Loam	Alluvial lowland (saline-alkali)
3	610	Bluebunch wheatgrass-Blue grama	Wibaux searing	Scoria land
3a	250	Bluebunch wheatgrass-Blue grama	Rough broken-searing Searing gravelly loam	Scoria land Scoria land
4	20	Big sagebrush-Western wheatgrass-Blue grama	Renohill clay loam	Sideslope (rolling)
4a	1,030	Big sagebrush-Western wheatgrass-Blue grama	Renohill loam	Sideslope (rolling)
5	820	Big sagebrush-Western wheatgrass-Blue grama	Rough broken land	Rough broken land
6	2,474	Big sagebrush-Needleandthread-Blue grama	Ulm loam (reddish subsoil)	Upland (undulating)
6a	330	Big sagebrush-Needleandthread-Blue grama	Ulm loam	Upland (rolling)
6b	10	Big sagebrush-Needleandthread-Blue grama	Ulm clay loam (shallow)	Upland
7	510	Big sagebrush-Blue grama	Renohill clay loam	Upland (undulating)
Total	6,714			

Note: For detailed description of the ecosystem see description in appendix for this lease.

Table 11



LEGEND

- 1 Western Wheatgrass-Foxtail Barley
- 1a Western Wheatgrass-Slender Spikerush
- 2 Inland Saltgrass-Western Wheatgrass
- 3 Bluebunch Wheatgrass-Blue Grama*
- 3a Bluebunch Wheatgrass-Blue Grama*
- 4 Big Sagebrush/Western Wheatgrass-Blue Grama*
- 4a Big Sagebrush/Western Wheatgrass-Blue Grama*
- 5 Big Sagebrush/Western Wheatgrass-Blue Grama*
- 6 Big Sagebrush/NeedleandThread-Blue Grama*
- 6a Big Sagebrush/NeedleandThread-Blue Grama*
- 6b Big Sagebrush/NeedleandThread-Blue Grama*
- 7 Big Sagebrush/Blue Grama
- Boundary of Arco Coal Property

*Difference In Soils

Figure 9

Vegetation Community Boundaries (A.R.Co. Coal Property)

The following vegetative types have been identified on the leases:

Ecosystem No. 1: Western wheatgrass-foxtail barley grassland on playas with deep clayey soils.

This ecosystem is found on the playas which are present on nearly level uplands. Soils are deep, clayey, and subject to periodic inundation from runoff, but water does not remain above the surface for long periods. The general appearance of the vegetation is a sparsely vegetated grassland dominated by western wheatgrass. Shrubs or trees do not occur. When not inundated or muddy, this ecosystem can provide water for animals, and when inundated may be habitat for amphibians and aquatic birds.

Ecosystem No. 1a: Western wheatgrass-slender spikerush grassland on playas with deep clayey soils.

This grassland ecosystem is found on small playas which are present on nearly level uplands. Soils are deep, clayey, and subject to periodic inundation from runoff. The period of high water appears to be longer than in the western wheatgrass-foxtail barley ecosystem (No. 1) and the vegetative cover is greater, but the general appearance is still a grassland devoid of woody vegetation. When dry, this ecosystem can be grazed by livestock and wildlife; when wet it can provide water for animals and may be habitat for amphibians and other aquatic wildlife.

Ecosystem No. 2: Inland saltgrass-western wheatgrass, blue grama, riparian grassland on alluvial lowlands with deep saline-alkaline soils.

This ecosystem is confined to clayey alluvial soils in flat, narrow valleys of stream courses where saline salts accumulate. These valleys may be periodically flooded by runoff water. The vegetation

is a grassland community type dominated by inland saltgrass. The ecosystem is grazed by both domestic livestock and wildlife.

Ecosystem No. 3: Bluebunch wheatgrass-blue grama grassland on scoria land with shallow, gravelly soils.

This ecosystem occurs on ridges and hills derived from reddish colored scoria. Soils are shallow and gravelly and tend to be droughty. The general physiognomy is a somewhat sparsely vegetated grassland characterized by scattered tussocks of bluebunch wheatgrass. The ecosystem provides grazing for livestock and wildlife, and the steeper outcrops may provide nesting or perching sites for owls, hawks, and other cliff-dwelling birds.

Ecosystem No. 3a: Bluebunch wheatgrass-blue grama grassland on scoria land with shallow to moderately deep soils.

This ecosystem occurs on ridges and hills derived from reddish colored scoria. It differs from Ecosystem No. 3 in that soils are shallow to moderately deep and tend to be less droughty. The general physiognomy is a somewhat sparsely vegetated grassland characterized by scattered tussocks of bluebunch wheatgrass (*Agropyron spicatum*). The ecosystem provides grazing for livestock and wildlife. The steeper outcrops may provide nesting or perching sites for owls, hawks, and other cliff-dwelling birds. It is present only on the Atlantic Richfield lease.

Ecosystem No. 4: Big sagebrush-western wheatgrass-blue grama shrub steppe on dissected sideslopes with moderately deep soils.

This ecosystem occurs on sideslope terrain which is somewhat dissected. Soils are shallow to moderately deep and tend to be

clay loam or clayey in texture. The vegetation is a shrub steppe with big sagebrush (Artemisia tridentata) the shrub layer dominant. The herbaceous layer is characterized by western wheatgrass (Agropyron smithii) and blue grama (Bouteloua gracilis). It provides grazing for livestock and wildlife.

Ecosystem No. 4a: Big sagebrush-western wheatgrass-blue grama shrub steppe on dissected sideslopes with moderately deep soils with loamy surfaces.

This ecosystem occurs on sideslope terrain which is somewhat dissected. Soils are shallow to moderately deep and tend to be more loamy in texture than those in Ecosystem No. 4. The vegetation is a shrub steppe with big sagebrush (Artemesia tridentata) as the shrub layer dominant. The herbaceous layer is characterized by western wheatgrass (Agropyron smithii) and blue grama (Bouteloua gracilis). This is also a major ecosystem on the lease area. It provides grazing for livestock and wildlife.

Ecosystem No. 5: Big sagebrush-western wheatgrass-blue grama shrub steppe on rough broken land side slopes with shallow clayey soils.

This ecosystem is present on rough and broken topography. Soils are shallow; textures tend to be somewhat clayey, but drainage is not impeded. The vegetation is a very open shrub-steppe of big sagebrush (Artemesia tridentata) with a sparse herbaceous understory of grasses. It is grazed by both livestock and wildlife but is low in production of herbage.

Ecosystem No. 6: Big sagebrush-needleandthread-blue grama shrub steppe on nearly level to gently sloping uplands with moderately deep loamy soils.

This ecosystem is characterized by gently sloping to rolling uplands

with moderately deep soil with texture loamy to sand. The vegetation is a shrub steppe community type with big sagebrush as the shrub-layer. The understory is composed of grasses and forbs common to the Great Plains area. It is used by both livestock and wildlife for grazing and is moderately productive.

Ecosystem No. 6a: Big sagebrush-needleandthread-blue grama shrub steppe on dissected sideslopes with shallow to moderately deep loamy soils.

This ecosystem occurs on dissected sideslope terrain. Soils are loamy in texture and shallow to moderately deep. The vegetation is a shrub steppe community type with big sagebrush as the shrub layer dominant. The understory is composed of grasses and forbs common to the Great Plains grassland. It is used by both livestock and wildlife for grazing and is moderately productive.

Ecosystem No. 6b: Big sagebrush-needleandthread-blue grama shrub steppe on gently sloping to rolling uplands with shallow loamy soils.

This ecosystem is characteristic of nearly level to gently sloping uplands with shallow loamy to sandy-textured soils. The vegetation is a shrub steppe community type with big sagebrush as the shrub-layer dominant. The understory is composed of grasses and forbs common to the Great Plains grassland. This is the most widely distributed ecosystem of the lease area. It is used by both livestock and wildlife for grazing and is moderately productive.

Ecosystem No. 7: Big sagebrush-blue grama shrub steppe on gently sloping uplands moderately deep clay loam soils.

This ecosystem is characteristic of nearly level to gently sloping uplands with clay loam textured soils. The vegetation is a

shrub steppe community type with big sagebrush as the shrub layer dominant. The herbaceous layer has blue grama as the major grass. Western wheatgrass and needleandthread are rare. The ecosystem is used by both livestock and wildlife for grazing and is moderately productive.

Archeological and Paleontological Values

Six archeological or paleontological sites have been identified on the A.R.Co. lease site; two of these may be excavated. However, Dr. George Frison, Department of Anthropology, University of Wyoming, has been contracted by the Wyoming Environmental Institute and is proceeding with an environmental study of the area. This study should be completed some time in 1974.

The A.R.Co. lease area could produce a significant find but most await Dr. Frison's report for more specific possibilities. If a site is found, it must be properly assessed and excavated before the mining operation may proceed.

There is little known of the paleontology potential of the lease area, but the Wasatch and the Fort Union formations that lie on the lease area can be expected to yield some vertebrate remains.

Historical Values

The National Register of Historic Places, the State Historic Preservation Officer, and local references and people were consulted and no known significant sites, trails, or areas occur on this lease area. However, Indian tribes probably passed through and hunted buffalo and other game in the area. No campsites or other permanent habitation evidence by these tribes are known on the lease.

Homesteads were established on the area in the early 1900's. There was at least one homestead site in section 28, but only the foundation and a few boards are left as evidence of the original structure, and no historical significance can be placed on this site. Other sites probably existed, but no historical events or persons can be attributed to the area from knowledge available.

There were two major reasons for land abandonment.

(1) Many potential farm families settled on tracts of 160 to 640 acres that were physically and economically unfitted for cultivation.

(2) An even larger number of settlers either originally or subsequently attempted livestock production on units of one or two sections that proved to be inadequate for this type of operation.

Cultivated tracts were usually less than 160 acres in size. In some instances, the land was tilled only to comply with a provision of the Homestead Act. Homestead principles developed for a humid climate further east were misapplied to the semiarid plains.

Operators remaining in the area encountered grave financial difficulties. Tax delinquency was a serious problem. County governments were hard pressed to maintain schools, roads, and other government activities. The above history of the land gave reason for the following governmental programs.

Homesteading continued until 1934 when the public domain was closed to homestead entry. Considerable acreage of these old homestead lands were repurchased by the Federal Government in the 1930's.

The Thunder Basin National Grassland was initiated in 1934 as the Northeastern Wyoming Land Utilization Project under the Agricultural Adjustment Administration. The program since that time has been administered by the Resettlement and the Farm Security Administration, the Bureau of Agriculture Economics, and the Soil Conservation Service to the Forest Service in 1954.

While the project was started late in 1934, the purchasing of units was started in 1935 and the last of the purchases made in the early forties. The original project included the area now in the Thunder Basin Grazing Association and the Spring Creek Association. The area now in the Inyan Kara Grazing Association was organized in 1938 as a project.

The A.R.Co. lease area is within the boundaries of the Thunder Basin Grazing Association.

Aesthetics

The overall landform of the lease area is a result of sedimentary deposits from upper Cretaceous to recent geologic times and the natural weathering that has occurred since the deposition.

The landform on the Atlantic lease is similar to a wide portion of the Powder River Basin. Gently rolling uplands comprise approximately 60 percent of the lease area. This type of terrain gives a very weak form to the landscape character. The remaining 20 percent of the area is of an undulating, rolling uplands type between the gently rolling uplands and the dissected, rough broken lands. These give a moderate form to the landscape character.

The northern half of the lease area is of the gentle to moderately rolling landform, except for a strip of rough broken land that skirts the eastern edge of the area and turns to an east-west direction just north of Little Black Thunder Creek. The south half of the lease area is well dispersed with the three basic types of landform in the area, giving a good amount of form variety to the overall landscape character.

Textures are created by the vegetative patterns and degree of erosion on the land. The textures in the gently rolling uplands are smoother than those displayed in the rough, broken, eroded terrain. The natural vegetation, consisting mainly of sagebrush and native grasses fairly evenly mixed, gives a moderately roughened texture to the surface of the rolling landform. Textures in the dissected, rough broken land are generally rougher due to the heavily eroded soils and the sparse, more bunchy grouping of sagebrush.

Some small areas have been cultivated at various times in the past. These have since revegetated with wild grasses and forbs. The texture here

is the smoothest found anywhere throughout the lease due to the one basic soft-textured vegetative type.

Line is subtly displayed where contrasting landform and large groups of vegetative types join. Line is most evident where man's activities have created contrasting vegetative changes. The cultivated areas and pipeline route are examples of this element. The horizon line is probably the most evident line that is displayed in this landscape.

The color within the area is muted tones of grays, greens, reds, and browns. The brightest colors occur in spring and early summer when the sage brush and grass is its greenest and wildflowers are in bloom. The most color contrast occurs in the wintertime when the white snowdrifts contrast with the darker tones of soils and winter vegetation. The predominant color tones for most of the year are light browns and light grays. These are displayed by the grass as the seasons progress from spring through the winter. Grays and light browns are displayed when soil is exposed by either erosion or disturbance. Reddish tones appear in the scoria soil zones, mostly in the southeastern corner of the lease.

In the gently rolling upland area with the low sagebrush and grass vegetation, it is very difficult for the observer to define distance or size. In the moderately rolling to rough broken land where the terrain is steeper, the observer can get more of a feeling of enclosure that enables him to relate to the sizes and distances in the landscape.

At present, few intrusions have been introduced into the general landscape. Fences, roads, windmills, oil wells, storage tanks, pipeline, and utility lines are the major intrusions found in the area. Fences, being normally three or four strand wire on wood and steel posts, are absorbed into the landscape beyond the foreground zone due to the vertical accent

on an otherwise horizontal plane. Utility lines give the same relative effect on the landscape as fences. These intrusions are spaced at intervals that prevent them from being undesirable or discordant in the landscape.

The landscape quality of the lease area is considered to be relatively low when compared to areas of rugged, dissected, and colorful mountains with much variety in form, line, color, and texture. However, on the microscale one can find much variety in plants, insects, wildlife, and soils from one area of the lease to another. The element of water in the intermittent streams and the Reno Reservoir give additional interest and quality to this lease area.

Wildlife and Fish

The lease area is habitat for a wide variety of wildlife. A list of known animals is shown on Tables 29 to 32, Appendix C.

Big game

Mule deer

This is a fringe area for mule deer and not a critical habitat except for the few that have moved in from the main herd in the Rochelle Hills to the east. They stay close to cover and are usually found in brushy bottoms along streams and in nearby rough land. Most are in the Little Thunder Creek and the North Prong drainages.

Deer tend to remain yearlong in the same area, but move short distances when snow covers the food supply. Some move back into the ponderosa pine hills to the east for part of the winter.

Most of their water and forage requirements are met in the drainage bottoms. Grasses and forbs are available during the spring and summer and sagebrush is available in the drainage bottoms or on nearby uplands. A high percentage of the spring diet is made up of grasses, especially bluegrasses, sixweeks fescue, and cheatgrass, because they are the first plants to start growing. Grazing of forbs by deer reaches a peak in summer and decreases as the plants become unpalatable or unavailable. Then the deer begin to eat shrubs, mainly sagebrush.

Deer food habits conflict with livestock. Competition with livestock occurs in spring and summer when both types of animals graze succulent forage in the creek bottoms. Deer move from place to place to avoid livestock concentrations. Coyotes, bobcats, and eagles are predators on the deer.

The lease is in the Wyoming Game and Fish Department's Deer Management Area 21. For the last few years, deer hunting has been for either sex. The 1973 hunting season was October 1 to 21. Most deer are taken as a sideline to antelope hunting.

Pronghorn antelope

Approximately 50 to 65 antelope inhabit the lease during different seasons of the year. Their numbers have been increasing slightly. There is some use of forbs such as cushion eriogonum and rockcress. The few crested wheat fields on the lease area are used in early spring. Antelope begin to eat Douglas rabbitbrush in late spring and early summer before going back to sagebrush which provides the bulk of their diet. Big sagebrush is a crucial species for them but may be less important in this area where snowfall is light and does not remain on the ground long.

Suitable habitat is generally available throughout the lease area. There is cover for young fawns and for adults during severe storms. Much of the sagebrush is short, so antelope must go elsewhere to eat when snow cover remains for more than a week. Lack of water in outlying areas causes some winter concentration of the animals along Little Thunder Creek.

Antelope have adapted to domestic grazing and fencing patterns. They share range with both cattle and sheep. Competition for forage between antelope and sheep is not significant when sagebrush is available. The greatest competition for feed is in the spring when cattle, sheep, antelope, and other grazing animals eat the bluegrasses. Sheep use sagebrush from late fall through the winter, so there is some conflict when they are with antelope on winter range.

The A.R.Co. lease is in the south end of State Antelope Management Area 24 which covers the southeast corner of Campbell County, south of Gillette (Highway 16) and east of Highway 59. In 1971 and 1972, 750 hunting permits were issued in Area 24 for 20 to 30 days of October. In 1973, the season was October 1 to 21 and the number of permits was increased to 900.

Elk

Twelve elk were released in the hills east of this area in 1969. They spread out and have increased in number to about 45. These elk use the lease area sometimes but are not full-time residents on the lease.

Other mammals

Predators

Bobcats are solitary animals and are normally less plentiful than foxes and coyotes; however, their numbers are increasing. Rough topography of the land on the lease provides cover. Bobcats usually feed on small mammals or birds. They may eat young antelope, deer, lambs, and calves and have been known to attack adult animals.

As predators, bobcats usually do not receive quite as much attention as coyotes. They have been trapped recently for their fur. Pelts sold for an average of $85.00 or more (1973).

The coyote is of economic significance as a predator and a fur-bearer. An estimate of the coyote population is not available, but the animals are considered increasing in numbers which is causing the livestock operators some concern.

Coyotes are very adaptable and consume a wide variety of feeds, from vegetation, to small mammals to occasionally big game animals and

livestock. Reports of livestock losses indicate coyotes are more numerous because of the 1972 ban on the use of toxicants for predator control. There is also a possibility that the increase is caused, in part, by an increase in rabbit populations. Control methods include trapping and shooting from the ground or from aircraft. Prices (1973) of up to $70.00 for pelts have encouraged control efforts.

The red fox seems to be increasing. Its main food items are small mammals and birds. Foxes have not been controlled as predators. Recently, fur prices have risen causing an increase in trapping. Fox pelts sold for up to $35.00.

Furbearers

Other furbearers on the lease include the long-tailed weasel, badger, skunk, and the raccoon. Badgers feed on burrowing rodents and on many other small animals, including ground nesting birds and their eggs. Weasels eat many of the same animals. Striped skunks feed on insects, fruits, mice, and other small rodents, also carrion if necessary. The spotted skunk eats insects, small rodents, lizards, salamanders, and snakes. Raccoons usually prefer a moist habitat with trees, such as along Little Thunder Creek. Their food includes crayfish, insects, grubs, roots, eggs, mice, fruit, and grain. All of these small furbearing predators are trapped on the lease for their fur, but most are taken while trapping for the more valuable furbearers.

Upland gamebirds

The only upland game bird known to be on the lease is the sage grouse. Its population is about 50. Its summer range is along Little Thunder Creek, North Prong, and around outlying small reservoirs where

succulent vegetation, insects, and water are available for broods. The area north and south of Little Thunder provides sagebrush essential for food and cover the rest of the year. Strutting grounds on the lease area have not been identified and documented. Sage grouse management during the last few years has been directed toward opportunities for habitat improvement and a limited harvest. In 1973, the season was September 15 to 18.

Waterfowl

The 57-acre Reno Reservoir and smaller stockwater reservoirs scattered across the lease area provide a resting place for several species of waterfowl during migration. They include Canada geese, mallards, pintails, gadwalls, widgeons, teal, goldeneyes, mergansers, and coots.

An estimated 8 to 10 pairs of ducks summer in the vicinity of Reno Reservoir, and a few more pairs nest in other suitable locations. They include mallards, teal, and gadwalls. All are puddle ducks and primarily vegetarians. They travel long distances to grain fields in the fall. Canada geese were introduced on Little Thunder Reservoir in 1973 as the beginning of a resident flock. Ducks are providing an increased amount of hunting since they are available during the season.

Other birds

Raptors

Raptors found on the lease include the turkey vulture, marsh hawk, red-tailed hawk, Swainson's hawk, ferruginous rough-leg, golden eagle, bald eagle, and the sparrow hawk. Their habits are discussed in Chapter IV, Part I.

Shore birds

There are several shore birds associated with the small reservoirs, but little is known about them. The killdeer is common around the reservoirs and meadows and along streams. Snipes, gulls, the American avocet, the Wilson's phalarope, and the longbilled curlew may be found around the water holes.

Fish

The Reno Reservoir provides a warm water fishery of bass, bluegills, and bullheads. Fishing and other recreational use is increasing.

Reptiles and amphibians

Little is known about reptiles and amphibians, another animal group living on this area.

The Tiger salamander, chorus frog, and leopard frog frequent the playas, reservoir, and wet drainage bottoms. The great plains toad, lesser earless lizard, and short-horn lizard are present on the lease. The prairie rattlesnake and western terrestrial garter snake are common.

Threatened species

No threatened species have been reported as indigenous to the lease area.

Recreation

Recreation can best be described as people doing things for their physical or psychological well being. There are few activities that occur on this lease area that serve these needs.

Zoological

Fishing in the Reno Reservoir is probably the most active recreation present with approximately 100 visitor days of use per year estimated for this activity.

Hunting antelope, deer, cottontail, jackrabbits, sage grouse, and waterfowl is the second most participated in activity with an estimated total 75 visitor days use per year.

Other

Other activities such as sightseeing, artifact hunting, photography, and picnicking probably occur on the lease area in amounts of one to 20 visitor days per year.

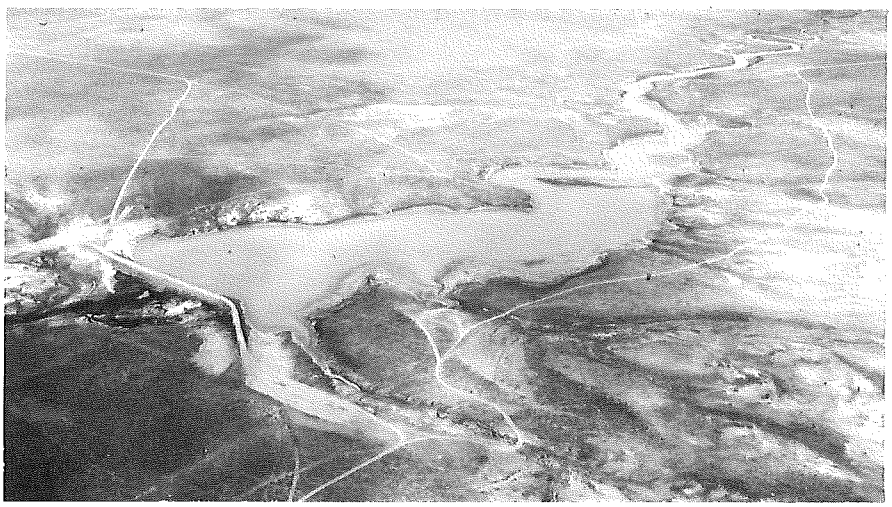


Figure 10
Reno Reservoir

Agriculture

Livestock grazing

Cattle ranching is the most important agricultural activity in this area. Dryland crop production is interspersed with grazing in the general area but not on the lease area. Some dryland farming was tried on the lease area but was unsuccessful and abandoned in favor of native grass under natural conditions.

Surface mining on a 160-acre tract of the lease will affect the Stuart Brothers' ranch. The 160 acres are located in a summer pasture. Under the proposed mining plan, this area will not be disturbed until after the year 1990. Approximately 40 AUMs will be affected in section 17, T34N, R70W.

The Reno Livestock Company uses the remaining area in the lease (private, state, and federal lands) for grazing. Four pastures will be affected by the mining. Pasture #1 is a calving pasture which will be completely disrupted during the course of mining. It consists of 3,040 acres supporting 760 AUMs. In pasture #2 there are approximately 1,880 acres at the west end supporting 470 AUMs which will be disrupted. Pasture #3 is a lambing and winter pasture where approximately 960 acres and 240 AUMs will be disturbed. The area is located in the northwest corner of the pasture and is not planned for mining until 1995 or later. Pasture #4 is a large summer pasture where 480 acres and 120 AUMs will be disturbed by mining. A total of approximately 1,630 AUMs will be affected during the mining operations.

Facilities associated with grazing that will be affected by mining are dams and fences. There are three dams, all on private land:

Big Reno Reservoir	424 acre-feet
2 small reservoirs	(No volume recorded)

Other roads

Woods Petroleum Co. constructed a road through the south end of the Atlantic Richfield lease for access to its producing oil wells.

There are a number of unimproved roads on the lease area that are used by the ranchers to maintain fences and care for livestock. The location of these is not critical to the livestock operation as alternate routes can be used.

Pipelines

The lease area has two oil pipelines that cross the area. Phillips' pipeline crosses sections 16, 17, and 22 which are located near the north end of the lease.

Belle Fourche pipeline crosses sections 16, 17, 21, 27, 28, 34, and 35 of T43N, R70W, and section 2 of T42N, R70W. This pipeline crosses the whole lease area from north to south (Figure 82, Chapter IV, Part I).

Socio-Economic Conditions

The existing conditions of the study area, which include this proposed development, are described in Part I, Chapter IV.