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Documentation Of The
Demonstrated Reserve Base
Of Coal In The United States
(Final Report)
Volume Two

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Prepared by:

Albert J. Herhal
Scott G. Britton
Chris A. Minnucci

Prepared for:

Energy Division
Oak Ridge National Laboratory

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SYNERGIC RESOURCES CORPORATION

ONE BALA-CYNWYD PLAZA, SUITE 630 • BALA-CYNWYD, PA. 19004

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APPENDIX A

EASTERN STATES

- Alabama
- Georgia
- Illinois
- Indiana
- Kentucky, Eastern
- Kentucky, Western
- Maryland
- Michigan
- North Carolina
- Ohio
- Pennsylvania
- Tennessee
- Virginia
- West Virginia

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ALABAMA

The 1979 DRB estimate for Alabama's bituminous coal is based on preliminary data developed under a DOE grant¹ by the Geological Survey of Alabama (GSA). The preliminary data, found in the field office files, consist of 9 sets of handwritten tables, which present the original resources, remaining resources (as of January 1978), and the 1978 DRB estimates for the Warrior, Plateau and Cahaba field. In the 3 sets of tables presenting the 1978 DRB estimates (one for each coal field), the estimates are broken down by county, bed, reliability category (measured and indicated) bed thickness category (14'-28", 28"-42", and >42"), and potential mining method (strip, covering the coal under 120' of overburden and less, and underground, covering the coal in the 120'-1000' depth range).² At the end of each table the total strippable and underground DRB estimate for each field is given. These totals could not be used in the development of the 1979 DRB, however, because summation errors had been made, and because GSA had included 14"-28" coal in the 120'-1000' depth category in their estimates. To calculate the January 1978 DRB using EIA's standards, the data presented in the 3 sets of remaining resources tables were keypunched and entered into the computer. State total DRB estimates for surface and underground mining, excluding the 14"-28" underground resources, were calculated. The estimates included strippable coal (0-120' overburden depth) >14" thick in the measured and indicated categories, and underground coal (120'-1000' overburden depth) >28"

¹Geological Survey of Alabama, Preliminary-Reserve Base of Bituminous Coal and Lignite in Alabama, U.S. Bureau of Mines Grant Agreement G177080, later administered by U.S. Department of Energy 1980.

²In addition, resources in the 1000'-2000' depth category were broken out separately for some bed/county combinations.

thick in the measured and indicated categories. Also, measured and indicated resources of the Mary Lee bed in Jefferson and Tuscaloosa Counties, and the Pratt bed in Tuscaloosa County, >42" thick and at depths of 1000-2000' (and 2000'-3000' for the Mary Lee bed in Tuscaloosa County) were included in the computer-calculated DRB estimates because this coal is currently being mined. Finally, 5.23 million tons of underground resources and 3.2 million tons of surface resources in the Coosa coal field (which was not included in the GSA study) were included in the DRB estimates.³ The Coosa coal field estimates are discussed in the following paragraph.

The Coosa coal field estimates are based on W. C. Culbertson's Geology of the Coal-Bearing Rocks of Alabama,⁴ with additional information from H. E. Rothrock's Geology and Coal Resources of the Northeast Part of the Coosa Coal Field, St. Clair County, Alabama.⁵ Table 9 in the Culbertson report (see Exhibit 1) presents reserve estimates by county, bed, reliability category (measured and indicated, and inferred), overburden depth (0-1000', 1000'-2000', 2000'-3000'), and bed thickness (14"-28", 28"-42", >42"). The Rothrock report pre-

³In SRC's review of the Alabama file, an attempt was made to duplicate the DRB estimates presented on DOE's computer printouts using GSA's handwritten DRB tables. All resources meeting EIA's DRB criteria were obtained from the GSA tables and summed. For strippable coal, the result of this calculation matched the computer estimate of 1,993.28 million tons. SRC's underground estimate exceeded the computer estimate of 3,711.26 million tons by 8.43 million tons.

⁴Culbertson, W. C., Geology of the Coal-Bearing Rocks of Alabama, U.S. Geological Survey Bulletin 1182-B, 1964.

⁵Rothrock, H. E., Geology and Coal Resources of the Northeast Part of the Coosa Coal Field, St. Clair County, Alabama, Geological Survey of Alabama Bulletin 61, 1949.

Exhibit 1

ESTIMATED REMAINING RESERVES OF COAL IN THE COOSA FIELD,

ALABAMA, AS OF JANUARY 1, 1958, BY COUNTY AND BED

(Rank is High-Volatile A Bituminous and Medium-Volatile Bituminous)

Coal bed	Overburden (feet)	Reserves, in millions of short tons, for thickness of beds, in inches as shown											Grand total
		Measured and indicated				Inferred				Total all categories			
		14-28	28-42	>42	Total	14-28	28-42	>42	Total	14-28	28-42	>42	
St. Clair County ¹													
Hammond.....	D-1,000					0.4			0.4		0.4		0.4
Coal City.....	D-1,000	0.6	0.2		0.8		0.5		.5	0.6	.2	0.5	1.3
Broken Arrow.....	D-1,000	1.0	.8		1.8					1.0	.8		1.8
Marion.....	D-1,000	2.9			2.9	3.0			3.0	3.9			6.9
Garr.....	D-1,000	1.7			1.7					1.7			1.7
Fairview.....	D-1,000	13.5	.6		14.1	1.9			1.9	15.4	.6		16.0
	1,000-2,000		1.0		1.0	1.6			1.6	1.6	1.0		2.6
Total, Fairview.....		13.5	1.6		15.1	3.5			3.5	17.0	1.6		18.6
Upper Chapman.....	D-1,000	1.1			1.1					1.1			1.1
Total, all beds.....	D-1,000	20.8	1.8		22.4	4.9	.4	.5	5.8	25.7	2.0	.5	28.2
	1,000-2,000		1.0		1.0	1.6			1.6	1.6	1.0		2.6
Grand total.....		20.8	2.8		23.4	6.5	0.4	.5	7.4	27.3	3.0	.5	30.8
Shelby County													
Martin.....	D-1,000		1.2	3.0	4.2					1.2	3.0		4.2
	1,000-2,000					1.0	2.7		3.7	1.0	2.7		5.7
	2,000-3,000					.7	2.0		2.7	.7	2.0		2.7
Total.....			1.2	3.0	4.2	1.7	4.7		6.4	2.9	7.7		10.6

¹All reserve figures for St. Clair County are derived from the reserve figures by Rothrock (1949, p. 88-89).

sents reserves by bed thickness (14"-20" and >20") bed, coal basin, and reliability category (measured, indicated, inferred). Exhibit 2 presents the reserves summary tables from the Rothrock report. The Alabama Methodology as presented in the 1979 DRB states that "Between the two reports, the proper thickness and reliability categories for the various coal beds were determined. The reports do not give strippable reserves. EIA developed an estimate of the strippable portion based on core log data in Rothrock." Unfortunately, the methodology employed for assigning the reserves to thickness, reliability and mining method categories could not be determined, because calculation sheets for the Coosa field could not be obtained. It is not clear how the Coosa field bed/county estimates entered into the computer were derived from Exhibits 1 and 2. For example, for the Coal City seam/St. Clair County combination, estimates of 0.08 million tons of underground coal and 1.16 million tons of surface coal were entered into the computer. Referring to Exhibits 1 and 2, it is clear that a portion of the Exhibit 1 14"-28" measured and indicated Coal City reserves was included as strippable coal, but without the Rothrock core log data and additional calculation sheets, the methodology employed to determine the portion taken cannot be determined.⁶

⁶Depletion of the Coosa field reserves (from 1/1/58, the date of the Culbertson data, to present) was set equal to zero. According to the Alabama Methodology, GSA personnel indicated that there had "not been any significant mining activity in the Coosa field since the date of the Culbertson report.

Exhibit 2-A

RESERVES OF COAL IN PLACE IN COAL BEDS 20 INCHES OR MORE THICK

Name and Location of of Bed	Measured			Indicated			Inferred			Total in Each Bed		
	Average Thickness (Inches)	Area (Acres)	Reserves (Short Tons)	Average Thickness (Inches)	Area (Acres)	Reserves (Short Tons)	Average Thickness (Inches)	Area (Acres)	Reserves (Short Tons)	Average Thickness (Inches)	Area (Acres)	Reserves (Short Tons)
Fairview Bed												
Fairview Basin	28	3,307	13,430,000*	-	-	-	26	262	990,000	28	3,569	14,420,000
Coal City Basin	-	-	-	32	205	947,000	-	-	-	32	205	947,000
Hammond Bed												
Coal City Basin	-	-	-	-	-	-	36	77	400,000	36	77	400,000
Coal City Bed												
Coal City Basin	37	32	170,000	26	167	630,000	46	75	500,000	35	274	1,300,000
Broken Arrow Bed												
Coal City Basin	-	-	-	27	324	1,270,000	-	-	-	27	324	1,270,000
Marion Bed												
Coal City Basin	21	206	620,000	-	-	-	21	146	440,000	21	352	1,060,000
Coal of Each Class of Reserves												
	28	3,545	14,220,000	28	696	2,847,000	29	560	2,330,000	-	-	-
Grand Total										28	4,801	19,397,000

*Area of Fairview coal believed to offer the best possibility for future development.

Exhibit 2-B

RESERVES OF COAL IN PLACE IN COAL BEDS RANGING FROM 14 TO 19 INCHES IN THICKNESS

A-6

Name and Location of of Bed	Measured			Indicated			Inferred			Total in Each Bed		
	Average Thickness (Inches)	Area (Acres)	Reserves (Short Tons)	Average Thickness (Inches)	Area (Acres)	Reserves (Short Tons)	Average Thickness (Inches)	Area (Acres)	Reserves (Short Tons)	Average Thickness (Inches)	Area (Acres)	Reserves (Short Tons)
Fairview Bed												
Coal City Basin	-	-	-	16	271	624,000	16	1,098	2,559,000	16	1,369	3,183,000
Broken Arrow Bed												
Fairview Basin	14	80	120,000	-	-	-	-	-	-	14	80	120,000
Coal City Basin	-	-	-	16	176	410,000	-	-	-	16	176	410,000
Marion Bed												
Fairview Basin	15	398	860,000	17	499	1,230,000	-	-	-	16	897	2,090,000
Coal City Basin	19	77	210,000	-	-	-	17	1,020	2,510,000	17	1,097	2,720,000
Fairview Bed												
Fairview Basin	14	626	1,270,000	14	190	390,000	-	-	-	14	816	1,660,000
Chapman Bed												
Fairview Basin	-	-	-	16	479	1,140,000	-	-	-	16	479	1,140,000
Coal of Each	15	1,181	2,460,000	16	1,615	3,794,000	16	2,118	5,069,000	-	-	-
Total										16	4,914	11,323,000

The state total estimates from DOE's computer printout represent the DRB estimates as of January 1978. Exhibit 3 presents the data contained in the depletion summary sheet found in the field office files. The source of these data was the DOE computer printout, and depletion factors of 2 for underground production and 1.25 for surface production were employed. Applying the 1978 depletion estimates to the January 1978 DRB estimates, the following results are obtained:

Surface:

1993.28 million tons 1978 DRB
- 16.22 depletion
1977.06 million tons calculated 1979 DRB, as compared with
1977.10 published 1979 DRB

Underground:

3711.26 million tons 1978 DRB
- 11.30 depletion
3699.96 million tons calculated 1979 DRB, as compared with
3699.74 published 1979 DRB

The small discrepancies could be due to the fact that more than one computer printout was developed for Alabama, and the printout found in the field office files may include revisions to the printout used in developing the 1979 DRB estimates.

The 1979 lignite reserve estimate is based on January 1971 remaining resource data developed in August 1973, by Reynold Q. Shotts. His data, identify strippable resources by county, reliability category (measured, indicated and inferred) and bed thickness category (2.5'-5', 5'-10', and >10'). To determine the 1979 DRB, the resources in the 2.5'-5', 5'-10' and >10', measured and indicated categories were summed across all counties to yield the state total January 1971 remaining (1,083 million tons) resources. EIA coal data systems show that no lignite was produced in Alabama between 1971 and 1979, and thus the January 1971 remaining resource estimate of 1,083

Exhibit 3

ALABAMA PRODUCTION

Year	<u>Underground</u>					<u>Surface</u>				
	<u>>14"</u>	<u>14"-28"</u>	<u>28"-42"</u>	<u>>42"</u>	<u>Total</u>	<u>>14"</u>	<u>14"-28"</u>	<u>28"-42"</u>	<u>>42"</u>	<u>Total</u>
1978	0	0.520	1.857	3.792	6.169	1.409	8.219	3.562	1.194	14.384

Underground:

Depletion <14" = 12.34

Depletion >28" = 11.30

Surface:

Depletion <14" = 1.76

Depletion >14" = 16.22

million tons was published as the 1979 (strippable) lignite DRB estimate. It should be noted that the overburden depth range of the lignite resources is not known.

As would be expected, the bituminous surface and underground DRB estimates cannot be derived by depleting the 1976 or 1971 estimates, which were based on sources other than the GSA data. In 1976 the underground estimate was 1975.5 million tons less than the 1979 estimate, and the 1976 surface estimate was 1,692.7 million tons less than the 1979 estimate. The 1971 surface and underground estimates are also less than the 1979 estimates (by 1,902 million tons for underground, and 1,820 million tons for surface). The 1976 published lignite estimate matches the 1,083-million-ton 1979 estimate, but the 1971 estimate is 56 million tons less.

GEORGIA

The 1979 DRB for Georgia was derived from two principal sources. The first source, Johnson (1949),⁶ covered the reserves of Dade and Walker Counties, while the second source, the Georgia Department of Natural Resources,⁷ identified the reserves of Chattooga County.

The Johnson report covered the six beds of Dade and Walker Counties. All coal estimates were considered to be in the "measured and indicated" category, and lie mainly in two fields - the Sand Mountain and Lookout Mountain coal fields. Table 1 summarizes the coal reserves identified by Johnson.

Since Johnson reported the Dade and Walker County reserves in thickness categories of less than 17", 17 to 24 inches, and greater than 24 inches, it was necessary to redistribute the reserves by appropriate thickness. These were graphically redistributed into 14"-28", 28'-42", and greater than 42" categories, as illustrated by Exhibit 1.

The Johnson report estimated reserves of some 23.8 million short tons, as broken out by the calculations sheets of Exhibit 2. Based on the strict interpretation of DRB criteria, 3.16 million tons can be identified as a demonstrated reserve base for 1/1/46. However,

⁶Johnson, V. H., Coal Deposits on Land and Lookout Mountains, Dade and Walker Counties, Georgia, Preliminary Coal Inventory Map published by the U.S. Geological Survey, 1946. Reprinted 1959.

⁷Georgia Department of Natural Resources, Surface Mined Land Reclamation Program Report, 1978.

Table 1

COAL RESERVES OF DADE AND WALKER COUNTIES

Bed	Estimated Reserves					
	Thicker Than Two Feet		Thicker Than Seventeen Inches		Total	
	Tons	Average Height	Tons	Average Height	Tons	Average Height
Lookout Mountain	300,000	2.2 ft.	500,000	1.5 ft.	1,000,000	1.3 ft.
Durham	500,000	3.3 ft.	500,000	3.2 ft.	*	*
Number 4 Bed	1,500,000	2.3 ft.	2,900,000	1.7 ft.	10,000,000	1.5 ft.
Sand Mountain	840,000	2.3 ft.	2,700,000	1.8 ft.	12,000,000	1.4 ft.
Number 8 Bed	50,000	2.2 ft.	100,000	1.6 ft.	*	*
Number 9 Bed	50,000	3.0 ft.	100,000	2.0 ft.	200,000	*

*No estimates provided.

Source: Johnson, USGS Report 1959.

Exhibit 1

A-Seam

Seam Thickness

0-17"	17"-24"	24-30" max
.50	.20	.30
50%	70%	100%

41%	< 14"
48%	14"-28"

Exhibit 1
(Continued)

NO.4 - Seam

Seam Thickness

0-17"	17"-24"	24"-40" max	50%	< 14"
7.1	1.40	1.50	30.5%	14"-28"
71%	85%	100%	11.5%	28"-42"

to arrive at the January 1979 DRB, 3.33 million tons were taken from the Johnson report. Therefore, some 14"-28" underground reserves⁸ may have been added to the reported DRB.

To break the Johnson estimates into separate county totals required splitting only the Lookout Mountain reserves between counties. Based on maps contained in the Johnson report, a 70/30 split between Walker and Dade Counties, respectively, was made by planimetering the seams.

Johnson did not break out a strippable reserve for Walker or Dade Counties. Therefore, a conservative estimate of 10 percent was made on a bed-by-bed basis. Exhibit 2 shows the worksheets for Walker and Dade Counties, which outline the strippable reserves as a component of the total reserve, at a thickness greater than 14 inches.

Walker and Dade County estimates were depleted to January 1979 by using the production data from the BOM Yearbooks and EIA reports.

The production and depletion can be summarized as the following:

<u>Year</u>	<u>Production</u>		<u>Depletion</u>		<u>Total</u>
	<u>Underground</u>	<u>Surface</u>	<u>Underground</u>	<u>Surface</u>	
1947-1974	0.212	0.125	0.423	0.157	0.580

This can also be seen in Exhibit 2 for each county.

⁸Although there is little evidence to suggest which 14"-28" underground reserves were added, it appears the "A" seam and Durham #3 in Dade County were used for a total of 0.16 million tons. The 0.01 could have been a rounding error.

Exhibit 2

COAL RESERVES OF WALKER AND DADE COUNTIES

	Measured and Indicated as of 1/1/46						Measured and Indicated as of 1/1/79				
County/Coal Bed	14"	14-28"	28-42"	>42"	Total	Depletion	14'	14-28'	28-42'	>42'	Total
Walker County											
"A" No. 1 Seam											
0-1000 foot	0.29	0.34	0.08	0.00	0.71	0.26	0.27	0.16	0.00	0.00	0.45
Strip	0.03	0.03	0.01	0.00	0.07	0.06	0.03	0.00	0.00	0.00	0.03
Underground	0.26	0.31	0.07	0.00	0.64	0.20	0.26	0.16	0.00	0.00	0.42
Durham #3											
0-1000 foot	0.00	0.07	0.25	0.04	0.36	0.26	0.00	0.04	0.02	0.04	0.10
Strip	0.00	0.01	0.03	0.00	0.04	0.06	0.00	0.00	0.00	0.00	0.00
Underground	0.00	0.06	0.22	0.04	0.32	0.20	0.00	0.04	0.02	0.04	0.10
Durham #4											
0-1000 fbot	4.08	2.14	0.81	0.00	7.03	0.00	4.08	2.14	0.81	0.00	7.03
Strip	0.41	0.21	0.08	0.00	0.70	0.00	0.41	0.21	0.08	0.00	0.70
Underground	3.67	1.93	0.73	0.00	6.33	0.00	3.67	1.93	0.73	0.00	6.33
Dade County											
"A" No. 1 Seam											
0-1000 foot	0.12	0.14	0.03	0.00	0.29	0.00	0.12	0.14	0.03	0.00	0.29
Strip	0.01	0.01	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.02
Underground	0.11	0.13	0.03	0.00	0.27	0.00	0.11	0.13	0.03	0.00	0.27

Exhibit 2

(Continued)

		Measured and Indicated as of 1/1/46					Measured and Indicated as of 1/1/79					
County/Coal Bed		14"	14-28"	28-42"	>42"	Total	Depletion	14'	14-28'	28-42'	>42'	Total
Dade County												
Durham #3												
0-1000 foot		0.00	0.03	0.10	0.01	0.14	0.00	0.00	0.03	0.10	0.01	0.14
Strip		0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01
Underground		0.00	0.03	0.09	0.01	0.13	0.00	0.00	0.03	0.09	0.01	0.13
A-16	Durham #4											
	0-1000 foot	1.72	0.91	0.34	0.00	2.97	0.00	1.72	0.91	0.34	0.00	2.97
	Strip	0.17	0.09	0.03	0.00	0.29	0.00	0.17	0.09	0.03	0.00	0.29
	Underground	1.55	0.82	0.31	0.00	2.68	0.00	1.55	0.82	0.31	0.00	2.68
Number 8 Seam												
0-1000 foot		7.63	3.75	0.48	0.24	12.10	0.06	7.63	3.71	0.46	0.24	12.04
Strip		0.76	0.38	0.05	0.02	1.21	0.04	0.76	0.34	0.05	0.02	1.17
Underground		6.87	3.37	0.43	0.22	10.89	0.02	6.87	3.37	0.41	0.22	10.87
Number 9 Seam												
0-1000 foot		0.09	0.07	0.01	0.03	0.20	0.00	0.09	0.07	0.01	0.03	0.20
Strip		0.01	0.01	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.02
Underground		0.08	0.06	0.01	0.03	0.18	0.00	0.08	0.06	0.01	0.03	0.18

A-16

Exhibit 2

(Continued)

Measured and Indicated as of 1/1/46							Measured and Indicated as of 1/1/79					
County/Coal Bed	14"	14-28"	28-42"	>42"	Total	Depletion	14'	14-28'	28-42'	>42'	Total	
Dade County												
Durham #3												
0-1000 foot	0.00	0.03	0.10	0.01	0.14	0.00	0.00	0.03	0.10	0.01	0.14	
Strip	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	
Underground	0.00	0.03	0.09	0.01	0.13	0.00	0.00	0.03	0.09	0.01	0.13	
A-17	Durham #4											
	0-1000 foot	1.72	0.91	0.34	0.00	2.97	0.00	1.72	0.91	0.34	0.00	2.97
	Strip	0.17	0.09	0.03	0.00	0.29	0.00	0.17	0.09	0.03	0.00	0.29
	Underground	1.55	0.82	0.31	0.00	2.68	0.00	1.55	0.82	0.31	0.00	2.68
Number 8 Seam												
0-1000 foot	7.63	3.75	0.48	0.24	12.10	0.06	7.63	3.71	0.46	0.24	12.04	
Strip	0.76	0.38	0.05	0.02	1.21	0.04	0.76	0.34	0.05	0.02	1.17	
Underground	6.87	3.37	0.43	0.22	10.89	0.02	6.87	3.37	0.41	0.22	10.87	
Number 9 Seam												
0-1000 foot	0.09	0.07	0.01	0.03	0.20	0.00	0.09	0.07	0.01	0.03	0.20	
Strip	0.01	0.01	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.02	
Underground	0.08	0.06	0.01	0.03	0.18	0.00	0.08	0.06	0.01	0.03	0.18	

A-17

The January 1979 reserve base for Chattooga County is based on a 1978 report by the Georgia Department of Natural Resources. This report identified 855 acres, or 1.795 million tons of strippable coal, averaging 14". This was considered the measured and indicated reserve for the county (Exhibit 3). This reserve was in turn split in two to reflect a judgement in the thickness of the reserves. One-half of the total reserves was considered greater than 14" thick, and one-half considered less than 14" thick. Therefore, 0.900 million tons was estimated as the reserve base for the DRB.

Production for Chattooga County in 1978 from EIA reports amounted to 88,961 tons,⁹ with a total depletion of 0.111 million tons respectively. However, because all production was from beds less than 14", no depletion was necessary.

The January 1979 DRB, therefore, can be derived by the following methodology:

3.330	(Walker and Dade Counties - Johnson)
-0.580	(Depletion to 1979 of Walker and Dade)
<u>+0.900</u>	(Chattooga reserves - 1978)
3.650	

⁹It is shown as 89,000 tons for 1978 in the BOM Yearbook.

Exhibit 3

COAL PERMITS FOR CHATTOOGA COUNTY

<u>Operator</u>	<u>Permit Number</u>	<u>County</u>	<u>Acres Remaining to Reclaim</u>
Inoyle Construction Co. P. O. Box 2454 Jasper, Alabama 35501	581	Chattooga	47
Lookout Mountain Coal Company P. O. Box 703 Franklin, Tennessee 37064 (615) 794-8890	477	Chattooga	715
Mineral Extractors, Inc. East Main Street Crossville, Alabama 35962 (205) 528-7700	562	Chattooga	23
MorCoal, Inc. P. O. Box 43 Menlo, Georgia 30731 (404) 862-2600	508	Chattooga	15
Summit Mining Company 3287 South Perry Montgomery, Alabama 36105 (205) 634-4569	506	Chattooga	55
Total			855

ILLINOIS

The Illinois 1979 underground DRB estimate can be derived by depleting the 1971 estimate, as follows:

53,442 million tons 1971 DRB
<u>-484 depletion¹⁰</u>
52,958 million tons calculated 1979 DRB, as compared with
52,958 published 1979 DRB

The 1979 surface DRB estimate, however, cannot be derived by depleting the 1971 estimate. In 1971, the surface estimate was 12,223 million tons, 2,524 million tons less than the 1979 estimate.

Both the surface and underground 1979 estimates can be derived by depleting the 1976 estimates, as follows:

Surface:

14,841.2 million tons 1976 DRB
<u>- 93.7 depletion</u>
14,747.5 million tons calculated 1979 DRB, as compared with
14,747.4 published 1979 DRB

Underground:

53,128.1 million tons 1976 DRB
<u>- 170.5 depletion</u>
52,957.6 million tons calculated 1979 DRB, as compared with
52,957.6 published 1979 DRB

¹⁰ Depletion is based on production data obtained from the BOM Minerals' Yearbooks (1971-1975) and the EIA annual reports (1976-1978). Cumulative surface production was multiplied by a depletion factor of 1.25, and cumulative underground production was multiplied by a depletion factor of 2.00.

The 1979 DRB is based primarily on bed/county-level data obtained from Cady's Mineable Coal Resources of Illinois¹¹ report. Additional data from Illinois State Geological Survey (ISGS) Circulars¹² were

¹¹Cady, G. H., Mineable Coal Resources of Illinois: Illinois State Geological Survey Bulletin 78, 1952.

¹²Clegg, K. E., Surface Geology and Coal Resources of the Pennsylvanian System, Sangamon, Macon, Menard and parts of Christian and Logan Counties, Illinois State Geological Survey Circular 312, 1961.

Clegg, K. E., Surface Geology and Coal Resources of the Pennsylvanian System in Clark and Edgar Counties, Illinois, Illinois State Geological Survey Circular 380, 1965.

Hopkins, M. E., Harrisburg (Number 5) Coal Reserves of Southeastern Illinois, Illinois State Geological Survey Circular 431, 1968.

Reinersten, D. L., Strippable Coal Reserves of Illinois, Part 4, Adams, Brown, Calhoun, Hancock, McDonough, Pike, Schuyler and the southern parts of Henderson and Warren Counties, Illinois State Geological Survey Circular 374, 1964.

Searight, T. K., and Smith, W. H., Strippable Coal Reserves of Illinois, Part 5B, Mercer, Rock Island, Warren and parts of Henderson and Henry Counties, Illinois State Geological Survey Circular 439, 1969.

Smith, W. H., Strippable Coal Reserves of Illinois, Part 1, Gallatin, Hardin, Johnson, Pipe, Saline and Williamson Counties, Illinois State Geological Survey Circular 22, 1957.

_____, Strippable Coal Reserves of Illinois, Part 2, Jackson, Monroe, Perry, Randolph and St. Clair Counties, Illinois State Geological Survey Circular 260, 1958.

_____, Strippable Coal Reserves of Illinois, Part 3, Madison, Macoupin, Jersey, Greene, Scott, Morgan and Cass Counties, Illinois State Geological Survey Circular 311, 1961.

_____, Strippable Coal Reserves of Illinois, Part 6, LaSalle, Marshall Counties, Illinois State Geological Survey Circular 419, 1968.

Smith, W. H., and Berggren, D. J., Strippable Coal Reserves of Illinois, Part 5A, Fulton, Henry, Knox, Peoria, Stark, Tazewell and parts of Bureau, Marshall, Mercer and Warren Counties, Illinois State Geological Survey Circular 348, 1963.

used to develop the estimates for some of the counties, as illustrated in the following example.

The Herrin No. 6 seam, in Bureau County, was selected as an example. This bed/county combination, like many in Illinois, contains both surface- and underground-mineable coal. The Cady report does not present reserve estimates by mining method, and hence it was necessary to refer to one of the ISGS Circulars providing strippable reserve estimates. In Table 7 of Circular 348, strippable reserve estimates are presented by bed, township, overburden depth category (0-50', 50'-100', and 100'-150'), reliability category (Class I and Class II) and seam thickness for Bureau, Fulton, Henry, Knox, Marshall, Mercer, Peoria, Stark, Tazewell, and Warren Counties. The Class I and Class II reliability categories are used throughout the ISGS Circulars, and these categories are also used in the Cady report (with Class I broken down into I-A--proved and I-B--probable, and Class II broken down into II-A--strongly indicated, and II-B--weakly indicated). According to the Illinois Methodology, the definitions of these reliability categories are the same throughout the ISGS documents, and the definitions are presented in Cady's report. Although the definitions of I-A and I-B reserves differ from the definitions of measured and indicated reserves (Class I-A and I-B standards allow a maximum of 2 miles between data points, while the maximum allowed under the DRB measured and indicated standards is 3/4 mile), EIA equates the I-A reserves with their measured category, and the I-B reserves with their indicated category, due to the "high level of lateral continuity and consistency of thickness of Illinois coal beds experienced by ISGS investigators". Thus, the Class I reserves from Table 7 of Circular 348 were placed in the measured and indicated categories, while the Class II reserves were placed in the inferred category (EIA equated Class II reserves with their inferred category). Exhibit 1, which is a typed version of the summary sheet¹² of strippable coal reserves developed by the field office for the No. 6 seam/Bureau County combination, shows the breakdown of the reserves by reliability category. Exhibit 1 can be compared with Exhibit 2,

ESTIMATED REMAINING RESERVES OF COAL AS OF
JANUARY 1, 1971 BY COAL - BUREAU COUNTY
(Millions of Tons)

[illegible]

Exhibit 2

A PORTION OF THE FIRST PAGE
OF TABLE 7 FROM CIRCULAR 348

	Class I Reserves at				Class II Reserves at				Total I & II	Blind out (square miles)
	0-50	50-100	100-150	Total	0-50	50-100	100-150	Total		
	BUREAU				COUNTY					
150-62										
48					628	28.090	44.980	73.714	73.714	
54	1.564	19.773	39.244	60.581					60.581	
TOTAL	1.564	19.773	39.244	60.581	628	28.090	44.980	73.714	134.295	
150-72										
48						2.959	22.105	25.064	25.064	
54	353	9.483	2.774	12.610					12.610	
TOTAL	353	9.483	2.774	12.610		2.959	22.105	25.064	37.674	
150-82										
48	762	4.008	11.747	16.517					16.517	
54		464	8.777	9.231					9.231	
TOTAL	762	4.472	20.524	27.746					27.746	
160-62										
54	7.294	14.780	3.349	27.593					27.593	4.74
TOTAL	7.294	14.780	3.349	27.593					27.593	4.74
160-72										
54	8.979	8.053	4.641	19.673					19.673	
TOTAL	8.979	8.053	4.641	19.673					19.673	.17
160-82										
54	8.296	4.507	3.329	16.132					16.132	
TOTAL	8.296	4.507	3.329	16.132					16.132	

a typed version of a portion of the first page of Table 7 from Circular 348, showing the No. 6 Class I and Class II reserves by township. If the No. 6 reserves in Exhibit 2 are summed across all townships, thickness and overburden depth categories, totals of 98.78 million tons of Class II reserves and 163.34 million tons of Class I reserves are obtained. The Class II reserves were taken as the inferred reserves by the field office, as Exhibit 1 indicates, but the Class I reserves were reduced by 2.24 million tons prior to being taken as the measured and indicated reserves in Exhibit 1. The reduction represents surface depletion from July 1, 1959 (which was taken as the date of the remaining reserves presented in Table 7) to January 1971, the basis for all the county summary sheets. The depletion is based on production data from a set of calculation sheets found in the Illinois file entitled, "Annual Production of Coal in Illinois by Counties--BOM Minerals Yearbooks". Spot checking indicates that the production data on the sheets does match production data from the Minerals Yearbooks. But since the Minerals Yearbooks provide production data only on a county level, it is clear that the Yearbooks themselves were not employed.

¹²The field office developed one summary sheet of the total reserves for each county. On this sheet reserves were broken down by bed, reliability category (measured, indicated, inferred and measured and indicated) and thickness category (14"-28", 28"-42", 42"). For those counties with strippable reserves, a separate sheet was developed for the strippable coal. The data on the summary sheets was transcribed onto coding sheets, and then keypunched and entered into a computer.

The Illinois procedure states the following: "All resource data listed in both the Cady report and the subsequent Illinois survey circulars were depleted to January 1, 1971, by tabulating and totaling individual coalbed production from data reported to Bureau of Mines annual survey of coalbed production". Thus, the backup data to the Minerals Yearbooks, rather than the Yearbooks themselves, were used to deplete to January 1971. A surface depletion factor of 1.25 was used to convert the production data to depletion figures.

Exhibit 1 indicates that in addition to breaking reserves down into reliability category, the estimates for each bed/county combination were broken down by the standard thickness categories of 14"-28", 28"-42", and >42". For the No. 6 seam/Bureau County combination, the breakdown was relatively straightforward. Referring to Exhibit 2, it can be seen that the lowest "thickness" for which reserve estimates are made for the No. 6 seam is 48". Thus, all reserve estimates were placed in the 42" category in Exhibit 1. In spot checking other bed/county combinations, it was found that, on the county summary sheets, reserves were grouped in the 14"-28" range whenever the reserves in the appropriate ISGS Circular had a thickness less than 28". When the thickness of the reserves was 28" to 41", the reserves were assigned to the 28"-42" category, and when the thickness cited in the Circular was 42" or greater, the reserves were assigned to the >42" category. The same procedure was employed when the total reserves (from the Cady report) were subdivided according to thickness categories. Apparently this procedure was applied not only to the Cady report, but to the ISGS Circulars as well, to distribute reserves by thickness category.

After developing the summary sheet for the surface reserves, the summary sheet for the total No. 6 seam/Bureau County reserves remained to be developed. Exhibit 3 is a copy of a portion of one of the pages

Exhibit 3

BUREAU COUNTY/NUMBER 6 RESOURCE DATA

FROM PART III OF CADY'S REPORT

RESOURCES BY COUNTY: FOUR CATEGORIES OF RESERVES—(Continued) (In thousands of tons)

Coal bed; Average thickness, inches	I-A Proved	I-B Probable	II-A Strongly indicated	II-B Weakly indicated	Total
BUREAU CO.					
Harrin No. 6					
28	—	—	—	182,957	182,957
35	10,462	21,905	—	—	32,367
42	2,554	7,886	4,747	—	14,987
48	32,507	56,047	—	—	88,554
54	39,545	5,834	1,715	—	44,944
60	33,684	117,755	—	—	151,440
66	18,187	1,541	—	—	19,729
Total, coal bed	136,540	209,019	6,462	182,957	534,978

from Part III (entitled "Tabulated Data") from Cady's report. The Cady reserve estimates for the No. 6 seam/Bureau County combination are presented in this Exhibit. Exhibit 4 presents a copy of the total reserves summary sheet for Bureau County. The total No. 6 seam/Bureau County reserves in Exhibit 3, when estimates are summed across thickness categories, equals 534.98 million tons, as compared with 647.19 million tons from Exhibit 4. The difference is due to the fact that, like the estimates for many other bed/county combinations, the No. 6 seam/Bureau County estimates have been revised by the ISGS since publication of the Cady report. The revisions for each bed/county combination are presented in a set of calculation sheets entitled "ILLINOIS COAL RESERVES - Adjustment of total coal reserves, Bull. 78, based on subsequent work of the Illinois Geological Survey". The Illinois procedure writeup which describes the methodology used in developing the 1979 DRB, confirms that the new information contained in the ILLINOIS COAL RESERVES calculation sheets was indeed "obtained from the I.G.S. to update our report." For the No. 6 seam/Bureau County combination the ILLINOIS COAL RESERVES sheets indicate that the estimate should be increased by 114.45 million tons, which, when the strip depletion of 2.24 million tons is taken into account, is the difference between the summary sheet total reserve estimate and the Cady report estimate. To distribute the total reserves by reliability and thickness categories, the following procedure was followed. First, the percentage of the 534.98 million ton total Cady reserve estimate falling in each reliability and thickness category was calculated from the data presented in Part III of the Cady report. As an example of a percentage calculation, consider the >42", measured category. Exhibit 3 shows the following figures in the I-A,¹³ 42" and greater category:

¹³It should be recalled that the I-A category was equated to the measured category by EIA.

Exhibit 4

ESTIMATED REMAINING RESERVES OF COAL AS OF JANUARY 1, 1971

BY COAL BED - BUREAU COUNTY

(Millions of Tons)

Depth Range 0 to 1,200 Feet, Strip 0 to Feet

A-29	Coal Bed Name	Code Number	Measured			Indicated			Inferred			Measured and Indicated			Total		
			14"-28"	28"-42"	> 42"	14"-28"	28"-42"	> 42"	14"-28"	28"-42"	> 42"	14"-28"	28"-42"	> 42"	14"-28"	28"-42"	> 42"
No. 7 348 (59)	480	0	27.72	15.29	0	100.87	42.42	105.72	61.15	0.00	10.38	60.56	0.00	116.10	250.30	57.71	
No. 6 348 (59)	484	0	7.57	91.28	0	15.86	135.47	0.00	132.45	103.46	0.00	0.00	161.10	0.00	155.88	491.31	
No. 2 78 (50)	496	0	266.55	161.16	0	135.00	30.25	0.00	628.83	0.00	0.00	0.00	0.00	0.00	1,030.38	191.41	

<u>Thickness</u>	<u>Reserves</u> <u>(Thousands of Tons)</u>
42"	2,345
48"	32,507
54"	39,345
60"	33,684
66"	18,187
Total	126,078

The 126.078-million-ton total is 23.57 percent of the 534.98 million ton bed/county total. The 23.57 percent figure appears in the first column of handwritten figures in the right hand margin of the field office's copy of the report.

The calculated percentages were applied to the total underground reserves for the No. 6 seam/Bureau County combination. The underground reserves, equal to 387.31 million tons, were calculated by subtracting the total No. 6 seam/Bureau County strippable reserves (259.88 million tons) from the revised No. 6 seam/Bureau County total reserves of 647.19 million tons. After distributing the underground reserves according to the category percentages, the surface reserves in each thickness/reliability category were added to the underground reserves in each category to yield the total in each category (see Exhibit 4).¹⁴ It should be noted that the reserves in the Cady report, and the revisions to those reserves, apparently include all coal from 0'-1200' in depth. The Illinois Methodology states:

"The amount of resource data falling in the 1000 to 1200-foot depth interval are minor but have not been quantified by EIA, and are included in the 0-1000 foot depth category in Illinois."

¹⁴There was no underground production between 1950 and 1971; if there had been it would have been necessary to deplete the revised Cady underground reserves (a depletion factor of 2.00 would have been used).

The procedure employed in determining and distributing strippable and total reserves for other bed/county combinations was essentially the same as that employed for the No. 6 seam/Bureau County combination. A few remarks should, however, be made regarding the determination of reserves for other combinations. First, in some cases, when the strippable reserves were subtracted from the revised total reserves, no coal was left as underground reserves. In these cases, distributed estimates on the strippable reserve summary sheet were simply carried over to the total reserve summary sheet. For other bed/county combinations, there were no strippable reserves and no revisions to the total reserves; in these cases the distributed reserve estimates presented in Part III of the Cady report could simply be used, without adjustment, on the total reserve summary sheet. When there were no strippable reserves for a bed/county combination, but a revision had been made to Cady's total reserve estimates, the total reserves were distributed to thickness/reliability categories in the same manner that the underground reserve estimate was distributed for the No. 6 seam/Bureau County combinations. Finally, for bed/county combinations where there were no revisions to the total reserves, but where there were strippable reserves, either the total distributed reserve estimates from the Cady report were taken, without adjustment, and carried over to the total reserve summary sheet, or the underground reserve estimate was distributed as per the No. 6 seam/Bureau County methodology, and then the underground and surface reserves in each thickness/reliability category were added to obtain the totals for the total reserve summary sheet; examples of both procedures were discovered.

The format in which the strippable reserve data was presented in Circular 348 was also used in most of the other ISGS Circulars.¹⁵ One exception was Circular 439, in which strippable reserves of the No. 1

¹⁵Thus, strippable reserves consist of coal 150' deep or less.

seam in Mercer, Warren, Henderson, Henry, and Rock Island Counties were presented as a lump sum for each bed/county combination. For these bed/county combinations, strippable reserves were distributed to thickness/reliability categories using the Cady report distributed data and the same procedure employed to distribute underground No. 6 seam/Bureau County reserves.

Two final exceptions to the methodologies presented above were discovered for Edgar County, Nos. 7 and 6 seams. For these 2 bed/county combinations (which do not contain any strippable coal) the Cady total reserve estimates were replaced by estimates from ISGS Circular 380 (lump sum Class I and Class II estimates were presented in this Circular). The Circular 380 estimates were distributed to thickness/reliability categories on the basis of the distributed data in the Cady report (in the usual manner). Finally, it should be noted that other undiscovered bed/county methodologies may have been employed in certain cases. Although our spot checks of bed/county methodologies were fairly extensive, time did not permit a check of every bed/county combination, and so it is possible that other methodologies may have been used. However, it is believed that the methodologies discussed above cover most of the bed/county combinations.

After strippable and total summary sheets, containing January 1971 bed/county reserve data, were developed for each county, the bed/county strippable 14"-28", 28"-42", and >42", measured and indicated reserves were summed across all the sheets, yielding a state total strippable reserve estimate of 15,024.18 million tons. Then, the bed/county total 28"-42" and >42", measured and indicated reserves were summed across all the total reserve summary sheets, and from the result the state total strippable reserves in the same categories were subtracted, yielding a January 1971 state total underground reserve estimate of 53,441.86 million tons. These January 1971 estimates were depleted to January 1979, using (according to the Illinois Methodology) production data "from the U.S. Department of Energy

computer listing."¹⁶ A summary sheet of the depletion calculation, providing cumulative depletion estimates for the period 1971 to 1977, based on (according to a note on the sheet) the "DOE computer printout" was discovered in the Illinois file.¹⁷ Since the 1978 computer printout data were not provided on the sheet, the production from the 1978 EIA annual report was used to supplement the data from the computer printout.¹⁸ The following results were then obtained:

Underground:

53,441.86 million tons 1/1/71 remaining reserves
<u>484.26 depletion</u>
52,957.60 million tons calculated 1979 DRB, as compared with
52,957.60 published DRB

Surface:

15,024.18 million tons 1/1/71 remaining reserves
<u>276.79 depletion</u>
14,747.39 million tons calculated 1979 DRB, as compared with
14,747.39 published DRB.

Exhibit 5 is a flow sheet illustrating the Herrin No. 6/Bureau County methodology, in graphic form.

¹⁶Depletion factors employed were 1.25 for surface mining, and 2.00 for underground mining.

¹⁷The production data on the summary sheet were checked against one version of the DOE printout, and although most of the figures matched, there were a few discrepancies. Since the printout is constantly revised, it is quite possible that the version used to develop the depletion summary sheet differed from the version used to check the summary sheet.

¹⁸The data from the annual reports appear to match the data from the printouts fairly closely, especially for later years.

EXHIBIT 5

HERRIN NO. 6/BUREAU COUNTY METHODOLOGY

(For Exceptions to this Methodology See Text)

INDIANA

The Indiana 1979 DRB includes 8938.89 million tons of bituminous coal amenable to underground mining, and 1682.19 million tons of bituminous coal amenable to surface mining. The surface estimate cannot be derived by depleting the 1971 DRB,¹⁹ but the underground estimate can:

8949 million tons underground DRB
- 10 depletion²⁰
8939 million tons calculated underground DRB, as compared
with
8939 published 1979 DRB

Both the 1979 surface and underground DRB estimates can be derived by depleting the 1976 estimates, with only minor discrepancies:

Underground:

8939.8 million tons 1976 DRB
- 3.0 depletion
8936.8 million tons 1979 calculated DRB, as compared with
8938.9 published DRB.

¹⁹The 1971 DRB surface estimate equaled 1674 million tons, which is eight million tons less than the 1979 estimate (surface depletion during the 1971-78 period exceeded 200 million tons).

²⁰Depletion is based on production data from the BOM Minerals Yearbooks (1971-75), and EIA annual reports (1976-78). Total production from 1971 through 1978 was multiplied by 1.25 for surface mining and 2.00 for underground mining.

Surface:

1774.5 million tons 1976 DRB
- 94.8 depletion²¹
1679.7 million tons 1979 calculated DRB, as compared with
1682.2 published DRB

The 1979 DRB is based on a set of tables developed by EIA, which present remaining reserves as of January 1, 1965, by seam, depth category (either 0-60' and 60', or 0-90' and greater than 90', depending on the seam), and measured, indicated, and inferred reliability categories. There is a separate table for each county, and a summary table that presents the total reserves for each county, broken out by mining method (strippable, corresponding to the 0-60' and 0-90' depth categories, and underground corresponding to the > 60' and > 90' depth categories). This summary table, entitled "Coal Reserves of Indiana - Summary By County", corresponds with Table 6 in Charles E. Weir's report, Coal Resources of Indiana²². Since Table 6 is identical to the "Coal Reserves of Indiana...." summary table, it is believed that the summary table and the county tables maintained by EIA represent backup tables for Weir's report. This view is confirmed by the Indiana Methodology, which states: "The Demonstrated Reserve Base (DRB) for Indiana is based on Weir.... the Indiana Survey furnished the U.S. Bureau of Mines unpublished tables from the Weir report, which reveals the total underground and surface resources for each seam in each county". Thus, the tables found in the files will hereafter be referred to as the Weir tables.

²¹Depletion is based on production data from the BOM Minerals Yearbooks (for the years 1971-75), and the EIA annual reports (1976-78). Total production from 1971 through 1978 was multiplied by 1.25.

²²Weir, C. E., Coal Resources of Indiana, Indiana Geological Survey, Bulletin 42-I, 1973.

The January 1965 total reserves presented in the Weir county tables, for each bed/county combination, were used as the basis of the 1979 DRB. Basically, the January 1965 bed/county surface and underground reserves were depleted to 1971, and then the total and surface reserves were subdivided by reliability²³ (measured, indicated, and inferred) and thickness (14"-28", 28"-42", and > 42") category to yield the bed/county total and surface reserves on which the 1979 DRB is based.

Strippable reserves²⁴ in the 14"-28", 28"-42", and > 42" thickness categories, and measured and indicated reliability categories, were summed across all bed/county combinations to yield a total state reserve estimate as of 1/1/71, which was depleted to derive the 1979 DRB. Total reserves in the 28"-42" and > 42" thickness categories, and measured and indicated reliability categories, were also summed across all county/bed combinations. From the result the total state strippable reserves in the 28"-42" and > 42" measured and indicated categories was subtracted to yield the total 1/1/71 underground reserves. This total was depleted to yield the 1979 DRB. To illustrate the specific procedure and sources employed, an example of a bed/county calculation is presented in the following paragraphs.

The Danville VII seam in Knox County was selected for the example. The Weir Knox County table indicates that the Danville seam contained 73.91 million tons of coal under < 90' of cover, and 1155.277 million tons of coal under a depth of > 90', as of 1/1/65.

²³Although the Weir county tables do subdivide the reserves by measured, indicated, and inferred reliability categories, the Weir subdivision was not used in deriving the DRB. The methodology employed in making the reliability category subdivision is discussed later in this section.

²⁴Strippable coal consists of coal less than 60 feet deep for some seam/county combinations, and less than 90 feet deep for others.

Depletion of the seam from 1965 through 1970 was calculated on the basis of production records (found in the DOE field office files) which present annual production for the 1965-70 period for each mine operating in each county. In the production records, the seam in which each mine is operating, along with the mine type (surface or underground), is indicated. Also, the source(s) of the production data is given for each county. The following sources are cited:

- Indiana Coal Association
- Indiana Geological Survey
- Indiana Bureau of Mines and Mining

In reviewing the Indiana files, the production source documents could not be found, so it could not be confirmed that the sources listed above provided the 1965-70 production data.

Only one mine is listed as having produced coal from the Danville seam in Knox County during the 1965-70 period. This mine produced 216,00 tons during the period, and since it was an underground mine, this cumulative production figure was multiplied by 2.00 to determine depletion of the seam (surface production, in those seam/county combinations in which surface mining was conducted, was multiplied by 1.25 to determine depletion). Thus the 1/1/65 underground reserves (consisting of the coal below > 90 feet of cover) was depleted by 432,000 tons from 1155.277 million tons to 1154.845 million tons. Surface reserves remained at 73.91 million tons. These reserves were then subdivided into coal between 14" to 28" thick, coal between 28" to 42" thick, and coal > 42" thick. The data on which the subdivision was based were obtained from Table 2 of F. D. Spencer's Coal Resources of Indiana,²⁵ which presents reserve estimates broken down by county,

²⁵Spencer, F. D., Coal Resources of Indiana, U.S. Geological Survey Circular 266, 1953.

mining method, reliability category (measured, indicated, inferred, and total), and thickness category (14"-28", 28"-42", and > 42"). To subdivide the coal in Knox County's Danville seam (and for all other bed/county combinations), the total of the measured, indicated, and inferred coal in each thickness category was divided by the total (surface and underground combined) of the measured, indicated, and inferred coal in all thickness categories. The resulting fractions for each thickness category were multiplied by the January 1971 calculated reserves to yield the reserves in each thickness category. Table 1 shows the total reserves in each thickness category presented in Table 2 of the Spencer report, the thickness category fractions calculated on the basis of these data, and the fractions used by EIA to determine the amount of coal to be assigned to each thickness category.²⁶ Applying the calculated fractions to the January 1971 surface and underground reserves, the reserve breakdown presented in Table 2 is obtained. For comparison purposes, the EIA calculated breakdown (obtained from a calculation sheet in the Indiana file) is also presented.

Having subdivided the reserves by thickness category, it remained to subdivide the reserves by reliability category. This was accomplished, for each bed/county combination, with the aid of data

**It is not clear why the calculated fractions and the fractions employed by EIA differ slightly. However, there is no doubt that the EIA fractions are based on the calculated fractions. Calculation sheets found in the Indiana file shows the calculated fractions (along with the calculations used to obtain them) alongside the fractions used to make the reassignment for each county. For most counties, there is a slight difference between the two sets of fractions due to rounding. The Knox County differences are believed to be due to inaccurate rounding.

Table 1

CALCULATION OF THICKNESS CATEGORY FRACTIONS

	14"-28"			28"-42"			> 42"		
	Reserves (Thousand Tons)	Calculated Fraction	Fraction Employed	Reserves (Thousand Tons)	Calculated Fraction	Fraction Employed	Reserves (Thousand Tons)	Calculated Fraction	Fraction Employed
Strippable	17,794	-	-	16,818	-	-	49,924	-	-
Underground	571,004	-	-	1,387,800	-	-	3,606,038	-	-
Total	588,878	0.1042	0.108	1,404,618	0.2486	0.247	3,655,962	0.6471	0.645

Table 2

RESERVES
(Millions of Tons)

	<u>14"-28"</u>		<u>28"-42"</u>		<u>42"</u>	
	<u>SRC</u> <u>Calculated</u>	<u>EIA</u> <u>Calculated</u>	<u>SRC</u> <u>Calculated</u>	<u>EIA</u> <u>Calculated</u>	<u>SRC</u> <u>Calculated</u>	<u>EIA</u> <u>Calculated</u>
Strippable	7.98	7.98	18.26	18.26	47.67	47.67
Underground	124.72	127.18	285.25	285.25	744.88	742.42

from the Indiana Geological Survey's Preliminary Coal Maps (PCM) series. PCM 1 through PCM 15 were used to develop bed/county reliability category breakdowns; for Knox County PCM 12 was employed. The reserve data presented in the maps for each county are broken down by bed, overburden depth category (either 0-40' and > 40', 0-60' and > 60', or 0-90' and > 90', depending on the specific bed/county combination), and reliability category (measured, indicated, and inferred). The fraction of coal falling into each reliability category, as shown in the PCMs, was calculated and applied to the January 1971 reserves to obtain a reliability category distribution. Instead of calculating single fractions to be applied to both surface and underground coal for the entire county (as was the case with the depth category calculation), two fractions were calculated (one for surface coal and one for total reserves) for each bed/county combination. For the Danville Seam in Knox County, the reserve data from PCM 12, along with the fractions calculated from the data, are presented in Table 3.

The reliability category fractions presented in Table 3 were employed to determine the final distribution of the January 1971 Danville/Knox County reserves. Two summary sheets were developed by EIA for each county; one sheet shows the distribution of the strippable reserves for each bed in the county, and the other shows the distribution of the total reserves for each bed. Exhibit 1 is a typed version of the strippable reserves summary sheet for Knox County, and Exhibit 2 is a typed version of the total reserves summary sheet for Knox county. In both exhibits, the VII seam is the same as the Danville seam. For comparison purposes, we have used the fractions calculated (by SRC) in Table 3, along with the SRC calculated reserves by thickness category, to derive our own estimated reserves by thickness and reliability category. The results of our calculations are shown below the EIA-calculated estimates for the Danville seam in Exhibits 1 and 2.

The methodology presented in the preceding example, and the data sources cited in the example, were used to determine the January 1971

Table 3

CALCULATION OF RELIABILITY CATEGORY FRACTIONS

<u>Overburden Depth</u>	<u>Measured</u>		<u>Indicated</u>		<u>Inferred</u>	
	<u>Reserves (Thousand Tons)</u>	<u>Fraction</u>	<u>Reserves (Thousand Tons)</u>	<u>Fraction</u>	<u>Reserves (Thousand Tons)</u>	<u>Fraction</u>
0'-90'	35,429	0.4794	18,280	0.2473	20,201	0.2733
90'-700'	37,891	-	125,799	-	991,677	-
Total	73,320	0.0596	144,079	0.1172	1,011,878	0.8231

Exhibit 1

ESTIMATED REMAINING RESERVES OF COAL
AS OF JANUARY 1, 1971 BY COALBED - KNOX COUNTY
(Millions of Tons)

Coalbed Name	Code Number	Measured			Indicated			Inferred			Measured and Indicated			Total		
		14-20	20-42	> 42"	14-20	20-42	> 42"	14-20	20-42	> 42"	14-20	20-42	> 42"	14-20	20-42	> 42"
VII	400	3.83	8.75	22.05	1.97	4.52	11.79	2.10	4.99	13.03				7.90	10.26	47.67
		3.83	8.75	22.05	1.97	4.52	11.79	2.10	4.99	13.03						
VI	403	6.39	14.61	30.15	0	0	0	0	0	0				6.39	14.61	30.15
V	409	4.04	11.07	28.89	0	0	0	0	0	0				4.04	11.07	28.89

Exhibit 2

ESTIMATED REMAINING RESERVES OF COAL

AS OF JANUARY 1, 1971 BY COALBED

(Millions of Tons)

Depth Range 0 to 1000 feet; Strip 0 to _____

Coalbed Name	Code Number	Measured			Indicated			Inferred			Measured and Indicated			Total		
		14-28	28-42	> 42"	14-28	28-42	> 42"	14-28	28-42	> 42"	14-28	28-42	> 42"	14-28	28-42	> 42"
VII	400	8.06	18.09	47.09	15.05	35.60	92.68	111.25	249.02	650.32				135.16	303.51	790.09
		7.91	18.09	47.24	15.55	35.57	92.84	109.23	249.82	652.35						
VI	403	50.92	116.47	304.13	12.83	29.34	76.62	49.29	112.72	294.35				113.04	258.53	675.10
V	409	60.84	157.45	411.14	15.00	34.30	89.56	21.70	49.63	129.59				105.54	241.38	630.29
IV	493	13.55	30.93	80.90	5.41	12.38	32.34	50.90	116.42	304.01				69.86	159.70	417.25
III	502	1.34	3.05	8.00	1.69	3.87	10.11	79.14	101.00	472.66				82.17	187.93	490.77

reserves for all the bed/county combinations in Indiana, with only a few exceptions:

- For the seams in Daviess County, the reserve estimates are not based on the Weir county tables. Instead, the total underground and strippable reserves for each seam were obtained from PCM 15. Since PCM 15 presents reserves as of 1/1/71, depletion calculations were unnecessary for the Daviess County seams. Distribution of the reserves to thickness categories was accomplished using the Danville/Knox County methodology.
- For the seams in Perry County, the reserve estimates are based on PCM 14 rather than the Weir County tables. PCM 14 provides reserve estimates as of 6/30/70; depletion from 6/30/70 to 1/1/71 was obtained and applied to the PCM data. Distribution of reserves to thickness categories was accomplished using the Danville/Knox County procedure.
- The PCMs for Fountain and Perry Counties estimate only measured reserves. EIA assigned all reserves for these counties to the measured category. PCM 15 for Daviess County presents measured and indicated, but not inferred, estimates. All reserves for Daviess County were assigned to the measured and indicated category. (The Danville/Knox County procedure was used to distribute the reserves to the two categories.)
- There was no PCM available for Posey and Dubois Counties, so Table 2 of the Spencer report was used to determine the fraction of coal falling in the measured, indicated and inferred categories. In Table 2, Posey and Dubois Counties are shown as containing no surface reserves; thus one measured, one indicated, and one inferred fraction were calculated for the entire county from the total measured, indicated and inferred underground reserve estimates in Table 2.
- The Spencer report presents no reserve data for Fountain and Warren Counties. Thus, the thickness category percentage breakdown for these counties was assumed to be similar to the breakdown for Parke County to the south. The following table presents the thickness breakdown percentages for Parke County and the assumed percentages for Fountain and Warren Counties.

	<u>Parke</u>	<u>Fountain and Warren</u>
14"-28"	00.00%	0%
28"-42"	00.06%	10%
42"	99.94%	90%

Also, both the Weir county tables and PCM 9 presented combined data for Fountain and Warren Counties, and no attempt was made to break the reserves down by county.

- For Vigo County, PCM 1 did not present reserve data for three of the seams (Minshall, Upper Block and Lower Block). EIA assumed that all reserves for these three seams were measured. Also, for the rest of the Vigo County seams, PCM 1 does not provide a breakdown of reserves by overburden depth category; thus the reliability category fractions calculated for the total reserves were applied to both the total and the strippable 1/1/71 reserves.

The reserves presented in the county reserve summary sheets (examples of which are provided in Exhibits 1 and 2), were used to develop the statewide DRB estimate. In summing the strippable reserves in the 14"-28", 28"-42", and > 42" measured and indicated categories, across all bed/county combinations, a total of 1920.91 million tons of coal is obtained. The sum of the total reserves (both strippable and non-strippable) in the 28"-42" and > 42" measured and indicated categories is 10,622.57 million tons. When strippable reserves in the same thickness and reliability categories are subtracted from this total, a result of 8948.49 million tons of underground reserves is obtained.

Exhibit 3 presents a typed version of EIA's depletion summary sheet for Indiana, showing production and depletion for the years 1971-77. The source of these data is, apparently, the EIA production computer printouts (see note at the top of the sheet). When the 1978 surface and underground production data from the EIA 1978 annual report are added to the production data in Exhibit 3, and depletion factors of 1.25 for surface mining and 2 for underground mining are employed, the 1/1/71 reserves can be updated as follows:

Exhibit 3

INDIANA PRODUCTION*

Year	Underground					Surface					Grand Total
	< 14	14-27	28-42	> 42	Total	< 14	14-27	28-42	> 42	Total	
1971				1,051,796	1,051,769		85,595	5,196,011	14,863,040	20,144,646	21,396,415
1972				1,139,597	1,139,597		270,327	5,417,513	19,103,883	24,791,723	25,931,320
1973				780,739	780,739		57,746	5,641,319	18,761,941	24,461,006	25,249,745
1974				139,699	139,099		157,749	8,459,743	12,132,005	20,749,497	20,888,596
1975				188,316	188,316		390,160	7,178,609	17,208,601	24,777,570	24,965,886
1976				437,459	437,459		2,000,895	7,517,102	15,330,304	24,928,345	25,365,804
1977				503,436	503,436		2,305,126	7,021,882	17,166,813	27,293,821	27,797,257

Cumulated 1971-1977 Prod. (Thous.)

4,248

167,347

Depletion (X2) (Thous.)

3,496

Depletion (X1.25)

209,184

*Production Data Source - EIA Computer Printout - 1971-1977

Surface:

1920.91 million tons remaining reserves (1/1/71)
-338.72 depletion
1682.19 million tons calculated 1979 DRB, as compared with
1682.19 published DRB

Underground:

8948.49 million tons remaining reserves (1/1/71)
- 9.60 depletion
8938.89 million tons calculated 1979 DRB, as compared with
8938.89 published DRB.

Exhibit 4 is a flowsheet illustrating the Danville/Knox
County basic methodology.

EXHIBIT 4

DANVILLE/KNOX COUNTY METHODOLOGY

For Exceptions to this Methodology see Text

KENTUCKY - EASTERN

The 1979 published demonstrated reserve base for Eastern Kentucky was derived simply by depleting the 1971 DRB using state-level coal production data maintained by EIA. The major research activities for the development of eastern Kentucky reserve estimates were performed as part of the 1971 effort.

The 1971 DRB for the eastern Kentucky coal field was derived from data prepared by Huddle and others.²⁷ Their work derived the original resource estimates for all but five counties, which were covered by "Dowd"²⁸ reports, and were incorporated into the Huddle work. These five counties calculated the remaining reserves as of the year identified, (i.e., Floyd: 1-1-49, Harlan: 1-1-52, Knott: 1-1-50, Letcher: 1-1-52, and Pike: 1-1-48).

The Huddle report presented the resource estimates by reliability and thickness categories on a bed, quadrangle, and county level. The "Dowd" counties identified the remaining reserves by reliability and thickness category by bed, and by quadrangle.

Depletion of the original resource to the 1/1/71 resource base was achieved by using various production sources. Pre-1955 production was obtained from the Kentucky Department of Mines and Minerals Annual Reports on a bed and county basis. Production from 1955 to 1971 was identified in file notes as coming from BOM Microfilm files and BOM Annual Yearbook figures.

²⁷Huddle, J.W., Lyons, E.L., Smith, H.L., and Fern, J.C., Coal Reserves of Eastern Kentucky, U.S. Geological Survey Bulletin 1120, 1963.

²⁸"Dowd" reports are coal resource reports prepared on selected counties throughout Appalachia focusing primarily a coking coals.

Exhibit 1 provides an example of the type of information found in both Huddle and Dowd. This particular example (from Huddle) lists original resources by bed, by quadrangle for Boyd County, Kentucky. The problems faced by the government analysts in preparing the 1971 DRB were: (1) identifying sources of information on bed/county production, and (2) estimating the proportion of reserves available for surface mining.

As stated above, pre-1955 production information was obtained, for the most part, from the Kentucky Department of Mines and Minerals with subsequent data coming from BOM and EIA. Exhibit 2 shows the depletion estimates used for Boyd County. As can be seen from this Exhibit, reserves were depleted in only three of the ten seams found in Boyd County. Also of interest is that no production was reported for the Princess No. 3 seam which in 1980 was the second major source of coal in the Princess Reserve District behind the No. 7 seam. Old production reports are notorious for showing mining activity in only the most dominant seams in any given area. While the total production levels are generally accurate the output by seam is questionable.

In terms of estimating the proportion of reserves available for surface mining, neither the Huddle or Dowd reports provided significant information on depth of cover. It appears that the strippable resource estimates or the January 1971 resource base were simply a straight percentage of the total resource by bed. It is unclear how the percentages were derived since no documentation was available to review the methodology used to estimate strippable reserves. However, an Eastern Regional Office memorandum stated, in part "...the method used for determining the percentage of strippable coal, by seam was checked and found to be a quick and dirty calculation used by the BOM in 1968 due to a lack of time and personnel." The memorandum goes on to say that the Kentucky Geological Survey believes that the strippable reserve estimate is high and that this belief is shared by DOE field office personnel.

EXHIBIT 1

ORIGINAL COAL RESOURCES - BOYD COUNTY, KENTUCKY

(Million of Tons)

Quadrangle and bed	Measured reserves in beds of indicated thickness in inches				Indicated reserves in beds of indicated thickness in inches				Inferred reserves in beds of indicated thickness in inches				Total, each category			Quadrangle and county totals, all beds
	14 to 28	28 to 42	42	Total	14 to 28	28 to 42	42	Total	14 to 28	28 to 42	42	Total	14 to 28	28 to 42	42	
Boyd County																
Ceredo:																
Princess No. 3					1.00			1.00	8.22			8.22	10.12			10.12
Princess No. 4					.45			.45	6.00			6.00	6.45			6.45
Princess No. 5					8.36	8.03	2.27	18.66	14.23	3.59		17.82	22.59	11.62	2.27	36.48
Princess No. 5A					8.03	6.04		14.07	14.01	3.07		17.08	22.04	9.11		31.15
Princess No. 5B					7.75			7.75	7.04			7.04	14.79			14.79
Princess No. 6					7.51	17.51	7.28	32.30	17.62	12.73	3.34	33.69	25.13	30.24	10.62	65.99
Princess No. 7					18.21	38.40	7.57	64.18	12.52	33.98		45.50	30.73	72.44	7.67	110.74
Princess No. 8					8.14	2.35	3.18	13.67	25.60			25.60	33.74	2.35	3.18	39.27
Princess No. 9					2.23			2.23	13.04	4.17		17.21	15.27	4.17		19.44
Princess No. 10									3.19			3.19	3.19			3.19
Total					62.58	72.39	20.30	155.27	121.47	57.54	3.34	182.35	184.05	129.93	23.64	337.62
Grayson:																
Princess No. 3									7.49	3.56		11.05	7.49	3.56		11.05
Princess No. 4									2.06			2.06	2.06			2.06
Princess No. 5					4.54	7.31		11.85	4.77	8.65		13.42	9.31	15.06		25.27
Princess No. 5A					3.56			3.56	11.80			11.80	15.36			15.36
Princess No. 6									2.38	.37		2.75	2.38	.37		2.75
Princess No. 7					.97	14.99	25.71	41.82	.16	6.36	7.22	13.73	1.07	21.35	32.93	55.35
Princess No. 8					1.62	1.10	.25	2.97	2.94	1.13		4.07	4.56	2.21	.25	7.04
Total					10.04	23.40	25.96	60.00	31.50	20.07	7.22	58.89	42.23	43.47	33.18	118.88
County total					73.72	95.79	46.26	215.27	153.09	77.61	10.60	241.23	226.28	173.40	56.82	456.50

Exhibit 2

BOYD COUNTY DRB WORKSHEET FOR 1-1-71

(Million Tons)

Cumulative Production to 1-1-71

A-54	<u>Seam</u>	<u>Original Resource</u>	<u>Underground</u>	<u>Strip</u>	<u>Auger</u>	<u>Remaining Resource</u>	<u>Remaining Strippable Resource</u>
	Princess 10	3.19	0.00	0.00	0.00	3.19	2.71
	Princess 9	19.44	0.00	0.00	0.00	19.44	16.52
	Princess 8	46.31	0.05	0.00	0.00	46.20	25.93
	Princess 7	166.09	10.98	3.49	0.14	139.51	81.74
	Princess 6	63.74	0.32	0.00	0.00	68.10	29.56
	Princess 5B	14.79	0.00	0.00	0.00	14.79	5.92
	Princess 5A	46.51	0.00	0.00	0.00	46.51	17.67
	Princess 5	61.75	0.00	0.00	0.00	61.75	22.23
	Princess 4	8.51	0.00	0.00	0.00	8.51	2.55
	Princess 3	21.17	0.00	0.00	0.00	21.17	5.08

In general, the methodology used to prepare the DRB eastern Kentucky estimate as of 1-1-79 was straightforward, consisting of a review of the 1-1-71 procedure and depletion based on state-level production records. However, the bed/county accuracy of the January numbers and the estimation of strippable reserves are questionable.

KENTUCKY - WESTERN

The methodology used to derive the Demonstrated Reserve Base of Coal in western Kentucky is based simply on the depletion of resource estimates provided by Smith and Brant.²⁹ The report prepared by Smith and Brant provided original resource information by bed, county, thickness category, reliability (Class I, Class II, Class III), and overburden thickness (0 to 150 feet and greater than 150 feet). Exhibit 1 provides an example of the county summary information given in the report.

In developing the baseline DRB reserve estimates, two assumptions were made: that the reliability classification of Smith and Brant correspond to the DRB categories (Class I equals measured, Class II equals indicated, and Class III equals inferred), and that all coal under less than 150 feet of cover is considered strippable.

Depletion of western Kentucky resources was conducted in two stages: the first covering the period 1790 through 1975 using information provided by the Kentucky Geological Survey; the second covering the period 1976 through 1979 using EIA production statistics.

The Smith and Brant report contained a table (Exhibit 2) listing total depletion ("Mined and Lost") by county through 1975. Subsequent to this report Brant and Hester³⁰ published a production summary for the western Kentucky coal field covering the same time period

²⁹Smith, G.E., and Brant, R.A., Western Kentucky Coal Resources, Kentucky Geological Survey, University of Kentucky, 1980.

³⁰Brant, R.A., and Hester, N.C., Coal Resources of Kentucky, Kentucky Geological Survey, 1980 Handout.

Exhibit 1

WESTERN KENTUCKY COAL RESOURCES

COUNTY SUMMARIES

(Coal Resources in Thousands of Tons)

	TOTALS				0-150' OVERBURDEN CATEGORY				150' + OVERBURDEN CATEGORY			
	TOTALS	14-28"	28-42"	42"+	TOTALS	14-28"	28-42"	42"+	TOTALS	14-28"	28-42"	42"+
BRECKINRIDGE COUNTY												
R. CLASS I	10	10			10	10						
II	0	0			0	0						
III	258	258			258	258						
TOTAL	268	268			268	268						
BUTLER COUNTY												
R. CLASS I	73,870	25,145	33,857	14,868	69,312	24,653	30,284	14,375	4,558	492	3,573	493
II	312,221	30,820	57,374	24,027	100,115	29,106	50,013	20,996	12,106	1,714	7,361	3,031
III	227,601	65,746	79,685	92,170	152,579	46,409	61,124	45,046	75,022	9,337	18,561	47,124
TOTAL	413,692	111,711	170,916	131,065	322,006	100,168	141,421	80,417	91,686	11,643	29,495	50,648
CALDWELL COUNTY												
R. CLASS I	7,229	0	2,169	5,060	7,229	0	2,169	5,060	0	0	0	0
II	23,182	1,518	6,386	15,278	22,459	1,446	6,386	14,627	723	72	0	651
III	36,965	361	21,688	14,916	32,941	289	21,086	11,666	4,024	72	602	3,350
TOTAL	67,376	1,879	30,243	35,254	62,629	1,735	29,641	31,253	4,747	144	602	4,001
CHRISTIAN COUNTY												
R. CLASS I	63,151	2,421	29,615	31,115	63,151	2,421	29,615	31,115	0	0		
II	2,521	1,623	998	0	2,476	1,478	998	0	45	45		
III	5,048	3,120	1,928	0	4,991	3,063	1,928	0	57	57		
TOTAL	70,720	7,064	32,541	31,115	70,618	6,962	32,541	31,115	102	102		
CRITTENDEN COUNTY												
R. CLASS I	8,291	867	6,988	436	8,291	867	6,988	436	0		0	
II	12,728	1,541	8,265	2,922	12,295	1,541	7,832	2,922	433		433	
III	20,615	506	14,880	5,229	20,615	506	14,880	5,229	0		0	
TOTAL	41,634	2,914	30,133	8,587	41,201	2,914	29,700	8,587	433		433	

Exhibit 2

WESTERN KENTUCKY COAL FIELD

BY COUNTY

(Thousands of Short Tons)

	TOTALS	MINED & LOST	REMAINING
BRECKINRIDGE COUNTY	268	0	268
BUTLER COUNTY	413,692	9,058	404,634
CALDWELL COUNTY	67,376	236	67,140
CHRISTIAN COUNTY	70,720	7,378	63,342
CRITTENDEN COUNTY	41,634	0	41,634
DAVIESS COUNTY	1,330,323	22,500	1,307,823
EDMONSON COUNTY	159,607	1,214	158,393
GRAYSON COUNTY	105,038	181	104,857
HANCOCK COUNTY	170,276	2,702	167,574
HENDERSON COUNTY	6,852,765	32,114	6,820,651
HOPKINS COUNTY	8,814,801	879,702	7,935,099
MCLEAN COUNTY	3,576,413	22,876	3,553,537
MUHLENBERG COUNTY	4,723,837	981,488	3,742,349
OHIO COUNTY	1,824,572	220,545	1,604,027
UNION COUNTY	6,506,974	124,460	6,382,514
WARREN COUNTY	8,148	96	8,052
WEBSTER COUNTY	6,322,849	58,184	6,264,665
WESTERN KENTUCKY COAL FIELD TOTAL	40,989,293	2,362,731	38,626,562

(Exhibit 3). According to the EIA worksheets used to prepare the western Kentucky DRB the Brant and Hester data were used for depletion purposes.

As is shown by Exhibit 3 the Brant and Hester handout summarized production in three basic categories: undifferentiated, surface, and underground. To establish depletion EIA field office personnel assumed that the undifferentiated production was split 60 percent underground, 40 percent surface. A second assumption was then made that all underground production would be depleted based on a recovery factor of 55 percent. If one follows this procedure an underground depletion of 215.22 million tons is derived. A note found on one of the worksheets states that this tonnage should be adjusted to 217.90 million tons. Curiously enough when this adjustment is made, coupled with the use of a 55 percent recovery factor for underground mining the calculated total depletion (underground and surface) matches exactly the mined and lost tonnages presented in Smith and Brant. However, as shown by Exhibit 4, the county level depletion estimates differ significantly.

Depletion for the years 1976 through 1978 was computed using EIA annual production records for western Kentucky as a whole. Unlike depletion through 1975, underground depletion for these three years was based on a recovery factor of 50 percent. Surface depletion for all years was based on 80 percent recovery.

The final derivation of the published DRB was simply the sum of all Class I and II resources greater than 28 inches as presented by Smith and Brant minus the calculated depletion for the period 1790 through 1978. The one unresolved issue is why different underground depletion factors were used pre- and post- 1976.

Exhibit 3

PRODUCTION SUMMARY FOR THE WESTERN KENTUCKY COAL FIELD, 1970-1975

(In Short Tons)

County	Undifferentiated 1790-1889*	1890-1975	Surface 1890-1975	Underground 1890-1975	Total Production 1790-1975
Breckinridge	75,000				75,000
Butler	226,524	345,899	3,384,489	3,373,648	7,330,560
Caldwell			117,903		117,903
Christian	210,172	2,310,477	1,411,254	2,511,725	6,443,628
Crittenden	301,418	10,613	63,935	141,768	517,734
Daviess	920,500	1,279,733	22,805,847	6,744,839	31,750,919
Edmonson	178		705,822	165,364	871,364
Grayson	892		634,573	5,000	640,465
Hancock	783,970	426,674	1,427,360	651,156	3,299,160
Henderson	928,817	6,182,446		15,016,521	22,127,784
Hopkins	4,853,557	60,554,978	165,677,798	283,352,889	514,439,222
McLean	840,179	2,589,623	5,047,186	1,913,414	10,390,402
Muhlenberg	2,397,465	51,764,430	300,987,395	184,648,222	539,797,512
Ohio	1,792,048	19,196,891	100,139,178	38,028,718	159,156,835
Todd	530				530
Union	1,900,567	14,817,040	1,936,580	109,131,887	127,786,074
Warren	24,155		2,000		26,155
Webster	184,051	22,172,608	15,320,760	53,040,757	90,718,176
TOTAL	15,440,023	181,651,412	619,662,080	698,735,908	1,515,489,423

* Separated from later undifferentiated production figures because of numerous estimates.

Exhibit 4

COMPARISON OF DEPLETION SOURCES

<u>County</u>	Mined and Lost 1790-1975 <u>(Smith and Brant)</u>	Depletion 1790-1975 <u>(Brant and Hester)</u>
Breckinridge	0	119
Butler	9,058	11,282
Caldwell	236	147
Christian	7,375	10,348
Crittenden	0	835
Daviess	22,500	44,286
Edmonson	1,214	1,184
Grayson	181	802
Hancock	2,702	4,915
Henderson	32,114	38,651
Hopkins	879,702	826,931
McLean	22,876	15,251
Muhlenberg	981,488	798,517
Ohio	220,545	227,797
Union	124,460	227,657
Warren	96	41
Webster	<u>58,184</u>	<u>151,278</u>
TOTAL	2,362,731	2,360,041

MARYLAND

The 1979 DRB is based on data contained in J. J. Wallace, et. al., Estimate of Known Recoverable Reserves of Coking Coal in Allegheny County, Maryland,³¹ along with information from Paul Averitt's Coal Resources of the United States, January 1, 1974.³² Wallace and others presented total remaining resource estimates (as of 1/1/51) for Allegheny County by bed, measured, indicated and inferred reliability categories, and thickness categories (14"-28", 28"-42", and > 42"). Exhibit 1 is a typed version of a handwritten summary sheet (found in the DOE field office files) presenting data taken from Wallace and others. As the exhibit indicates, the total Allegheny County seams equal 730.1 million tons.

From the Averitt report, a percentage breakdown of the coal falling in each of the five Maryland coal basins was obtained. The breakdown obtained is as follows:

Georges Creek Basin	50%
Upper Potomac Basin	20%
Castleman Basin	15%
Upper Youghiogheny Basin	5%
Lower Youghiogheny Basin	10%

³¹Wallace, J. J., Dowd, J. J., Williams, L., Abernethy, R. F., and Reynolds, D. A., Estimate of Known Recoverable Reserves of Coking Coal in Allegheny County, Maryland, U.S. Bureau of Mines Report of Investigations 4970, 1953.

³²Averitt, Paul, Coal Resources of the United States, January 1, 1974, U.S. Geological Survey Bulletin 1412, 1975.

Exhibit 1

ALLEGHENY COUNTY DATA FROM WALLACE AND OTHERS

Coalbed	Measured			Indicated			Inferred			Resource	DRD
	14-28	28-42	42	14-28	28-42	42	14-28	28-42	42		
Waynesburg	0.94	3.37	0.11	0.00	2.06	0.21	7.07	1.50	0.00	16.22	5.75
Sewickley	4.23	7.42	0.13	0.00	1.57	0.00	0.00	2.92	0.00	16.27	9.12
Pittsburgh	0.00	0.00	4.86	0.00	0.00	0.00	0.00	0.00	0.00	4.86	4.86
Barton	17.34	0.84	0.00	49.87	0.00	0.00	1.74	0.00	0.00	69.79	0.84
Harlem	4.50	0.00	0.00	45.17	0.00	0.00	0.62	0.00	0.00	50.29	0.00
Upper Bakerstown	1.66	3.98	0.00	31.79	62.10	2.81	17.50	1.47	0.00	121.39	68.89
Lower Bakerstown	4.45	6.44	3.25	33.93	42.21	43.34	19.92	4.21	0.00	157.75	95.24
Upper Freeport	1.65	7.24	6.71	21.06	27.06	39.43	36.82	15.69	0.00	156.46	80.44
Upper Kittanning	0.88	4.80	2.72	32.75	27.29	4.32	53.31	10.92	0.00	137.07	39.21
Total	35.65	34.17	17.78	216.25	162.29	90.11	137.06	36.79	0.00	730.10	304.35

Averitt also suggested that 75 percent of the coal contained in the Georges Creek Basin occurs in Allegheny County, while the remainder occurs in Garrett County (the only other coal-containing county in Maryland). The other four basins, according to Averitt, fall entirely within Garrett County. To determine the total resources in the Georges Creek Basin (in both Allegheny and Garrett Counties), Allegheny County total resource estimate of 730.1 million tons (from Exhibit 1) was divided by 0.75, yielding 973.47 million tons. This result appears as the resource estimate in the 0-1000' depth category for Georges Creek in Exhibit 2.³³ To obtain the total resources for the state, the 973.47 million ton figure was divided by 0.5, since Averitt has estimated that 50 percent of the resources in the state occur in the Georges Creek Basin. The total state resource estimate of 1,946.94 million tons was then distributed to the five Maryland coal basins according to Averitt's percentage breakdown given above. The results, for each basin, are presented as the 0-1000' deep resources in Exhibit 2.

To subdivide the basin resource estimates by mining method, EIA assumed that 10 percent of each basin estimate was amenable to surface mining, leaving 90 percent for potential underground mining. The 10/90 split was based, according to the Maryland Methodology, "upon professional judgement", and developed "in consideration of the structure, shape and relief of the coal basins and of the fact that all identified resource coal beds crop out". The results of the 10/90 split are presented in the "Resource" column in Exhibit 2.

To derive the January 1951 DRB from the resource estimates in Exhibit 2, the Allegheny County data from Wallace and others were employed. The first line of Exhibit 3 presents the total Allegheny

³³All of the data presented in Exhibits 2 and 3 was obtained from handwritten calculation sheets found in the DOE field office files.

Exhibit 2

STATE TOTAL JANUARY 1951 DRB SUMMARY SHEET

<u>Coal Basin</u>	<u>Averritt Breakdown</u>		<u>Resource</u>	<u>DRB</u>
Georges Creek Basin	50%	0-1000	973.47	439.40
		Strip	97.37	74.19
		UG	876.10	365.21
Upper Potomac Basin	20%	0-1000	389.39	175.76
		Strip	38.95	29.68
		UG	350.44	146.08
Castleman Basin	15%	0-1000	292.04	131.82
		Strip	29.21	22.26
		UG	262.83	109.56
Upper Youghiogheny Basin	5%	0-1000	97.35	43.94
		Strip	9.74	7.42
		UG	87.61	36.52
Lower Youghiogheny Basin	10%	0-1000	194.69	87.88
		Strip	19.47	14.84
		UG	175.22	73.04
State Total (Allegheny and Garrett Counties)		0-1000	1,946.94	878.80
		Strip	194.74	148.38
		UG	1,752.20	730.42

Exhibit 3

ALLEGHENY COUNTY RESOURCE AND DRB ESTIMATES

	<u>Measured</u>			<u>Indicated</u>			<u>Inferred</u>			<u>Resource</u>	<u>DRB</u>
	<u>14-28</u>	<u>28-42</u>	<u>42</u>	<u>14-28</u>	<u>28-42</u>	<u>42</u>	<u>14-28</u>	<u>28-42</u>	<u>42</u>		
0-1000	35.65	34.17	17.78	216.25	162.29	90.11	137.06	36.79	0.00	730.10	329.55
Strip (10%)	3.57	3.42	1.78	21.63	16.23	9.01	13.71	3.68	0.00	73.03	55.64
UG 0-1	32.08	30.75	16.00	194.62	146.06	81.10	123.35	33.11	0.00	657.07	273.91

County resource estimates, falling within 1000' of the surface, by reliability and thickness category (these data were obtained from the "Total" line at the bottom of Exhibit 1). As Exhibit 3 indicates, the 0-1000' deep resources were subdivided into resources amenable to surface mining and resources amenable to underground mining using the 10/90 split discussed in the previous paragraph. Then, the total strippable (73.03 million tons) and underground (657.07 million tons) resources in all thickness and reliability categories were calculated (see "Resource" column in Exhibit 3). Finally, a January 1951 surface DRB estimate of 55.64 million tons, and an underground DRB estimate of 273.91 million tons were calculated (see "DRB" column in Exhibit 3). The surface DRB estimate includes all the surface mineable resources 14" thick falling in the measured and indicated categories, while the underground estimate includes all the underground mineable resource 28" thick falling in the measured and indicated categories.

From the strippable and underground Allegheny County resource and DRB estimates presented in Exhibit 3, it was determined that 76.19% ($55.64 \div 73.03 \times 100$ percent) of the strippable resource meets the DRB criteria, and 41.69 percent ($273.91 \div 657.07 \times 100$ percent) of the underground resource meets DRB criteria. These percentages were applied to the basin surface and underground resource estimates in Exhibit 2 to yield the basin surface and underground January 1951 DRB estimates. For example, the 97.37 million tons of strippable resources in the Georges Creek basin (from Exhibit 2) was multiplied by 0.7619 to yield 74.19 million tons of strippable coal meeting DRB criteria.³⁴ After multiplying all the basin underground and surface resource estimates by the applicable

³⁴The 74.19 million ton DRB estimate appears in the "DRB" column of Exhibit 2, alongside the 97.37 million ton resource estimates.

fraction, the total surface and underground DRB estimates were calculated by summing estimates across basins. The results, as indicated in the "State Totals" at the bottom of Exhibit 2, were 148.38 million tons of strippable coal and 730.42 million tons of underground coal.

Depletion of the 1/1/51 DRB estimates was based on production data obtained from the annual reports of the Maryland Bureau of Mines (for the period 1951-1955), the U.S. Bureau of Mines annual reports (for the period 1955-1970), and the DOE computer tapes (for the period 1971-1978). The cumulative underground depletion was obtained by multiplying the 1951-1978 underground production by 200, while the cumulative surface depletion was determined using a depletion factor of 1.25. The results were 36.26 million tons of surface depletion, and 16.34 million tons of underground depletion. Thus:

For Underground:

730.42 million tons 1/1/51 DRB
<u>-16.34 depletion</u>
714.08 million tons calculated 1979 DRB, as compared with
714.08 published DRB

For Surface:

148.38 million tons 1/1/51 DRB
<u>-36.26 depletion</u>
112.12 million tons calculated 1979 DRB, as compared with
112.12 published DRB.

An overview of the methodology described above is provided in Figure 1.

Figure 1

FLOWCHART OF MARYLAND DRB

MICHIGAN

The coal demonstrated reserve base as of January 1, 1979 was computed using data in the U.S. Geological Survey coal resource estimate of 1950.³⁵ These data were modified for subsequent coal production and information on additional measured resources in the Kalliokoski study (1976).³⁶ The U.S. Geological Survey did not attempt to breakdown the indicated and inferred resources into thickness categories. For the demonstrated reserve base it was judged reasonable to assign the thickness categories for the indicated and inferred resources in the same proportion as the measures resource. The 50 to 100 feet overburden depth was considered to be the surface mineable demonstrated reserve base.

Production and depletion of Michigan coal reserves are also taken from Cohee et al (1950). Table 6, page 56 supplied the production from 1860 to 1949 on a state level. Depletion was assumed at 40 percent production based on the Cohee (1950) study. There has been no appreciable production since 1950 in Michigan.

The 1979 DRB can be derived by applying the following methodology:

1950 DRB (Cohee et. al, 1950 Table 4, 5, & 6)
+ 8.33 (million tons of Saginaw Co. reserves; Kalliokoski, 1976)
- 0.02 million tons (1950-52 production not depleted;
Kalliokoski, 1976)
8.31 1979 DRB

³⁵Cohee, G. V., Burns, R. N., Brown, A., Bront, R. A., and Wright, D., Coal Resources of Michigan, U.S. Geological Survey Circular 77, 1950.

³⁶Kalliokoski, J., Magnitude and Quality of Michigan's Coal Reserves, U.S. Bureau of Mines Open file Report 102-76, 1976.

NORTH CAROLINA

The derivation of the 1979 Demonstrated Reserve Base of Coal in North Carolina is based entirely on the work of Reinemund.³⁷ The majority of information used to derive the 1979 DRB came from two tables prepared by Reinemund, shown here as Exhibits 1 and 2. To use the information presented in these tables two basic problems had to be overcome:

- A methodology had to be derived to convert the Reinemund seam thickness categories and average thickness to standard DRB criteria (14" to 28", 28" to 42", and greater than 42").
- A methodology had to be derived to split the Reinemund resources figures reported at depths from 0 to 2,000 feet to the DRB criterion of 0 to 1,000 feet.

In terms of the seam thickness categories the following approach was followed:

- All coal shown in Exhibit 2 having an average thickness of 15, 18, 20, and 21 inches was placed in the 14 to 28 inch category along with 50 percent of the coal listed as having an average height of 28 inches.
- All 30- 32- 26- and 40-inch coal was placed in the 28" to 42" category, plus 50 percent of the 28-inch coal and 60 percent of the 42-inch coal.
- The remaining 40 percent of the 42-inch coal was considered as having a seam height greater than 42 inches.

³⁷Reinemund, J.A., Geology of the Deep River Coal Field of North Carolina, USGS Professional Paper 246, 1955.

Exhibit 1

RESERVES OF COAL IN THE DEEP RIVER COAL FIELD,
CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

(In Thousands of Short Tons)

Bed, reserve class, and overburden	Range in thickness (inches)	Area (acres)	Estimated original reserves	Mined and lost in mining, Jan. 1, 1950	Remaining reserves, Jan. 1, 1950	Recoverable reserves, Jan. 1, 1950 (assuming 50 percent recovery)
Cummock:						
Measured:						
0-2,000.....	>36	3,404	20,034	1,574	18,460	9,680
	29-36	2,483	9,037	15	9,022	4,511
	14-28	770	2,394	31	2,363	1,181
2,000-3,000.....	>36	199	1,183	0	1,183	592
	29-36	149	905	0	905	452
Indicated:						
0-2,000.....	>36	1,136	6,787	0	6,786	3,393
	29-36	813	3,963	0	3,963	1,982
	14-28	6,921	20,324	0	20,324	10,162
2,000-3,000.....	>36	1,255	7,302	0	7,302	3,651
	29-36	1,094	4,923	0	4,923	2,462
	14-28	494	2,055	0	2,055	1,027
Inferred: 0-2,000.....	14-28	8,195	27,573	0	27,573	13,787
Total.....			101,980	1,620	100,360	50,181
Gulf:						
Measured: 0-2,000.....	14-28	1,767	5,306	1	5,305	2,653
Indicated: 0-2,000.....	14-28	2,065	4,664	0	4,664	2,332
Total.....			9,970	1	9,969	4,985
Grand total.....			111,950	1,621	110,329	55,166
Total in beds:						
36 inches or more.....			36,206	1,574	34,631	17,316
29-36 inches.....			18,629	15	18,613	9,307
14-28 inches.....			57,125	32	57,093	28,547

¹ Includes 8,469 thousand tons averaging 42 inches in thickness.

Exhibit 2

THICKNESS AND ORIGINAL RESERVES OF COAL BY AREAS

Beds	Area No.	Thickness (inches)	Estimated original reserves (thousands of short tons)		
			Bituminous	Anthracite and coke	Total
Cummoek	1.....	36	5,368		5,368
	2.....	42	5,796	64	5,860
	3.....	28	3,881	228	4,109
	4.....	32	3,215	396	3,611
	5.....	36	805		805
	6.....	40	5,121	58	5,179
	7.....	32	2,804		2,869
	8.....	42	3,573	210	3,783
	9.....	40	1,183		1,183
	10.....	38	2,255	278	2,533
	11.....	40	6,412	374	6,786
	12.....	38	7,142	160	7,302
	13.....	30	839	2,795	3,637
	14.....	20	242	808	1,051
	15a.....	30	1,829	2,034	3,863
	15b.....	21	3,841	4,266	8,107
	16.....	21	236	260	496
	17.....	15	117	130	247
	18.....	18	202	224	426
	19.....	18	7,620	940	8,560
	20.....	18	19,915	2,455	22,373
	21.....	18	2,855	560	3,415
	22.....	18	202	224	426
Total Cummoek bed			85,519	16,470	101,989
Gulf	1 (part).....	18	1,343		1,343
	1 (part).....	15	1,118		1,118
	2.....	15	2,066	24	2,090
	4 (part).....	24	1,202	148	1,350
	4 (part).....	15	782	92	874
	6 (part).....	24	1,552	16	1,568
	6 (part).....	15	972	10	982
	8 (part).....	15	637	38	675
Total Gulf bed.....			9,642	328	9,970
Grand total.....			95,161	16,798	111,959

To further divide the resource base defined by Reinemund into depth-of-cover categories of 0 to 1,000 feet and greater than 1,000 feet, a complete review of the coalfield maps presented in the Reinemund report was conducted. Based on this review an estimate of the percent of the total resource lying within 1,000 feet of the surface was made for each coal bed area. This breakdown from as little as 3.5 percent of the identified resource (area 11, Exhibit 2) to as high as 100 percent or areas 14, 16, 17, 18, and 22.

Once the Reinemund estimates were adjusted to reflect standard DRB classifications, the resource estimates were depleted using production data through 1952, the last year of reported production.

Production records from 1852 through 1949 were taken directly from Reinemund. Depletion for this period was computed using a factor of approximately 1.52, based on Reinemund's estimates of recovery. Production for 1949 through 1952 came from Bureau of Mines production reports. For the years 1950 and 1951 it was necessary to adjust the BOM estimates because for these two years the Bureau reported a combined production for both North Carolina and Georgia. During these years combined production was reported as 41.9 and 26.6 thousand tons. The North Carolina production was estimated as 21.9 thousand tons in 1950 and 1.6 thousand tons in 1951. Since all reported production in North Carolina came from underground mines depletion was calculated based on a 50 percent recovery factor.

Lastly, it should be noted that the North Carolina resource base as reported by Reinemund includes both anthracite coal and coke. This resource is small and configured in a manner that makes it uneconomical to mine. However, because of the total configurations of the Deep River Coalfield, about 17 percent of the anthracite resource was included in the DRB.

OHIO

The 1979 DRB for Ohio, consisting of 6,029.53 million tons of bituminous coal amenable to surface mining, cannot be derived by depleting the 1971 DRB to 1979. The 1971 surface DRB estimate was actually 2,376 million tons lower than the 1979 estimate. The underground 1971 estimate was 4,418 million tons higher than the 1979 estimate, but underground depletion during the years 1971-78 was only 235.75 million tons.

The 1979 DRB can be derived by depleting the 1976 DRB, except for a small 5.7 million ton discrepancy³⁸ in the surface category. The calculations are as follows:

Underground:

13,090.5 million tons 1976 DRB
- 85.4 depletion (1976-78)
13,005.1 million tons calculated 1979 DRB, as compared with
13,005.14 published 1979 DRB

Surface:

6139.8 million tons 1976 DRB
-116.0 depletion
6023.8 million tons calculated 1979 DRB, as compared with
6029.53 published 1979 DRB

The depletion figures used in the above calculations were derived by multiplying the total surface and underground production during the years 1976 through 1978 (obtained from the DOE computer printout and, for 1978, the annual EIA reports) by 1.25 and 2.00 for surface (including auger) and underground production, respectively.

³⁸A portion of this discrepancy (2.24 million tons) is due to a change in the depletion factor used for auger mining.

A memo, dated January 6, 1977, to "Robert Kelly, Project Leader--State Reserve Base Reports" from Edwin Secor outlined the methodology used to revise the estimated "coal resources of Ohio as of January 1971" as presented in "IC 8680".

The Secor memo states that R. A. Brant's and R. M. Delong's Coal Resources of Ohio report,³⁹ along with the Decarlo January 1969 reserve estimates, was used to derive the total Ohio resources as of January 1971. The Brant and Delong report, in Table 37, presents original resource estimates, by county and bed, for proven, probable and inferred reliability categories, and for 14"-28", 28"-54", and >54" thickness categories. Coal resources unclassified as to reliability and thickness are also presented. In using the estimates presented in Table 37, Secor states that the proven reliability category was taken as being equivalent to BOM's measured category, and the probable category was taken as equivalent to BOM's indicated category.⁴⁰ The estimates were reassigned to thickness categories of 14"-28", 28"-42", and >42" on the basis of "the many various reference documents from which "B-58" (Bulletin 58) was compiled"; the memo goes on to state that these documents are listed in the bibliography of the "B-58" report.⁴¹

³⁹Brant, R. A., and Delong, R. M., Coal Resources of Ohio, Ohio Division of Geological survey Bulletin 58, 1960.

⁴⁰On page 11 of the Brant and Delong report, it is stated that "The term 'proven' as used in this report is the equivalent of the term 'measured' of the U.S. Geological Survey and the U.S. Bureau of Mines", and that "the term 'probable' is equivalent to the term 'indicated' as used by the U.S. Geological Survey and the U.S. Bureau of Mines."

⁴¹The resource estimates presented as "unclassified" in the Brant and Delong report were not distributed to either reliability or thickness categories.

Since the Brant and Delong "B-58" estimates represent original estimates, some method of depleting the estimates to January 1971 was required. This was accomplished by employing the DeCarlo January 1969 county/bed reserve estimates, which Secor states were "assumed to be an accurate sum of the total reserves of each coalbed, in each Ohio county with coal resources". The DeCarlo estimates were updated to January 1971, using production data from "USBOM tab sheets" and the Ohio Division of Mines annual reports. Depletion factors were 1.25 for surface production and 2.00 for underground production.⁴² The difference between the updated DeCarlo estimates and the Brant and Delong estimates was taken as the depletion for each bed/county combination. To distribute the depletion to the measured and indicated reliability categories, and the thickness categories of 14"-28", 28"-42", and >42", the total bed/county depletion was assigned to the six reliability/thickness categories in proportion to the Brant and Delong resources in each category. Two exceptions to this general distribution were stated as follows:

- "Exception Number 1 - If evidence indicated that a coalbed had never been surface mined, no depletion was assigned to either 14"-28" thickness category.
- "Exception Number 2 - If depletion in a category equaled the original resource of that category (signifying exhaustion of that category), yet evidence indicated mining currently occurring in that category, then a portion of the depletion equivalent to (annual production x depletion factor x expected years of life remaining in mine in question) was moved from that category to the inferred categories." (Apparently, this was done to "make room" for future depletion of the measured or indicated category in question.)

⁴²The memo states that auger production was depleted by a factor of 2, but a note penciled in the margin of the memo states that this was "changed to 1.25".

After the total depletion was distributed to each category, the Secor memo states, the depletion figures were subtracted from the Brant and Delong resource estimates in each category to obtain the updated January 1971 estimates. The Secor memo then presents three examples of the application of this methodology, as shown in the Examples on the following page.

Secor then described the methodology employed to determine the amount and distribution of the strip resources. Bob Kelly, the Project Leader for the State Reserve Base Reports, had developed estimates of total reserves by county as of January 1968, for beds >28" in thickness. These estimates, Secor states, were depleted to January 1971; the production data used to determine the depletion was obtained from the USBOM tab sheets and the Ohio Division of Mines annual reports, and 1.25 was used as the depletion factor. The January 1971 bed/county reserve estimates were then distributed to the four relevant categories (measured, 28"-42"; measured, > 42"; indicated, 28"-42"; and indicated, >42"), according to the proportion of the total (underground and surface) January 1971 reserves in each category, as calculated following the methodology described earlier. If the January 1971 surface estimate exceeded the January 1971 total reserve estimate in any category, Secor states, the former figure was reduced to equal the latter. Finally, to obtain the strip reserves in the 14"-28", measured and indicated categories, it was assumed that the 14"-28" reserves equaled the surface reserves, divided by the total reserves, in each reliability category, multiplied by the total 14"-28" reserves in the reliability category. Thus:

$$\begin{aligned} &\text{Measured, 14"-28", 1/1/71 surface reserves} = \\ &\text{measured, 14"-28", 1/1/71 total reserves} \times \frac{(\text{measured, >28", 1/1/71 surface reserves})}{(\text{measured, >28", 1/1/71 total reserves})} \end{aligned}$$

$$\begin{aligned} &\text{Indicated, 14"-28", 1/1/71 surface reserves} = \\ &\text{indicated, 14"-28", 1/1/71 total reserves} \times \frac{(\text{indicated, >28", 1/1/71 surface reserve})}{(\text{indicated, >28", 1/1/71 total reserves})} \end{aligned}$$

Example 1: Normal situation

"B-50" total = 100.00 revised DeCarlo total = 90.00 "Total depletion" = 10.00

	Measured			Indicated			Inferred			Total
	14"-20"	20"-42"	>42"	14"-20"	20"-42"	>42"	14"-20"	20"-42"	>42"	
"B-50"										
Distribution	5.00	10.00	15.00	0.00	10.00	12.00	10.00	13.00	17.00	100.00
Depletion	0.03	1.67	2.50	1.33	1.67	2.00	0.00	0.00	0.00	10.00
Remaining Resources 1-1-71	4.17	8.33	12.50	6.67	8.33	10.00	10.00	13.00	17.00	90.00

Example 2: Illustration of exception No. 1.

	Measured			Indicated			Inferred			Total
	14"-20"	20"-42"	>42"	14"-20"	20"-42"	>42"	14"-20"	20"-42"	>42"	
"B-50"										
Distribution	5.00	10.00	15.00	0.00	10.00	12.00	10.00	13.00	17.00	100.00
Depletion	0.00	2.13	3.19	0.00	2.13	2.55	0.00	0.00	0.00	10.00
Remaining Resources 1-1-71	5.00	7.87	11.84	0.00	7.87	9.45	10.00	13.00	17.00	90.00

Example 3: Illustration of exception No. 2 with revised DeCarlo number = 30.00, and a 1 million TPY strip mine in 35" coal with a 5-year life.

	Measured			Indicated			Inferred			Total
	14"-20"	20"-42"	>42"	14"-20"	20"-42"	>42"	14"-20"	20"-42"	>42"	
"B-50"										
Distribution	5.00	10.00	15.00	0.00	10.00	12.00	10.00	13.00	17.00	100.00
Depletion	5.00	3.75	15.00	0.00	10.00	12.00	2.06	2.68	3.51	62.00
Remaining Resources 1-1-71	0.00	6.25	0.00	0.00	0.00	0.00	7.94	10.32	13.49	38.00

The Secor memo ends with the following "miscellaneous information":

"A. Incomplete records: Often the (BOM) TAB sheets and state reports left out data on thickness, coal bed name, and breakdown between augered and stripped coal at the same mine. If no solid data could be found, these gaps were filled by the judgement of the worker (Edwin Secor and Robert Reese).

"B. Multiple bed coal strip mines: Records usually did not break production down by individual beds. Distribution of such production was either made proportional to remaining resource as of 1/1/71 or split evenly between beds, depending on worker's judgement."

After a search of the DOE field office files, the calculation sheets used by Secor in applying the methodology described above were discovered. One sheet was used for each county/bed combination. Also discovered in the files was a set of sheets on which the underground and surface production and depletion for the years 1969 and 1970, by thickness category (14"-28", 28"-42", >42") were presented. A third set of calculation sheets provided the Kelly January 1968 bed/county surface reserve estimates, along with the 1968 bed/county surface depletion. Spot checking the bed/county reserve calculation sheets, and crosschecking those sheets with the two other sets of calculation sheets (the 1969-70 depletion sheets, and the Kelly surface reserve, 1968 depletion sheets), the Brant and DeLong report, and the DeCarlo figures, indicated that the methodology discussed in the Secor memo had indeed been employed. However, the sources of the 1968-71 depletion, and the source of the Kelly surface reserve estimates could not be confirmed.

The 1969-70 surface and underground depletion shown on the calculation sheets was found to have been used to deplete the DeCarlo figures, as was stated in the memo. However, the BOM tab sheets could not be found in the DOE field office files, so the source of the depletion

figures could not be confirmed.⁴³ The Kelly January 1968 surface reserve estimates presented on the Kelly calculation sheets were found to have been the basis for the bed/county estimates, but the original Kelly files, on which the calculation sheets presenting the Kelly estimates are supposedly based, could not be found in the DOE field office files. However, a fourth set of calculation sheets presenting bed/county strippable reserve estimates matching the Kelly estimates was found in the files, and a marginal note on one of the sheets stated "M. Hinkle 9/2/71 revised reserve for Ohio (strip)". A 6-page report by the eastern field office to EIA in Washington sent by Telecopier on January 19, 1979, had stated: "The surface DRB is based on an unpublished BOM study by Reed, A. H. (1968, The Strippable Coal Reserves of Ohio). This study only estimated reserves for coalbeds with more than 28 inches of clean coal, but a folder of calculations indicate the study was revised by Hinkle, M. E., in 1971" (emphasis added). Unfortunately, the Hinkle calculation sheets do not indicate how the revisions to the estimates presented in the Reed report were calculated (the Reed estimates, which represent economically recoverable reserves, differ substantially from the Hinkle estimates). The "folder of calculations" could not be found in the DOE field office files.

Other than sources of the 1968-70 depletion figures, and the source of the January 1968 Kelly estimates, all statements made in the Secor memo were confirmed on the basis of the three sets of calculation sheets found in the DOE field office files. An example of the Secor methodology, as it was applied to one bed/county combination, is presented in the following paragraphs.

⁴³Likewise, the source of the 1968 surface depletion figures could not be confirmed as being based on production data from the BOM tab sheets and the 1968 Ohio Division of Mines annual report.

The Pittsburgh No. 8 seam, in Washington County, was selected for this illustrative example. Exhibit 1 presents a typed version of the calculation summary sheet developed by Secor for this bed/county combination. The first row of figures on this sheet was developed from the data presented in Table 37 of the Brant and Delong report. Exhibit 2 presents a copy of a page of that table listing the reserve data for the Pittsburgh seam/Washington county combination. In comparing the Exhibit 1 data with the Exhibit 2 data, it can be seen that for the measured category, the figures match. The figures in the inferred, 14"-28" category differ slightly, but this difference appears to be due to a transcription error. The figures in the other four categories differ because the thickness categories employed in the Brant and Delong report differ from the categories employed by Secor.⁴⁴ Here, Secor referred to the reference documents listed in the bibliography of the Brant and Delong report to obtain additional information needed to break the Brant and Delong reserve estimates down by the 28"-42" and >42" thickness categories. Although the figures in the individual thickness/reliability categories do not match, when the total >28" reserves in each reliability category are calculated from both Exhibit 1 and Exhibit 2, the totals match (or, at least, nearly match), as the following table indicates:

	<u>Brant and Delong</u>	<u>Secor</u>
Total >28" indicated (million tons) reserves	6.04	6.04
Total >28" inferred (million tons) reserves	13.79	13.59

⁴⁴This did not affect the measured category because the Brant and Delong report indicated that there was no reserves in the 54" category.

Exhibit 1

ESTIMATED REMAINING RESERVES OF COAL AS OF JANUARY 1, 1971 BY COAL BED
(Millions of Tons)

Coal Bed Name	Code Number	Measured			Indicated			Inferred			Measured and Indicated			Total		
		14"-20"	20"-42"	>42"	14"-20"	20"-42"	>42"	14"-20"	20"-42"	>42"	14"-20"	20"-42"	>42"	14"-20"	20"-42"	>42"
Pittsburgh #8	ORIG 016	20.59	9.91	0	80.30	2.59	3.45	53.21	1.68	11.91	30.50	86.34	66.80			183.64
Minus Depletion to 1971		0.37	0.18	0	1.46	0.05	0.06	0.00	0.00	0.00	0.55	1.57	0.00			2.12
1-1-71		20.22	9.73	0	78.84	2.54	3.39	53.21	1.68	11.91	29.92	84.77	66.80			181.52
Stripable Reserves 1/1/71			1.36	0		0.36	0.47									
		2.83			11.04											2.19
		0.00			0.00											13.87
		2.83	1.36	0	11.04	0.36	0.47	0.00	0.00	0.00						0.00
											4.19	4.87	0.00			16.06

A-03

Exhibit 2

FROM TABLE 37 - BRANT AND DELONG REPORT

County and Township	Total					Proven				Probable				Inferred			
	Thickness Category					Thickness Category				Thickness Category				Thickness Category			
	Total	14"-26"	26"-54"	54"-84"	Unclassified	Total	14"-26"	26"-54"	54"-84"	Total	14"-26"	26"-54"	54"-84"	Total	14"-26"	26"-54"	54"-84"
SCOTTS	67,282	6,728	6,118	-	78,418	2,307	120	2,187	-	8,178	4,743	3,926	-	1,358	1,358	-	-
Middle Blounting	7,750	1,351	100	-	-	-	-	-	-	858	258	106	-	885	885	-	-
Lower Blounting	4,908	2,719	2,149	-	-	1,094	120	974	-	3,452	2,377	1,176	-	362	362	-	-
Clarion	6,178	1,411	3,147	-	-	1,713	-	1,713	-	3,866	1,310	2,554	-	101	101	-	-
Tionesta	40,320	-	-	-	40,320	-	-	-	-	-	-	-	-	-	-	-	-
Upper Mercer	23,000	-	-	-	23,000	-	-	-	-	-	-	-	-	-	-	-	-
Lower Mercer	10,368	-	-	-	10,368	-	-	-	-	-	-	-	-	-	-	-	-
Quakerstown	1,728	-	-	-	1,728	-	-	-	-	-	-	-	-	-	-	-	-
STARR	1,442,857	212,540	707,641	15,196	507,852	118,021	19,442	92,398	8,961	822,512	86,492	426,385	6,218	289,772	100,114	185,358	-
Upper Freeport	25,517	1,117	1,057	12,815	-	4,721	872	880	4,558	19,188	3,877	8,212	0,218	264	110	121	-
Middle Blounting	348,454	16,833	321,197	-	-	46,674	4,176	42,399	-	211,581	11,112	200,416	-	90,673	1,510	88,953	-
Lower Blounting	362,214	162,244	209,922	-	-	28,346	7,265	21,111	-	144,923	66,161	98,760	-	488,923	98,878	90,015	-
Brookville	198,164	38,484	158,756	1,383	-	36,860	7,258	28,219	1,363	116,842	25,542	621,300	-	15,062	5,824	9,216	-
Tionesta	6,912	-	-	-	6,912	-	-	-	-	-	-	-	-	-	-	-	-
Bedford	3,456	-	-	-	3,456	-	-	-	-	-	-	-	-	-	-	-	-
Lower Mercer	5,184	-	-	-	5,184	-	-	-	-	-	-	-	-	-	-	-	-
Sharon	492,000	-	-	-	492,000	-	-	-	-	-	-	-	-	-	-	-	-
SUMMIT	228,000	-	-	-	228,000	-	-	-	-	-	-	-	-	-	-	-	-
Sharon	228,000	-	-	-	228,000	-	-	-	-	-	-	-	-	-	-	-	-
TRUMBULL	149,760	-	-	-	149,760	-	-	-	-	-	-	-	-	-	-	-	-
Sharon	149,760	-	-	-	149,760	-	-	-	-	-	-	-	-	-	-	-	-
TUSCARAWAS	2,026,110	538,940	1,409,712	35,810	44,618	900,331	81,740	478,388	20,893	1,009,931	301,894	592,412	15,413	471,208	182,300	288,902	-
Upper Freeport	731,607	8,886	90,172	77,164	-	79,785	468	17,818	11,812	82,707	5,973	60,070	10,790	8,715	2,266	2,470	-
Lower Freeport	18,281	9,084	9,197	-	-	9,444	3,101	6,443	-	8,737	5,983	2,754	-	-	-	-	-
Middle Blounting	1,000,390	84,486	902,822	12,870	-	364,992	16,200	330,744	8,843	498,186	47,087	623,266	4,827	180,213	1,411	148,802	-
Lower Blounting	749,643	121,842	326,101	-	-	91,816	28,473	66,403	-	353,104	176,467	174,663	-	304,548	167,582	137,016	-
Brookville	91,544	41,750	29,218	874	-	14,120	8,310	1,743	874	64,131	44,353	21,748	-	11,282	11,017	235	-
Tionesta	23,448	-	-	-	23,448	-	-	-	-	-	-	-	-	-	-	-	-
Upper Mercer	11,000	-	-	-	11,000	-	-	-	-	-	-	-	-	-	-	-	-
VINTON	8,172,123	333,319	508,784	9,300	323,720	276,875	61,971	208,732	4,472	834,161	234,205	297,051	3,128	37,143	33,443	-	-
Upper Freeport	21,138	10,029	6,109	1,088	-	17,810	2,522	8,050	1,948	4,771	3,787	1,259	-	-	-	-	-
Middle Blounting	133,353	89,216	109,820	4,317	-	11,177	19,321	50,379	1,477	100,081	37,408	58,441	2,640	2,087	2,087	-	-
Lower Blounting	303,967	140,006	61,161	-	-	43,669	17,838	25,831	-	131,271	99,718	37,510	-	33,070	23,070	-	-
Clarion	246,936	79,990	264,051	2,998	-	120,594	11,126	106,759	2,707	210,931	59,348	87,291	288	9,414	9,414	-	-
Brookville	102,811	43,568	59,243	-	-	24,825	9,112	11,713	-	73,161	31,634	41,510	-	2,622	2,622	-	-
Upper Mercer	28,920	-	-	-	28,920	-	-	-	-	-	-	-	-	-	-	-	-
Lower Mercer	28,800	-	-	-	28,800	-	-	-	-	-	-	-	-	-	-	-	-
Quakerstown	260,000	-	-	-	260,000	-	-	-	-	-	-	-	-	-	-	-	-
WASHINGTON	1,242,321	441,009	227,919	16,249	566,184	169,922	78,000	89,702	3,130	311,818	231,085	134,721	6,211	185,058	132,726	13,406	8,928
Washington	78,161	-	-	-	78,161	-	-	-	-	-	-	-	-	-	-	-	-
Waynesburg A	35,610	-	-	-	35,610	-	-	-	-	-	-	-	-	-	-	-	-
Uniontown	502,020	-	-	-	502,020	-	-	-	-	-	-	-	-	-	-	-	-
Mills Creek	512,353	287,106	219,961	6,484	-	139,476	87,416	79,880	2,130	264,478	180,769	121,535	2,384	88,249	79,703	1,546	-
Pittsburgh	183,644	183,641	17,958	11,188	-	30,496	20,844	9,917	-	84,338	80,294	1,184	2,887	66,899	53,021	8,074	8,928
WAYNE	10,526	10,526	10,371	-	239,758	6,225	6,443	3,292	-	3,279	4,416	2,712	-	6,213	866	1,161	-
Lower Blounting	13,571	7,121	9,411	-	-	4,085	1,713	2,313	-	2,258	817	2,712	-	6,213	866	1,161	-
Brookville	8,722	7,182	940	-	-	4,640	3,710	940	-	4,072	4,072	-	-	-	-	-	-
Tionesta	4,912	-	-	-	4,912	-	-	-	-	-	-	-	-	-	-	-	-
Bedford	4,912	-	-	-	4,912	-	-	-	-	-	-	-	-	-	-	-	-
Upper Mercer	3,456	-	-	-	3,456	-	-	-	-	-	-	-	-	-	-	-	-
Lower Mercer	2,304	-	-	-	2,304	-	-	-	-	-	-	-	-	-	-	-	-
Quakerstown	6,184	-	-	-	6,184	-	-	-	-	-	-	-	-	-	-	-	-
Sharon	216,000	-	-	-	216,000	-	-	-	-	-	-	-	-	-	-	-	-

After distributing the original reserve estimates to thickness categories, the next step was to deplete the reserves using the updated January 1971 DeCarlo reserve estimate. The January 1969 DeCarlo estimate for the Pittsburgh seam/Washington County combination was 181.7 million tons.⁴⁵ Depletion to January 1971 was obtained from the depletion calculation sheets found in the Ohio file; from the Pittsburgh seam/Washington County sheet it was found that the total surface production for the years 1969-70 was 143,053 tons (there was no underground production). This total was multiplied by 1.25, the depletion factor for surface mining,⁴⁶ to yield a total depletion of 0.18 million tons. When subtracted from the January 1969 Decarlo reserve estimate, an updated January 1971 estimate of 181.52 million tons is obtained. Referring to row 3 (1/1/71), last column of Exhibit 1, the 181.52 million ton estimate is found. Two rows above this figure (in the same column), the total original reserve estimate, equal to the sum of the estimates in each thickness/reliability category, is found. Finally, the difference between the original reserve estimate and the Decarlo January 1971 estimate is presented as the depletion, to January 1971, in the second row, last column. The 2.12 million tons was distributed to the measured and indicated,⁴⁷ 14"-28", 28"-42", and >42" categories in proportion to the percentage of reserves in each of these categories as per the Secor methodology.

⁴⁵This estimate was obtained from the DeCarlo calculation sheets currently kept by Richard Bonskowski.

⁴⁶For underground mining, the depletion factor employed was 2.00.

⁴⁷Under the Secor methodology, it should be recalled, depletion was not assigned to the inferred category unless there were insufficient reserves in the measured and indicated categories to cover the depletion. This was not the case for the Pittsburgh seam/Washington County combination.

For example, the total original, measured and indicated reserves in all thickness categories, from Exhibit 1, is 116.84 million tons. The 20.59 million ton estimate in the 14"-28", measured category is 17.6 percent of the 116.84 million ton total, thus 17.6 percent of the 2.12 million ton total depletion, or 0.37 million tons, was assigned to the 14"-28", measured category. After distributing the depletion to the thickness/reliability categories, the January 1971 reserve estimates for each category were obtained by subtracting the depletion from the original reserves for each category. The results are presented in row 3 of Exhibit 1.

Having determined total reserves for the standard thickness/reliability categories, the next step was to determine the strippable reserves. The strippable reserves, it should be recalled, were based on Hinkle's summary calculation sheets discovered in the Ohio file. Exhibit 3 presents a typed version of a portion of the first page of Hinkle's summary sheet; at the bottom of the page (first column) the 1/1/68 strippable reserve estimate for the Pittsburgh seam/Washington County combination is presented (2.5 million tons). This was depleted first to 1/1/69; as Exhibit 4 (a typed version of a portion of the Pittsburgh seam/Washington County January 1969 strippable reserve calculation sheet) indicates. The 2.37-million-ton January 1969 estimate from this sheet was further depleted to January 1971 using the 0.18 million ton surface depletion figure calculated earlier. The result, 2.19 million tons, matches the figure presented in the last column of the fifth row in Exhibit 1. The 2.19 million tons, it should be recalled, represents strippable reserves >28" in thickness. These reserves were distributed to the measured and indicated,⁴⁸ 28"-42" and >42" categories in proportion to the January 1971 total reserves

⁴⁸As the Secor memo stated, surface reserves were not allocated to the inferred category.

Exhibit 3

M. HINKLE 9-2-71 REVISED RESERVES FOR OHIO (STRIP)

IN THOUSANDS OF TONS

	Remaining Resource <u>1-1-68</u>	80% Recovery	Strippable Reserves
Pittsburgh			
Athens	55,900	44,700	13,000
Belmont	209,600	167,700	47,000
Gallif	46,700	37,000	8,900
Guernsey	75,200	60,200	13,500
Harrison	155,700	124,600	34,900
Jefferson	304,500	246,000	68,900
Meigs	14,700	11,800	2,400
Morgan	32,700	26,200	4,100
Muskingum	1,875	1,500	500
Noble	84,800	67,800	16,300
Washington	<u>2,500</u>	<u>2,000</u>	<u>400</u>
	986,700	789,500	212,700

Exhibit 4

PITTSBURGH SEAM/WASHINGTON COUNTY 1/1/69

STRIPPABLE RESERVE CALCULATION SHEET

State	Ohio	Code	390
County	Washington	Code	167
Reference	Tab sheets - Kelly's County Files		

Seam	Code Number	Strippable Production 68	Auger Production 68	Strippable Depletion 68	Auger Delpetion 68	Total Reserves 1-1-68	Total Reserves 1-1-68
Washington							
Waynesburg A							
Uniontown							
Meigs Creek #9						64,600,000	64,600,000
Pittsburgh #8	107,429 (54)			134,286		2,500,000	2,365,714

8-3-68

in these categories (see rows 3 and 5 of Exhibit 1). Strippable reserves in the 14"-28" measured and indicated categories were determined by assuming that the percentage of total strippable reserves to total reserves in the 28"-42" and >42", measured and indicated categories would be the same as the percentage of strippable to total reserves in the 14"-28", measured and indicated categories. The total reserves in the 28"-42" and >42", measured and indicated categories equals $(9.73 + 0 + 2.54 + 3.39 =) 15.66$ million tons, and the total strippable reserves in these categories (2.19 million tons) is 14% of the 15.66 million ton total. Thus, 14 percent of the 20.22 million ton 14"-28", measured total reserves was taken to obtain 2.83 million tons of strippable reserves, and 14 percent of 78.84 million tons was taken to obtain 11.04 million tons of 14"-28", indicated strippable reserves (see row 6 of Exhibit 1). Thus, the January 1971 strippable reserve estimates for the Pittsburgh seam/Washington County were derived and distributed to thickness and reliability categories (see row 8 of Exhibit 1).

After following the Secor methodology presented above for all bed/county combinations, all that remained to derive the 1979 DRB was to sum the January 1971 measured and indicated, 28"-42" and >42" total reserves, along with the January 1971 measured and indicated, 14"-28", 28"-42", >42" surface reserves, obtained from the calculation sheets based on the Secor methodology, across all bed/county combinations, and to deplete to January 1979. The summation yielded 18,273.28 million tons total January 1971 reserves, and 6437.05 million tons January 1971 surface reserves. To obtain the January 1971 underground reserves, the surface reserves in the 14" to 28" thickness range were summed across all bed/county combinations (yielding 1330.23 million tons), the resulting total was added to the 18,273.28 million tons of >28" total reserves, and the 6437.05 million tons of January 1971 surface reserves was subtracted to yield 13,166.46 million tons of January 1971 underground reserves. Depletion to January 1979 was

calculated using production data from the DOE and BOM computer printout; total surface production from 1971 through 1978 was multiplied by 1.25, and total underground production from 1971 through 1978 was multiplied by 2.00.. Then:

Surface:

6437.05	million tons 1/1/71 remaining reserves
<u>-318.92</u>	depletion
6118.13	million tons calculated 1979 DRB
<u>-6029.53</u>	published 1979 DRB
88.60	million tons discrepancy

Underground:

13,166.46	million tons 1/1/71 remaining reserves
<u>- 235.70</u>	depletion
12,930.76	million tons calculated 1979 DRB
<u>-13,005.14</u>	published 1979 DRB
- 74.38	million tons discrepancy.

The reasons for the discrepancies could not be ascertained. Thus, the methodology presented in the Secor memorandum could not, ultimately, be confirmed. Nonetheless, we believe the Secor methodology does represent the general methodology followed in deriving the published 1979 DRB. After calculating the January 1979 reserves on the basis of the Secor methodology and calculation sheets, and finding the discrepancies, a thorough re-review of the Ohio file was conducted to ascertain whether another basic methodology might have been employed to derive the 1979 DRB. Although numerous other calculation sheets were found, these all were determined to have been used to derive the 1971, not 1979, published DRB. Perhaps some small adjustments to the Secor methodology, not discovered during the review or included in the Secor memorandum, were

made, or perhaps an arithmetic⁴⁹ or coding error⁵⁰ was made, but we believe the general Secor methodology represents the methodology employed in deriving the 1979 DRB.

The Ohio methodology discussed above is presented in graphic form in Exhibit 5.

⁴⁹Either ours or the field office's.

⁵⁰The 1/1/71 bed/county total and surface reserve estimates by reliability and thickness categories, calculated employing the Secor methodology, were coded (on sheets referred to as the "green weenies" in the files) and apparently entered on computer. Since none of the calculation sheets found in the Ohio file presents total state reserves, it is believed that the 1979 DRB was calculated by computer from the coded bed/county data.

EXHIBIT 5

OHIO METHODOLOGY

PENNSYLVANIA

The reserve base for Pennsylvania must be divided into two separate discussions. The first covers the anthracite reserves of eastern Pennsylvania, while the second will discuss the bituminous reserve methodology. Although the methodologies are similar, different sources and factors provide sufficient contrast to warrant individual treatment. Also the emphasis of these discussions is on the procedure used to prepare the 1971 DRB, since the latest DRB estimates represent, for the most part, simple depletion from the 1971 totals. Figures 1 and 2 illustrate the general methodology for deriving the Pennsylvania DRB.

Pennsylvania Anthracite

The basic source for the anthracite DRB was Edmunds (1972)⁵¹, which estimated original anthracite resources. The original resource base for Pennsylvania anthracite is taken from Appendix A, column 1, of Edmunds (1972) as 24,460.0⁵² million short tons. This was computed from Ashley (1945), and includes coal greater than 14" thick. The demonstrated reserve base estimates were derived from the remaining resource figures from Appendix A of Edmunds.

The basic methodology for obtaining the 1979 DRB hinges on the procedure used to derive the 1/1/71 DRB. The Edmunds estimate was for a total original resource, and the first step was to deplete the resource figures to 1971.

⁵¹Edmunds, W. E., Coal Reserves of Pennsylvania -- Total Recoverable and Strippable (January 1, 1970), Pennsylvania Bureau of Topographic and Geological Survey Information Circular 72, 1972.

⁵²Sullivan County was included as bituminous, but is part of the anthracite fields.

Figure 1

FLOWCHART OF PA ANTHRACITE

Figure 2

FLOWCHART OF PA BITUMINOUS

The BOM procedure for obtaining the 1971 resource base rests on the production records contained in the annual state reports of the Pennsylvania Anthracite Division. The production, both strip and underground was totaled from 1870 to 1971. Depletion was obtained by using the factors of 2.0 for underground, and 1.11 for surface reserves. The 1.11 reflects historical surface depletion factors for anthracite contained in Bureau files.

The depletion was then subtracted from the original county resource estimate to derive the January 1971 resource figure. For example, Edmunds estimated Carbon County contained 630 million short tons of in-place coal originally. Underground and surface production from 1870 to January 1971 was 195.14 and 15.65 million tons respectively. This leads to a total depletion of 407.66 million tons, and a January 1971 resource figure of 222.34 million short tons. Each county was depleted in a similar manner, and Figure 3 shows the results.

Once the January 1971 resource base by county was obtained, the total county resource base for the Anthracite was split. This was done based on the following assumptions made by the Bureau:

Depth

- 50% of the county resource -- lies 0-1000'
- 35% of the county resource -- lies 1000'-2000'
- 15% of the county resource -- lies 2000'-3000'

Thickness

- 10% of the reserve (0-1000') is 14"-28"
- 41% of the reserve (0-1000') is 28"-42"
- 49% of the reserve (0-1000') is > 42"

Given these assumptions, the new total county resource base for 1/1/71 is as follows:

Figure 3

ANTHRACITE DEPLETION TO JANUARY 1971

(In Million Tons)

<u>County</u>	<u>Original Resource Base</u>	<u>Depletion</u>		<u>1/1/71 Resource Base</u>
		<u>Underground</u>	<u>Strip</u>	
Carbon	630.00	390.28	17.38	222.34
Columbia	615.00	195.14	12.63	407.23
Dauphin	870.00	63.53	0.35	806.12
Lackawanna	2,030.00	1,461.26	24.52	544.22
Lebanon	1,000.00	--	0.21	999.79
Luzerne	4,525.00	3,521.55	83.28	920.17
Northumberland	2,600.00	951.18	39.74	1,609.08
Schuylkill	12,130.00	2,457.83	150.60	9,521.57
Sullivan	35.00	13.61	0.34	21.05
Susquehanna	15.00	14.52	0.53	0.00
Wayne	10.00	7.26	0.02	2.72
				<u>15,054.29</u>

Revised January 1971 Resource Base

(in million short tons)

<u>County</u>	<u>Old 1/1/71 Resource</u>	<u>New 1/1/71 Resource</u>
Carbon	222.34	111.17
Columbia	407.23	203.62
Dolphin	806.12	403.06
Lackawanna ^a	544.22	408.17
Lebanon	999.79	499.90
Luzerne ^a	920.17	690.15
Northumberland	1,609.08	804.54
Schuylkill	9,521.52	4,760.76
Sullivan ^b	21.05	21.05
Susquehanna	0.00	0.00
Wayne ^b	2.72	2.72
Total	15,054.29	7,905.12

^a These counties were split 75/25, instead of 50/50. There is no explanation for the variance in the split.

^b These counties retained all their resource tonnage. Again, there is no information in the files to suggest why these counties retained all these resources.

Strippable resources for anthracite were developed on a county basis by BOM engineers. These reserve amounts and proportions prepared by BOM could not be derived/verified from the source documents by either SRC, or EIA. A note in a file memo of October 2, 1980 states:

"Once the total resource as of January 1, 1971, was calculated a strippable resource was estimated for each county...It appears that this estimate was made to allow for enough strippable coal for about a 40-year period."

Because the strippable reserve was underivable, the file estimates of 161.17 million tons cannot be documented. However, EIA accepted this figure as the January 1971 surface resource estimate. This in turn, became the surface reserve estimates for January 1971.

The underground reserve estimate of January 1971 was derived by following the Bureau thickness criteria of 90% percent (41 percent 28-42", 49 percent = >42") falling within DRB limits. By subtracting 161.17 million from 7,905.18 and then multiplying by 0.9007, the underground reserve of 6,975.27 million tons can be derived. No documentation was found in the files as to why 0.9007 was used. The total DRB of January 1971 therefore, comes to 7,136.40 million tons (6,975.27 + 161.17).

Depletion from January 1971 to January 1979 was relatively straightforward. Again, depletion was based on the factors of 2.00 and 1.11. The source for the production from 1971 thru 1976 was the U.S. Mineral Yearbooks, and for years 1977 and 1978, EIA production reports. Depletion for underground production totalled 12.16 million tons. Depletion for surface mining (excluding dredging and culm bank recovery) totalled 28.56 million tons.

By subtracting the depletion between January 1971 and January 1979 from the 1971 DRB, the 1979 DRB can be derived. This is shown in the tables below:

<u>Year</u>	<u>Anthracite Production Underground</u>	<u>1971-1978 Surface</u>	<u>Total</u>
1971	1.29	4.48	5.77
1972	0.94	3.48	4.42
1973	0.73	3.28	4.01
1974	0.66	2.87	3.53
1975	0.64	2.56	3.20
1976	0.58	3.00	3.58
1977	0.64	3.10	3.74
1978	0.60	2.96	3.56
Total	6.08	25.73	31.81

	<u>1/1/71 DRB</u>	<u>Depletion 1971-1978</u>	<u>1/1/79 DRB</u>
Total	7,136.44	40.72	7,095.72
UG	6,975.27	12.16	6,963.11
Strip	161.17	28.56	132.61

Pennsylvania Bituminous

A great number of sources were used in deriving the original reserve base of Pennsylvania bituminous coal. They are listed individually at the end of this discussion, but can be grouped under three major headings, namely:

- The "Dowd" reports, covering Allegheny, Armstrong, Cambria, Clarion, Clearfield, Fayette, Greene, Indiana, Jefferson, Somerset, Washington and Westmoreland Counties. The remaining reserves were reported as of the respective study dates.
- USGS Bulletins, used as the primary source in Beaver, Butler and Lawrence Counties. Original reserves were identified.

- Reese and Sisler (1978), used as the primary source in Bedford, Blair, Bradford, Cameron, Centre, Clinton, Elk, Fulton, Huntington, Lycoming, McKean, Mercer and Tioga Counties. In addition, this report supplemented the Dowd work on selected seams and in estimating the inferred reserves. Resources as of January 1977 were estimated in this report.

Strippable reserves were obtained from the unpublished Reed report, entitled The Strippable Coal Reserves of Pennsylvania.

The Dowd reports covered 12 counties and all major seams (i.e., coking coal) within these counties. The Dowd reports estimated coal reserves in standard thickness (14"-28", 28"-42", >42") in measured and indicated categories only. No inferred resources were estimated and not all seams were covered in the Dowd counties. The reserves were estimated as of January 1, usually 1 to 3 years prior to the date of publication. No strippable reserves were estimated by Dowd.

The USGS Bulletins were used for three counties. Again, reserves were estimated by standard thickness (14"-28", 28"-42", >42") and reliability (measured, indicated, and inferred) categories, however, these bulletins estimated original reserves. Strippable resources are estimated to a depth of 60 feet.

The Reese and Sisler report estimated resources on a bed/county level throughout the state. Unfortunately, the report was based on 1,692 tons/acre-foot, estimated resources >18", and gave no reliability categories.

Finally, the Reed report estimated strippable reserves >28 inches. No reliability or thickness categories were given. It appears EIA had little confidence in the data contained in Reed, but had no alternative sources to use.

Figure 4 shows the general sources used for the county and bed reserve estimates of underground Pennsylvania bituminous. Deriving

Figure 4

SOURCES FOR PENNSYLVANIA ESTIMATES

<u>County</u>	<u>Seam</u>	<u>Source</u>	
ALLEGHENY -	REDSTONE PITTSBURGH U. FREEPORT M. KITTANNING L. KITTANNING L. FREEPORT - R&S	} DOWD R&S	DOWD = Dowd Reports R&S = Reese and Sisler USGS = USGS Bulletins
ARMSTRONG -	PITTSBURGH U. FREEPORT L. FREEPORT U. KITTANNING M. KITTANNING L. KITTANNING CLARION MAHONING - UNKNOWN BROOKVILLE - R&S	} DOWD R&S	
BEAVER -	ALL FROM USGS		
BUTLER -	ALL FROM USGS		
CAMBRIA -	ALL FROM DOWD		
CLARION -	U. FREEPORT L. FREEPORT M. KITTANNING L. KITTANNING U. CLARION L. CLARION BROOKVILLE U. KITTANNING - R&S ALTON (MERCER) - R&S	} DOWD R&S	

Figure 4

(Continued)

CLEARFIELD - U. FREEPORT
L. FREEPORT
U. KITTANNING
M. KITTANNING
L. KITANNING
BROOKVILLE

} DOWD

CLARION - UNKNOWN

FAYETTE - WAYNESBURG
SEWICKLEY
PITTSBURGH
U. FREEPORT
REDSTONE
L. KITTANNING
BROOKVILLE

} DOWD

BAKERSTOWN - UNKNOWN
L. FREEPORT - R&S
U. KITANNING - R&S

GREENE - WAYNESBURG
SEWICKLEY
PITTSBURGH

} DOWD

U. FREEPORT - R&S

INDIANA - PITTSBURGH
U. FREEPORT
L. FREEPORT
U. KITTANNING
M. KITTANNING
L. KITTANNING
BROOKVILLE

} DOWD

JEFFERSON - MAHONING
U. FREEPORT
L. FREEPORT
U. KITTANNING
M. KITTANNING
L. KITTANNING
CLARION
BROOKVILLE

} DOWD

Figure 4

(Continued)

LAWRENCE - USGS

SOMERSET - REDSTONE
PITTSBURGH
U. FREEPORT
L. FREEPORT
U. KITTANNING
M. KITTANNING
L. KITTANNING
CLARION
SEWICKLEY - R&S
LITTLE PITTSBURGH - R&S
BAKERSTOWN - UNKNOWN
BROOKVILLE - R&S

WASHINGTON - WASHINGTON
WAYNESBURG
REDSTONE
PITTSBURGH
U. FREEPORT

WESTMORELAND - WAYNESBURG
REDSTONE
PITTSBURGH
U. FREEPORT
L. FREEPORT
L. KITTANNING
SEWICKLEY - UNKNOWN
M. KITTANNING - R&S

the underground and surface reserves for the January 1971 DRB was first done by BOM engineers using these sources in the following manner.

The underground Dowd county reserves for the January 1971 DRB, as Figure 4 illustrates, are the product of the Dowd reports, unknown source, and the Reese and Sisler report. To obtain the January 1971 underground reserve for a Dowd county required taking the Dowd estimates from 28" or greater and adding any additional seam estimates from Reese and Sisler.

To use Reese and Sisler, several manipulations of the data were necessary. First, the resources were multiplied by 1.066 to place the estimates on a standard tonnage density of 1,800 tons per acre-foot. Secondly, the thickness categories of 14"-28", 28"-42", >42" were graphically derived from source descriptions of each seam. From these manipulations, an original resource by thickness was obtained.

The original underground resource base for each Dowd county was then depleted to January 1971. A standard depletion factor of 2.00 was used. However, production for the period between the Dowd reports (early 1950s) to January 1971 required several stages.

The first stage was to deplete the resources of January 1927 of Reese and Sisler seams to the same year as the remaining reserves of the Dowd report. This was done using the Pennsylvania Department of Labor Production Statistics and a standard depletion factor of 2.00 for underground mining.

The entire county was then depleted to January 1971 from production reports of the U.S. Bureau of Mines. This depletion was not a strict yearly depletion of coal reserves, but included several short-cuts because, it seems, of a lack of time.

The first shortcut was an "averaging" of 10-year production between the years 1956 to 1965. This was done by adding the 1956 and 1965 production together, dividing by 2 and multiplying by 10.

The second shortcut was the "substituting" of 1969 production data for 1970. This was accomplished by using the 1969 production again for 1970 estimates.

This production was then depleted by using a factor of 2.00 for underground production.

To derive a percentage between "measured", "indicated", and "inferred" from the 1/1/71 resource total for the Reese and Sisler resources the BOM apparently used a proportion derived from a Dowd seam split between measured and indicated within the county. This proportion varied from county to county depending upon which split percentage was used. For example, in Armstrong County, the Brookville seam is taken from Reese and Sisler as a resource estimate of 175.91 (16.5 x 1.066) million tons. From the seam description, it was determined the thickness categories would at least include 28"-42" and > 42" (the minimum seam thickness was 28", the maximum was > 60 inches). During the graphical redistribution of the seam resources, the resources were split into 14"-28" (12.49 million tons), 28"-42" (12.888 million tons), and > 42" (34.54 million tons).

The apportioning of Reese and Sisler seams into measured, indicated, and inferred resources in Armstrong county required using the same reliability splits of the closest (stratigraphic) Dowd seam, the Lower Kittanning. (Inferred resources on the Dowd seams were derived from map data by planimetering.) The two seams are isolated from worksheets to illustrate this proportion:

	<u>Dowd</u> <u>Lower Kittanning</u>	<u>Reese and Sisler</u> <u>Brookville</u>	<u>%</u>
Measured			
14-28	31.54	3.52	
28-42	213.23	24.28	> 22.5
> 42	103.66	11.85	
Indicated			
14-28	6.01	0.70	
28-42	174.96	19.88	> 11.3
> 42	--	--	
Inferred			
14-28	72.26	8.27	
28-42	745.97	84.72	> 66.20
> 42	199.47	22.69	
Total	<u>1,546.60</u>	<u>175.91</u>	

Although there is evidence in the files to suggest the Reese and Sisler estimates were generally broken into a 40/60 reliability split (measured and indicated/inferred), it was found this strict apportioning had been replaced in favor of the Dowd derived percentages.

The USGS counties estimated original reserves for underground Pennsylvania bituminous. To update these counties to 1/1/71, it was necessary to deplete the underground reserves by yearly production and the standard depletion factor of 2.00. Sources for this production included BOM production reports and Pennsylvania Department of Labor reports. Again, the production between 1956 and 1965 was averaged, and the 1970 production estimated.

The Reese and Sisler counties were handled in a somewhat similar manner to the USGS counties. The resources of January 1927 were depleted to January 1971 by using the production averaging methods between 1956 and 1965, estimating the 1970 production, and using a depletion factor of 2.0. The remaining resources were split, 40/60 (40 percent - measured & indicated, 60 percent - inferred) to derive the reserves of January 1971.

The strippable reserve estimates for 1/1/71 were developed by a completely different methodology based on the Reed report (1968), and Edmunds (1972).⁵³ This methodology appears to have been a "quick fix" solution to the uncertainty of information found in Reed.

The original strippable reserves for Pennsylvania bituminous were identified in Table 4 of Edmunds as 2,272.5 million tons. From this total, the strip coal production to January 1968 from Reed (Table 1, page 12) of 586.630 million tons was subtracted to yield a 1/1/68 figure of 1,685.87 million tons. (This production figure was not changed to a depleted figure before being used.) From this January 1968 figure, the depleted (1.25 = factor) strip and auger production from January 1968 to January 1971 of 90.024 million tons (from U.S. BOM Yearbooks) was subtracted to yield the January 1971 reserve base of 1,575.85 million tons. This total was broken down to a county basis to be added into the underground estimates.

In conclusion, the January 1971 bituminous reserve base was the sum of each county reserve depleted to January 1971. To summarize, Figure 5 shows the total January 1971 underground demonstrated reserve base for Pennsylvania bituminous as compiled by EIA on a county basis.

The January 1979 reserve base is a straight depletion of the January 1971 totals. Underground depletion used 2.00 as the depletion factor, while surface depletion used 1.25. Figure 6 is a table showing the production from 1971 through 1978 taken from EIA reports.

⁵³Edmunds, W. E., Coal Reserves of Pennsylvania -- Total, Recoverable, and Strippable (January 1, 1970), Pennsylvania Bureau of Topographic and Geological Survey Information Circular, 72, 1972.

Figure 5

1/1/71 RESOURCE AND RESERVE BASE

<u>COUNTY</u>	<u>DRB</u>	
Allegheny ^a	703.12	
Armstrong ^a	1,212.41	a 'Dowd' Counties
Beaver ^b	602.45	b USGS Counties
Bedford	20.05	
Blair	19.38	
Bradford	12.36	
Butler ^b	1,156.02	
Cambria ^a	1,533.27	
Cameron	25.61	
Centre	231.10	
Clarion ^a	818.31	
Clearfield ^a	1,306.35	
Clinton	43.32	
Elk	87.54	
Fayette ^a	1,080.90	
Fulton	10.80	
Greene ^a	6,599.72	
Huntington	36.53	
Indiana ^a	1,753.70	
Jefferson ^a	478.23	
Lawrence ^a	217.01	
Lycoming	12.52	
McKean	152.75	
Mercer	165.98	
Somerset ^a	1,315.02	
Tioga	39.59	
Venango	57.05	
Washington ^a	3,657.20	
Westmoreland ^a	765.30	
Total	24,384.79	

1/1/71 DRB

Total = 24,384.79

UG = 22,788.94

Strip = 1,595.85

Figure 6

BITUMINOUS PRODUCTION 1971 - 1978
(In Million Tons)

<u>Year</u>	<u>Underground</u>	<u>Surface</u>	<u>Total</u>
1971	44.32	27.53	
1972	49.16	26.63	
1973	45.70	28.79	
1974	42.09	38.14	
1975	44.63	39.51	
1976	43.70	42.07	
1977	38.36	46.25	
1978	32.93	47.85	
Total	340.89	296.77	

This production resulted in underground depletion of 681.70 million tons from the 1/1/71 DRB and a surface depletion of 370.96 million tons from the 1/1/71 DRB. This yields the 1/1/79 DRB as published and seen below.

	<u>1/1/71 DRB</u>	<u>Depletion</u>	<u>1/1/79 DRB</u>
Total	24,384.79	1,052.66	23,332.13
UG	22,788.94	681.70	22,107.24
Strip	1,595.85	370.96	1,224.89

TENNESSEE

The 1979 demonstrated reserve base for Tennessee is based upon the work of Luther (1959)⁵⁴, Luther and Johnson (1972)⁵⁵, and various BOM of Investigations (i.e., "Dowd" reports). This work was modified by a more recent study by Wilson (1979)⁵⁶ on the Richland and Sewanee seams in 11 Tennessee counties. Figure 1 shows the general progression of the reserve base methodology to 1979.

The original resource for six Tennessee counties was estimated by Luther as of January 1959. The recoverable resource for each seam by county was estimated by Luther by standard reliability (i.e., measured, indicated, and inferred) in thickness categories greater than 28" (28" -42", and > 42") with given recovery factors for each seam. To get the original resource of January 1959, the recoverable tonnage was divided by the appropriate recovery factor for each seam. The five Tennessee counties exempt from this procedure were Anderson, Campbell, Claiborne, Morgan, and Scott. These will be discussed later.

⁵⁴Luther, E.T., The Coal Reserves of Tennessee, Tennessee Department of Conservation and Commerce, Division of Geological, Bulletin 63, 1959.

⁵⁵Johnson, R.C., and Luther, E.T., Strippable Coal in the Northern Cumberland Plateau Area of Tennessee, Tennessee Department of Conservation, Division of Geology, Report of Investigations 34, 1972.

⁵⁶Wilson, R.L., Evaluation of the Coal Reserves in the Whitwell Shale in the Southern Cumberland Plateau in Tennessee, Geosciences Department, University of Tennessee at Chattanooga, under U.S. Department of Energy Grant Number DOE-ET-77-G-01-9009, 1979.

Figure 1

GENERAL TENNESSEE METHODOLOGY

The original resource figures of January 1959 for these six counties were then updated to January 1971 with production data from the BOM annual production surveys and depleted using the standard 2.00 for underground and auger, and 1.25 for strip. The January 1971 total resource was further proportioned into thickness, reliability, and mineability categories. The procedure followed is best illustrated by a county example. Putnam county, in east central Tennessee, will serve as a typical county. It contains one coal seam called Wilder.

Figure 2 shows the Putnam County calculations from January 1959 to January 1971 for 28" or greater coal reserves. The source of the January 1959 numbers is Luther (1953) (for the total figures), and Luther and Johnson (1972) (for the strippable and underground percentage). Basically, each category total, whether "measured", "indicated", or "inferred", was obtained from Luther (1959), Table 55, page 231, as shown in Figure 3. Here, the reserve categories were divided by the recovery factor to yield an original resource. For example, the measured reserves in Luther over 28" totals 4.874 million tons ($0.655 + 4.219$). When divided by the given recovery factor, 61.2 percent, it yields the total measured reserve of 7.964 million short tons for Putnam county, as seen in the appropriate total measured column of Figure 1. Each total column for each seam and county can be derived in this manner.

From the category totals, the strippable reserves were proportioned out. This was done on the basis of the Luther and Johnson report (1972), which identified strippable percentages in 5 of the 11 eastern Tennessee counties (called reference counties). These percentages were then extrapolated to the other counties based on professional judgement and proximity to a reference county. For Putnam County, the strippable percentage of Morgan County (a reference county) totals 16 percent of the total Morgan County reserve. Therefore, Figure 1 shows the strippable breakout of January 1959 based on the 16 percent strip factor applied to Putnam County.

Figure 2

PUTNAM COUNTY DEPLETION - 1959 to 1971

	1/1/59				1/1/71		
	<u>Measured</u>	<u>Indicated</u>	<u>Inferred</u>	<u>Depletion</u>	<u>Measured</u>	<u>Indicated</u>	<u>Inferred</u>
Total	7.96	18.10	14.25	0	6.70	15.25	11.99
UG	6.69	15.20	11.97	6.37	5.43	12.35	9.71
STRIP	1.27	2.90	2.28	0	1.27	2.90	2.28

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Figure 3

RECOVERABLE RESERVES OF PUTNAM COUNTY (LUTHER, 1959)

<i>Seam</i>	<i>Recovery factor (percent)</i>	<i>Thickness (inches)</i>	<i>Measured reserves</i>	<i>Indicated reserves</i>	<i>Inferred reserves</i>	<i>Total</i>
Wilder	61.2	28-42 +12	655,000	1,920,000	2,293,000	4,868,000
			4,219,000	9,160,000	6,425,000	19,804,000
			Seam total			
County total						24,672,000

To estimate the reserves falling within the 14"-28" category, EIA used the Dowd reports (a complete list is include at the end of this section). Figure 4 shows the calculations for coal resources between 14"-28" from January 1953 to January 1971 for Putnam County. This is based solely on a Dowd report, RI5029, entitled Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Putnam County, Tennessee, by Williams et. al., 1954. The January 1953 figures are taken directly from column 10, Table 1, page 9, showing 0.566 million measured and 0.498 (estimated at 0.50) million indicated tons respectively.

An assumption that all coal is underground mineable by EIA shows the strip reserves having no coal in January 1953 or January 1971.

Depletion to January 1971 for Putnam County was done on a porpor-tional reliability basis. The underground depletion, in other words, was not subtracted from only the measured category, but depleted from the measured, indicated, and inferred categories porportionally.

Depletion was subtracted from the January 1959 reserve base by using the reliability category proportions found in Luther (1959). Here, Luther broke the total reserve of Putnam County (Wilder Seam) into 20 percent measured, 45 percent indicated and 35 percent inferred reserves. Therefore, the total depletion, 6.37, was broken into these same proportions and subtracted from the appropriate reliability category.

To derive the January 1979 reserve base from the January 1971 DRB for all counties except Bledsoe, Cumberland, Grundy, Hamilton, Marion, Morgan, Rhea, Roane, Sequatchie, Van Buren and White (the so-called "Wilson" counties) was just a matter of depleting from January 1971 to January 1979. For Putnam, a non-Wilson County, the total production based on BOM mineral yearbooks is 0.813 million tons, yielding 1.63 million tons of underground depletion, as shown in a worksheet from Exhibit 1. When subtracted from the appropriate January 1971 DRB

Figure 4

"DOWD" ESTIMATES FOR PUTNAM COUNTY COAL (14"-28")*

	1/1/53				1/1/71		
	<u>Measured</u>	<u>Indicated</u>	<u>Inferred</u>	<u>Depletion</u>	<u>Measured</u>	<u>Indicated</u>	<u>Inferred</u>
Total*	0.57	0.50	0	0	0.57	0.50	0
UG	0.57	0.50	0	0	0.57	0.50	0
STRIP	0	0	0	0	0	0	0

*EIA assumed all 14-28 was underground mineable

Exhibit 1

WORKSHEET SHOWN DEPLETION BETWEEN 1971-1978

FOR NON-WILSON COUNTIES

TENNESSEE PRODUCTION
1971- 1978

"Non-Wilson" COUNTIES		1971	1972	1973	1974	1975	1976	1977	1978	TOTAL	DEPLETION 71-78
ANDERSON	1										
Oil/1000	2	2.319	2.497	1.912	1.782	1.848	2.063	1.810	1.726	15.957	26.82
STRIP	3	1.210	1.346	1.112	.607	.716	.539	.618	.648	6.796	8.50
UG	4	1.109	1.151	.800	1.175	1.132	1.524	1.192	1.078	9.161	18.32
CAMPBELL	5										
Oil/1000	6	1.984	1.872	1.552	1.430	1.920	1.686	1.979	2.423	14.916	20.94
STRIP	7	1.875	1.670	1.045	1.362	1.640	1.245	1.412	1.612	11.868	14.84
UG	8	.109	.202	.507	.061	.280	.441	.567	.881	3.048	6.10
CLAIBORNE	9										
Oil/1000	10	2.118	2.125	2.080	1.576	1.198	1.328	1.271	1.173	12.939	22.57
STRIP	11	.962	.849	.704	.619	.230	.336	.390	.322	4.412	5.52
UG	12	1.136	1.346	1.376	.957	.968	.992	.881	.851	8.527	17.05
FENTRESS	13										
Oil/1000	14	.137	.412	.062	.010	.403	.539	.842	.412	2.817	3.59
STRIP	15	.103	.307	.048	.010	.403	.518	.842	.410	2.721	3.40
UG	16	.034	.025	.014	0	0	.021	0	.002	.076	.19
OVERTON	17										
Oil/1000	18	0	.003	0	0	0	0	0	0	.003	0
STRIP	19	0	.003	0	0	0	0	0	0	.003	0
UG	20	0	0	0	0	0	0	0	0	0	0
POTNAM	21										
Oil/1000	22	.097	.082	.099	.100	.097	.120	.108	.110	.813	1.63
STRIP	23	0	0	0	0	0	0	0	0	0	0
UG	24	.097	.082	.099	.100	.097	.120	.108	.110	.813	1.63
PICKETT	25										
Oil/1000	26	0	0	0	0	0	0	0	0	0	0
STRIP	27	0	0	0	0	0	0	0	0	0	0
UG	28	0	0	0	0	0	0	0	0	0	0
SCOTT	29										
Oil/1000	30	.614	1.395	.759	1.133	1.036	1.291	1.026	1.661	9.184	12.49
STRIP	31	.526	1.214	.695	1.031	.758	.974	.948	1.538	7.834	7.72
UG		.019	.121	.264	.101	.278	.317	.148	.103	1.350	2.10

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column in Figure 2, the January 1979 numbers can be derived as part of the January 1979 state DRB totals (Figure 5).

The remaining procedure for obtaining the January 1979 DRB from the five counties initially missed (between January 1959 and January 1971) and the "Wilson" Counties (between 1/1/59 and 1/1/71) will be discussed next. Our example county for this derivation will be Morgan County, located in the center of the Tennessee coal fields. The original source documents for Morgan and the other counties was Luther and Johnson (1968) for strippable reserves, and Luther (1959) for the total reserves.

Basically, the total reserves and original resource base greater than 28", was obtained from Luther (1959). For Morgan County, this is shown in Figure 6, "Estimated Recoverable Coal Reserves in Morgan County, by Seams". When each seam reserve by reliability category is "backed out" by the recovery factor, the original resource as of is obtained.

The strippable portion of the total resource base of January 1959 is obtained from Luther and Johnson (1968). Here, the January 1968 strippable resource (from Table 11, pages 30-34) was added up by seam and quadrangle to give a county strippable total. This was entered on to a worksheet along with the total resource of January 1959 from Luther.

The production and depletion of strippable reserves from 1959 to 1968 by county and seam were obtained from the BOM annual survey of coal mine production using standard depletion factors. Depletion was added to the worksheet and the January 1968 strippable resource was added to the depletion to derive the January 1959 strippable resource.

The January 1959 underground resource became, simply, the product of the total resources minus the strippable. Underground production

Figure 5

1/1/79 DRB FOR THE "NON-WILSON" COUNTIES

<u>County</u>	<u>DRB</u>		
	<u>0-1000'</u>	<u>Strip</u>	<u>Underground</u>
Anderson	111.20	40.18	71.02
Campbell	264.04	75.46	188.58
Claiborne	29.53	10.72	18.81
Fentress	46.87	7.30	39.57
Overton	11.58	7.38	4.20
Pickett	0.60	0.21	0.18
Putnam	20.32	4.17	16.15
Scott	94.21	38.08	56.13
"Non-Wilson" County Totals	577.96	183.32	394.64

Figure 6

ESTIMATED RECOVERABLE COAL RESERVES
IN MORGAN COUNTY, BY SEAMS (LUTHER, 1959)
(In Short Tons)

Seam	Recovery factor (percent)	Thickness (inches)	Measured reserves	Indicated reserves	Inferred reserves	Total
Wilder	50.0	28-42 +42		186,000	625,000	811,000
						Seam total 811,000
Newton	50.0	28-42 +42		761,000	1,573,000	2,334,000
						Seam total 2,334,000
Rex	50.0	28-42 +42	2,289,000	1,854,000	4,849,000	9,031,000
						Seam total 9,031,000
Hoover	50.0	28-42 +42		71,000	912,000	1,016,000
						Seam total 1,016,000
Poplar Creek	50.0	28-42 +42	2,346,000 670,000	7,552,000 1,311,000	12,261,000 576,000	22,159,000 2,527,000
						Seam total 24,716,000
Jellison	50.0	28-42 +42	3,252,000 70,000	12,000		3,264,000 70,000
						Seam total 3,334,000
Joyner	50.0	28-42 +42	1,656,000	2,667,000	5,693,000	10,016,000
						Seam total 10,016,000
Winstaruk	50.0	28-42 +42	220,000	421,000	432,000	1,079,000
						Seam total 1,079,000
Big Mary	50.0	28-42 +42	1,971,000 2,840,000	2,958,000 5,645,000	1,449,000 7,828,000	6,378,000 16,353,000
						Seam total 22,731,000
Walnut Mountain	50.0	28-42 +42	1,761,000	1,533,000	2,880,000	6,180,000
						Seam total 6,180,000
Pewee	62.3	28-42 +42	1,611,000	778,000	180,000	3,369,000
						Seam total 3,369,000
Grassy Spring	50.0	28-42 +42		24,000		24,000
						Seam total 24,000
County total						84,641,000

MORGAN COUNTY RESERVES

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was obtained between 1959 and 1968 and depleted to yield a remaining resource for 1968.

A second file worksheet was used for the depletion of the production resource base for Morgan County from 1968 to January 1971. Again, BOM production data was used.

The derivation of the January 1971 underground reserve base from the January 1971 underground resource base for these five counties comes from Luther (1959). The reliability proportions reported by him in his original estimates among measured, indicated, and inferred reserves served as a guide. For Morgan County, the proportions are as follows:

<u>Seam</u>	<u>Measured Percent</u>	<u>Indicated Percent</u>	<u>Inferred Percent</u>	<u>Total Percent</u>
Wilder		23	77	100
Sewanee	0	33	67	100
Rex	25	21	54	100
Hooper	0	7	93	100
Poplar Creek	12	36	52	100
Jellico	100	0	0	100
Joyner	17	27	56	100
Windrock	21	39	40	100
Big Mary	21	38	41	100
Walnut Mountain	29	25	46	100
Pewee	48	23	29	100
Grassy Spring	0	100	0	100

These figures enabled the 1/1/71 resource figures to be split between reliability categories and thickness categories.⁵⁷

⁵⁷No worksheets showing these calculations were contained in the files, although indirect evidence suggests this was the methodology.

The strippable reserves were split from the resource numbers in a manner similar as the underground reserve by the reliability proportions found in Luther and Johnson (1968).

Updating the January 1971 reserve base to January 1979 for the so-called "Wilson" counties required using data from Wilson (1979)⁵⁸. The counties under scrutiny by Wilson were:

Bledsoe	Rhea
Cumberland	Roane
Grundy	Sequatchie
Hamilton	Van Buren
Marion	White
Morgan	

The object of the Wilson report was to estimate the reserves of two major seams, the Swannee and Richland, lying in the above counties.

The January 1979 can be generally derived for these countries from file worksheets by depleting the January 1971 DRB (as developed earlier) to January 1979 and incorporating the new Wilson data. EIA production records were the source of the underground and strip production, with depletion coming from the standard factors of 2.00 for underground and auger, and 1.25 for strip.

The basic procedure was to take the previous January 1971 DRB figures, subtract the identified January 1971 reserves of Swannee and Richland coals, then add in the new estimates based on Wilson's work to derive a new

⁵⁸Wilson, R.L., 1979, Evaluation of the Coal Reserves in the Whitwell Shale in the Southern Cumberland Plateau in Tennessee, U.S. Department of Energy, Final Report.

January 1971 estimate.⁵⁹ Figure 7 shows the summary of Wilson's work for Morgan county estimates on the Richland and Swanee seams. The rest of the seams in the counties in Wilson's work were updated to January 1979 by depletion from EIA production figures. Figure 8 shows the summarized January 1979 resource and DRB.⁶⁰

From the two summary worksheets (Figures 5 and 7) of the Wilson and non-Wilson Counties, the January 1979 DRB as published in the EIA document can be derived by adding the DRB totals for each of the counties.

⁵⁹This new 1/1/71 estimate was really a split figure, i.e., the Richland and Swanee seam reserves were of 1/1/79, but all the rest of the Non-Wilson counties and non-Wilson seams were still as of 1/1/71.

⁶⁰The calculation sheets for updating the non-Wilson seams were not available. However, it appears Morgan County did follow this methodology.

Figure 7

SUMMARY OF MORGAN COUNTY RESERVES OF
THE RICHLAND AND SWANEE SEAMS

(From Wilson)

Richland Seam

** No Reserves **

Swanee Seam (Average 30")

(In Tons)

	<u>14-28</u>	<u>28-42</u>	<u>>42</u>	<u>Total</u>
Measured	0	255,000	51,000	306,000
Indicated	0	135,000	80,000	215,000
Inferred	0	451,000	243,000	694,000
		<u>841,000</u>	<u>374,000</u>	<u>1,215,000</u>

Figure 8

1/1/79 DRB FOR THE "WILSON" COUNTIES

<u>County</u>	<u>DRB</u>		
	<u>0-1000'</u>	<u>Strip</u>	<u>Underground</u>
Bledsoe	45.54	12.28	33.26
Cumberland	49.71	13.72	35.99
Grundy	6.34	0.00	6.34
Hamilton	49.61	14.06	35.55
Marion	10.87	6.59	4.28
Morgan	98.40	41.92	56.48
Rhea	12.07	3.88	8.19
Roane	2.39	0.21	2.18
Sequatchie	82.42	23.02	59.40
Van Buren	52.52	29.93	22.59
White	9.90	4.08	5.82
"Wilson"	419.77	149.69	270.08
County Total			
1/1/79			

LIST OF "DOWD" PUBLICATIONS FOR TENNESSEE

1. Williams L., and Hershey, R.E., Estimate of Known Recoverable Reserves of Coking Coal in Bledsoe County, Tenn., U.S. Bureau of Mines Report of Investigations 5234, 1956.
2. Lowe, R.W., Crentz, W.L., and Miller, J.W., Estimate of Known Recoverable Reserves and Preparation Characteristics of Coking Coal in Fentress County, Tenn., U.S. Bureau of Mines Report of Investigations 5235, 1956.
3. Hershey, R.E., Williams, L., and Gandrud, B.W., Estimate of Known Recoverable Reserves of Coking Coal in Grundy County Tenn., U.S. Bureau of Mines Report of Investigations 5148, 1955.
4. Hershey, R.E., Williams, L., Crentz, W.L., and Miller, J.W., Estimate of Known Recoverable Reserves and the Preparation Characteristics of Coking Coal in Hamilton County, Tenn., U.S. Bureau of Mines Report of Investigations 5263, 1956.
5. Williams, L., Hershey, R.E., and Gandrud, B.W., Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Marion County, Tenn., U.S. Bureau of Mines Report of Investigations 5159, 1955.
6. Williams, L., Abernethy, R.F., Gandrud, B.W. Reynolds, D.A., and Wolfson, D.E., Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Overton County, Tenn., U.S. Bureau of Mines Report of Investigations 5131, 1955.
7. Williams, L., Lowe, R., Turnbull, L.A., Carman, E.P., Crentz, W.L., Reynolds, D.A., and Abernethy, R.G., Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Putnam County, Tenn., U.S. Bureau of Mines Report of Investigations 5029, 1954.
8. Williams, L., Hershey, R.E., Abernethy, R.F., Gandrud, B.W., and Reynolds, D.A., Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Sequatchie County, Tenn., U.S. Bureau of Mines Report of Investigations 5136, 1955.
9. Hershey, R.E., Williams, L., Crentz, W.L., and Miller J.W., Estimate of Known Recoverable Reserves and Preparation Characteristics of Coking Coal in Van Buren County, Tenn., U.S. Bureau of Mines Report of Investigations 5208, 1956.
10. Williams, L., James, C., Gandrud, B.W., and Reynolds, D.A., Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Anderson County, Tenn., U.S. Bureau of Mines Report of Investigations 5185, 1955.
11. Williams, L., Gibbs, H.K., Crentz, W.L., Miller, J.W., and Reynolds, D.A., Estimate of Known Recoverable Reserves and Preparation and Carbonizing Properties of Coking Coal in Campbell County, Tenn., U.S. Bureau of Mines Report of Investigations 5258, 1956.
12. Hershey, R.E., Williams, L., Crentz, W.L., Miller, J.W., Reynolds, D.A., Estimate of Known Recoverable Reserves and Preparation and Carbonizing Properties of Coking Coal in Claiborne County, Tenn., U.S. Bureau of Mines Report of Investigations 5229, 1956.
13. Williams, L., James, C., Crentz, W.L., and Miller, J.W., Estimate of Known Recoverable Reserves and the Preparation Characteristics of Coking Coal in Morgan County, Tenn., U.S. Bureau of Mines Report of Investigations 5266, 1956.
14. Williams, L., Gibbs, H.K., Crentz, W.L., and Miller, J.W., Estimate of Known Recoverable Reserves and Preparation Characteristics of Coking Coal in Scott County, Tenn., U.S. Bureau of Mines Report of Investigations 5232, 1956.

VIRGINIA

The principal sources for Virginia DRB reserves estimates are the reports by Brown and others and Hinkle. These reports provide reserve estimates of Virginia bituminous and anthracite coal as of 1/1/51. Brown and others reported resources by county and coalbed, by standard thickness categories, and by standard reliability categories. The strippable resources were derived from Hinkle, as of 1/1/68. The procedure used to derive the Virginia DRB is shown in Figure 1.

Both the bituminous and anthracite DRB figures for 1979 were re-developed from the original source documents. The first step in this process was to reestimate the Brown figures for identified coal resources as of 1/1/51. This was done to account for new information (Hinkle and Island Creek coal Company reserve data) on both strip and deep resources.

An example of the reestimation procedure can be shown by examining Buchanan County. Exhibit 1 shows the data taken directly from Brown and others (1952) as of 1/1/51. As shown by this exhibit the total estimated resource base for Buchanan County was 3650.09 million tons. Because Brown did not provide good estimates of strippable reserves/resources, the Hinkle (1969) report was used to adjust the 1/1/51 tonnage figures.

The strippable reserves came from Table 45, page 112 of Hinkle. The column entitled "Remaining Strippable Reserves" was used in the following manner:

- The total reserve estimates were depleted to 1/1/71 based on production data obtained from BOM annual reports.
- The strip production totals were then apportioned by seam, into thickness ranges and reliability categories based on information contained in Hinkle.

Figure 1.

VIRGINIA DRB METHODOLOGY

Exhibit 1

VIRGINIA IDENTIFIED COAL RESOURCE AND DEMONSTRATED RESERVE BASE - 1/1/1951

BASED ON USGS CIRCULAR 171 (1952)

COUNTY	COAL BED	CODE	MEASURED			INDICATED			INFERRED			RESOURCE	DRB
			'14"-28"	'28"-42"	'>42"	'14"-28"	'28"-42"	'>42"	'14"-28"	'28"-42"	'>42"		
BUCHANAN	027												
CEDAR GROVE	151							3.80				3.80	3.80
L. CEDAR GROVE	154					0.43		0.32	0.71		0.81	2.27	0.75
CAMPBELL CK.	168						30.23			19.52		49.75	30.23
CAINTWOOD	174		0.18	12.33		6.40	30.24	22.41	3.17	11.05		92.70	78.56
EAGLE	176	0.98	4.92	8.20	32.98	96.17	36.68	32.60	3.17			215.70	179.93
BLAIR	177						11.50	19.78	1.74	25.83	2.83	61.68	31.28
DORCHSTER	185	0.93	0.66			26.60	15.67		60.98	0.42		105.33	43.86
HAGY	195					25.70	168.62	11.44	75.11	22.90		303.77	205.76
SPASH DAM	210	3.28	26.93	35.72	262.57	240.28	92.37	47.35				708.50	661.15
U. BANNER	214					1.90	1.50		2.43			5.83	3.40
L. BANNER	216	0.76	2.12	3.94	96.32	31.24	12.87	132.18				286.43	154.25
BIG FORK	232					0.98			7.04	1.51		9.53	0.98
KEHLNDY	252	0.64	0.05		278.57	254.96	7.96	222.87	6.90			771.95	542.18
AILY	253					5.50			36.72			42.29	5.50
RAVEN	259	1.69	14.21	1.28	53.65	82.57		422.29				575.69	153.40
JAWBONE	266	0.25	2.11	1.59	57.47	138.63	7.17	120.77	8.24			336.92	207.22
TILLER	269	0.21	1.88	6.05	26.16	10.27	6.97	25.25	0.65			77.44	51.54
L. SEABOARD	285					0.42			7.23			7.65	0.42
WAR CK.	311								2.00	0.96		2.96	0
LEXINGTON	344							10.77	32.23	32.74	23.50	113.24	10.77
			2.74	53.06	62.11	215.65	1111.88	235.77	1178.51	102.96	4.60	3650.09	2367.40

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- The strippable reserves were then depleted back to 1/1/51 where appropriate adjustments were made to the Brown resource figures.

A good example of this three-step procedure is the Clintwood seam in Buchanan County. The 1/1/51 resource estimate for this seam, as established by Brown was 92.78 million tons. Hinkle estimates the remaining strippable resource as of 1/1/68 at 53.10 million tons. Strip and auger production for the period 1/1/51 to 1/1/71 was computed as 8.65 million tons, 5.27 and 3.38 million tons were assigned to Clintwood seam strip and auger production respectively. Strip production was depleted using the standard recovery factor of 80%, auger was depleted based on 50% recovery. Total depletion for the Clintwood seam through 1/1/71 was therefore estimated at 13.35 million tons (2.9 million tons for the period 1/1/68 to 1/1/71). The remaining strippable resource as of 1/1/51 was then computed to be 63.5 million tons ($53.10 - 2.9 + 13.35 = 63.5$). Hinkle estimated that 60% of the total Clintwood seam resources were strippable. Based on this information the 1/1/51 resource of 92.78 million tons, as reported by Brown, was increased to 105.06 million tons.

This basic procedure was followed for all counties and seams. In same cases the Hinkle numbers were used as a direct replacement for the Brown estimates. This was done for those seams reporting no underground production between 1951 and 1971 and where the Hinkle resources estimates were greater than those reported by Brown. Also, for the Pocahontas #3 seam, 600 million tons of inferred coal was added to the DRB. The most majority of the Pocahontas #3 seam in Buchanan County, Virginia lies at depths between 1,000 and 2,000 feet. Although this resource lies outside standard DRB criteria in both reliability and depth classifications the decision was made to include this coal in the DRB based on reserve estimates found in Island Creek Coal Company's Annual Report.

Virginia anthracite for the January 1979 DRB is based entirely on Brown and others (1952). The resource estimates found in Brown are original resources and therefore had to be fully depleted (Past DRB's assumed erroneously that the resource estimates were as of January 1951).. Exhibit 2 shows the derivation of the Virginia anthracite DRB estimate.

One assumption was made for Virginia anthracite figures, and that assumption centered around the apportioning of historical production from the anthracite fields. The historical production was split as 80 percent from Montgomery County and 20 percent from Pulaski County. Historical production records from Brown and others suggest the dominance of production from Montgomery County and the figures were adjusted to reflect this situation.

Exhibit 2

VIRGINIA ANTHRACITE IDENTIFIED RESOURCE AND DEMONSTRATED RESERVE BASE

	INDICATED				INFERRED				RESOURCE GRAND TOTAL		DRB
	14"-28"	28"-42"	>42"	TOTAL	14"-28"	28"-42"	>42"	TOTAL			
1											
2											
3					MONTGOMERY COUNTY						
4	ORIGINAL RESOURCE	18.16	9.45	63.31	90.92	18.10	4.36	19.14	41.60	132.52	
5	* DEPLETION			9.60	9.60					9.60	
6	11/79 RESOURCE	18.16	9.45	53.71	81.32	18.10	4.36	19.14	41.60	122.92	63.16
7											
8											
9											
10											
11					PULASKI COUNTY						
12	ORIGINAL RESOURCE	12.78	1.19	63.54	77.51	4.82	0	59.43	64.25	141.76	
13	* DEPLETION			2.40	2.40					2.40	
14	11/79 RESOURCE	12.78	1.19	61.14	75.11	4.82	0	59.43	64.25	139.36	62.33
15											
16											
17											
18											
19					WYTHE COUNTY						
20	ORIGINAL RESOURCE	0	0	0	0	.96	14.05	66.33	81.34	81.34	
21	* DEPLETION										
22	11/79 RESOURCE	0	0	0	0	.96	14.05	66.33	81.34	81.34	0
23											
24											
25											
26											
27					COUNTIES TOTAL						
28	ORIGINAL RESOURCE	30.94	10.64	126.85	168.43	23.88	18.41	144.90	187.19	355.62	
29	* DEPLETION			12.00	12.00					12.00	
30	11/79 RESOURCE	30.94	10.64	114.85	156.43	23.88	18.41	144.90	187.19	343.62	123.42
31											
* DEPLETION IS 1.00 X PRODUCTION. ORIGINAL RESOURCE AND PRODUCTION TAKEN FROM USGS CIRCULAR 177. PRODUCTION IS 80% OF PRODUCTION.											
											51,140,180

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WEST VIRGINIA

The 1979 demonstrated reserve base was derived using two basic methodologies; one for those counties covered by reserve reports prepared by Dowd and others, and another for the rest of the state. The basic source documents used are the Dowd et. al. reports, (1952-1956) Headlee and Nolting (1940), the West Virginia Geological Survey (WVGS) county reports (1909-1930), and Reed (1968). A complete bibliography is listed at the end of this discussion. The "Dowd" counties used Dowd et. al. (1952-1956), Headlee and Nolting (1940), and Reed (1968) as the source documents. The non-Dowd counties used the WVGS county reports (1909-1939), Headlee and Nolting (1940), and Reed (1968) to arrive at their estimates. Because the methodologies are different, separate discussions are warranted.

Non-Dowd Counties

The non-Dowd counties comprise 33 of the 44 coal bearing counties in West Virginia. A complete re-estimation of the reserves contained in these countries was done for the January 1979 DRB. Figure 1 outlines the methodological approach followed in each of these counties.

The principal difference between the reserve estimations for the Dowd and non-Dowd counties lies in the estimation of measured and indicated reserves. Prior to the preparation of the 1979 DRB coal underlying the 33 non-Dowd counties was assumed to be 40 percent measured and indicated and 60 percent inferred, since the source documents for these counties did not clarify reserves/resources by reliability category. In preparation for the 1979 DRB each WVGS county report was reviewed in detail to determine the extent of mining activity by bed, and to establish a qualitative assessment of the available information about each bed. The end product of this task

Figure 1

WEST VIRGINIA NON-DOWD COUNTY METHODOLOGY

was a redistribution of county resource information by reliability category. In some counties the "measured and indicated" tonnage estimates were more than doubled, while in other counties, where little information was available, coal reserves falling within DRB criteria were reduced dramatically.

In addition to adjusting the estimated resources within reliability categories, two other manipulations of the tonnage data were required. First, the non-Dowd-county source documents estimated original resources based on a coal density factor of 1,742 tons/acre-foot. To be consistent with Dowd and estimates of other states, resource tonnages were recalculated using 1,800 tons per acre-foot to reflect the standard density of in-place coal. This was accomplished by multiplying all bed-county estimates by 1.033.

The second adjustment made to the WVGS reports was to divide the reported resources tonnages into standard DRB seam thickness categories. The WVGS reports, for the most part, gave only the average bed thickness for a county and minimum and/or maximum seam thicknesses. These points were plotted based on corresponding tonnage assumptions (i.e., 50 percent of the total resource was at the average bed thickness). Linear intrapolation was then used to split the total resource into the appropriate thickness categories. An example of the adjustment procedures followed in non-Dowd counties can be found in Mineral County, West Virginia. The WVGS report for Grant and Mineral Counties identified an original resource for Mineral County of 628.95 million tons. The report provided tonnage estimates by seam and by average seam height. The first step taken to adjust the Mineral County resources was to standardize the coal seam tonnage based on the 1,800 tons per acre-foot density factor. This resulted in an increase in the total resource estimate from 628.95 to 836.51 million tons. Once the total resources were derived by seams they were divided into standard seam thickness categories and then, based on engineering judgement were further divided into reliability categories. The results of these adjustments are shown in Table 1.

Table 1

MINERAL COUNTY CALCULATIONS

Seam	Resources (MM Tons) @ 1800 T/AC ft.	<14	Thickness Category		>42	Total M&I Tonnage/%		Total Inf. Tonnage/%	
			14-20	20-42					
Sewickley	1.93				1.93	1.74	90	0.19	10
Redstone	5.25		0.89	3.05	1.31	1.05	20	4.20	80
Pittsburgh	42.58				42.58	38.32	90	4.26	10
Little Clarksburg	29.61		14.80	13.32	1.48	8.88	30	20.73	70
Elk Lick	71.65		35.83	32.24	3.58	35.83	50	35.83	50
Harlem	46.14		46.14			13.84	30	32.29	70
Upper Bakerstown	94.52		26.46	36.86	31.19	28.36	30	66.16	70
Bakerstown	151.51			139.39	12.12	75.76	50	75.76	50
Mahoning	107.91		33.45	42.62	31.83	53.95	50	53.95	50
Upper Freeport	221.86		39.93	119.80	62.12	110.93	50	110.93	50
Upper Kittanning	8.75	0.70	5.08	2.97		2.63	30	6.13	70
Lower Kittanning	54.80		33.43	21.37		10.96	20	43.84	80
Total*	836.51	0.70	236.01	411.62	188.14	382.24		454.27	

*May not be consistent across columns due to rounding.

It should be noted that based on the former 40 percent - 60 percent reliability category split the measured and indicated resources of mineral county were estimated at about 334.60 million tons. The new procedures set this tonnage at 382.24 million tons.

The strippable resource for Mineral County, and for that matter, all non-Dowd counties was obtained from Reed (1968) on a coal bed basis. According to the methodology reported in a EIA field office memo of 11/4/80:

"Depletion values from worksheets used in preparing the strip report by Avery Reed allowed calculation of an original strip resource".

These sheets are in the county files and the Mineral County figure can be derived by adding up the column entitled "Total Original Strippable Reserves (#4)" of the recapitulation section of the sheet. This amounts to 64.5 million tons. The original strippable coal reserve was calculated, according to the file memo, by multiplying the ratio of the total DRB estimate to the total resource estimate by the original strippable resource. In attempting to document this procedure for original strip reserves, we could not derive all estimates in this manner. Table 2 shows SRC's work-up of strippable reserves for Mineral County. By following the stated procedure we estimate Mineral County strippable reserves at 37.41 million tons whereas the figure used to prepare the 1979 DRB was 25.56 million tons. The reason for this discrepancy is at this time unknown.

Production for the non-Dowd counties was derived from the following documents and years:

Table 2

DERIVATION OF MINERAL COUNTY STRIPPABLE RESERVE ESTIMATES

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Coal Bed	(In Million Short Tons) Original Strip Resource ^a	Total Coal Bed DRB ^b Total Coal Bed Resource	Total Strippable Reserves
Sewickley	1.20 x	1.74/ 1.93 (90)	1.082
Redstone	3.30 x	1.05/ 5.25 (20)	0.660
Pittsburgh	20.90 x	38.32/ 42.58 (90)	18.809
Upper Bakerstown	11.80 x	28.36/ 94.52 (30)	3.540
Bakerstown	12.10 x	75.76/151.51 (50)	6.050
Mahoning	6.10 x	53.95/107.91 (50)	3.050
Upper Freeport	8.00 x	110.93/221.86 (50)	4.000
Lower Kittanning	1.10 x	10.96/ 54.80 (20)	0.220
Total	64.50		37.411

^aFrom Reed (1968) worksheets.

^bFrom County write-ups in file.

1800-1985: Eavenson, H. First Century and a Quarter of American Coal Industry

- 1886-1930: U.S.G.S. Mineral Reports
- 1931-1970: (Except 1954, 1961): BOM Annual Reports
- 1954, 1961: West Virginia Department of Mines Annual Reports
- 1971-1978: EIA production printouts.

This follows closely with the file memo outlining the procedure, and with the calculation sheets contained in the county files. The depletion was then calculated using 2.0 for underground and auger mining, and 1.25 for surface mining.

In Mineral County, the total production and depletion is:

<u>Underground</u>	<u>Surface</u>	<u>Total</u>
66.95	4.75	71.70

These are also seen in the 1979 worksheets for the total DRB.

The total depletion for each county was then subtracted from the original county DRB (>28"), and the strip depletion subtracted from the original strip reserve base estimate for that county. The underground reserve base was the result of subtracting the strip estimate from the total DRB. For our example of Mineral County, the DRB of January 1979 was simply; $292.90 - 71.70 = 221.11$ total DRB (>28"), and the strip DRB; $25.56 - 4.75 = 20.81$ with the underground DRB becoming simply 200.30 million short tons. Every non-Dowd county followed this methodology to arrive at the January 1979 DRB.

Dowd Counties

The 11 Dowd Counties of West Virginia used a different methodology to reach the January 1979 DRB. The basic source documents

for the Dowd counties included the Dowd reports, the Sheridan-Decarlo reserve numbers (based on Headlee & Nolting, 1940), and the Reed (1968) strip report. Figure 2 shows the general methodology.

The Dowd reports covered only the coking coals of a county and gave reserve estimates of the coal in the "measured and indicated" category with 14"-28", 28"-42", and >42 inch thickness. The reserve base was completed by using the Sheridan-Decarlo reserve estimates of January 1965. These numbers were based on the Headlee and Nolting (1940) study of West Virginia coals, which covered the entire state. Basically, the procedure to derive the "inferred" estimates centered around subtracting the Dowd numbers from the Sheridan-Decarlo numbers for every Dowd seam. If the result was positive, then the difference became the "inferred". If the result were zero or negative, the "inferred" was assumed to be zero.

An example Dowd county for illustration purposes is Brooke County, located in the northern tip of the state. Dowd (1955) reported on the Washington, Waynesburg, and Pittsburgh seams. The total reserve reported was:

<u>Seam</u>	<u>Reserves (> 28")</u>
Washington	-
Waynesburg	11.148
Pittsburgh	<u>179.172</u>
Total	190.320 million tons

These seams were depleted to January 1971 by using BOM production data.

Non-Dowd seams of Brooke County, as recorded by Sheridan-Decarlo, were the Bakerstown, Mahoning, Lower Freeport, Upper Kittanning, and Lower

Figure 2

WEST VIRGINIA DOWD COUNTIES METHODOLOGY

Kittanning. Headlee and Nolting (1940) show these seams containing some 230.0 million additional reserves (page 244, Brooke County table).

According to the methodology found in an EIA file memo of the Sheridan-Decarlo estimates of January 1965 were depleted to January 1971 and then split 40/60 into "measured and indicated" and "inferred" reliability categories respectively. These proportions were in turn divided into thickness estimates by the graphical method mentioned earlier. The reserve became the >28" total with the strip tonnage coming from Reed (1968).

Deriving the reserve base for January 1971 non-Dowd seams by using the suggested methodology appears to be difficult. For example, the Brooke County estimates of January 1965 from Sheridan-Decarlo estimates depleted to January 1971 are:

<u>Seam</u>	<u>Original Reserve (1/1/65)</u>	<u>Reserve Estimated (1/1/71)</u>	<u>%</u>
Bakerstown	30.0	20.7	69
Mahoning	50.0	48.0	96
Lower Freeport	50.0	48.0	96
Upper Kittoning	50.0	48.0	96
Lower Kittoning	50.0	2.0	25
	<u>230.0</u>	<u>166.7</u>	

What is suggested on the 1/1/71 worksheets for the non-Dowd seams in Brooke County between the original reserve and 1965 is a straight 55 percentage of the original reserve reported by Headlee and Nolting (1940). Other Dowd Counties, such as Logan and Ohio, similarly appear to reduce their non-Dowd seams using a percentage equal to 78.5 and 81 percent, respectively, for the January 1965 and subsequently, the

January 1971 totals.⁶¹ There is no mention in the file materials as to why the Decarlo depletion figures were dropped for the straight percentage.

Once the January 1971 reserve estimate was calculated, the 40/60 split and strippable reserves were broken out. We found no worksheets which further split the non-Dowd seams into thickness categories; however, Exhibit 1 shows a table developed from a worksheet where the split of non-Dowd seams was figured into the reserve base for Brooke County. Because our files had only copies of the computer forms we were unable to review the strippable and underground reserve apportionments reportedly done on the back of the originals.

Production and depletion through 1970 were taken from U.S. BOM Annual reports, except for 1954 and 1961 when West Virginia State Reports were used. Production from 1971-1978 was obtained from EIA production printouts.

The January 1979 DRB was a simple matter of depleting the underground and surface totals by thickness category from January 1971 to January 1979. In the case of Brooke County, Exhibit 2 obtained from the files, illustrates the procedure.

The methodology for the January 1979 DRB for both Dowd and non-Dowd Counties has been reviewed and found to be essentially correct. Deriving the January 1979 figures can be accomplished by this methodology with only a few minor adjustments.

⁶¹There appears to be no depletion of non-Dowd Counties between January 1965 and January 1971.

Exhibit 1

NON-DOWD SEAM ADDITION TO BROOKE COUNTY

(In Million Tons)

<u>Seam</u>	<u>Original Resources to 1/1/71</u> <u>(Headlee & Nolting)</u>	<u>Measured</u> <u>(40%)</u>	<u>Inferred</u> <u>(60%)</u>
Bakestown	16.50	6.60	9.90
Mahoning	27.40	10.96	16.44
Lower Freeport	27.50	11.00	16.50
Upper Kittanning	27.50	11.00	16.50
Lower Kittanning	27.50	11.00	16.50

Exhibit 2

BROOK COUNTY DEPLETION, 1971-1979

Production (In Million Tons)

<u>Year</u>	<u>Underground</u>	<u>Surface</u>	<u>Total</u>
1971	.511	.282	
1972	.682	.219	
1973	.636	.142	
1974	.603	.098	
1975	.653	.088	
1976	.766	.127	
1977	.635	.130	
1978	.528	.268	
	<u>5.014</u>	<u>1.354</u>	

Underground Depletion $5.014 \times 2.00 = 10.03$

Surface Depletion $1.354 \times 1.25 = 1.69$

	<u>1/1/71 DRB</u>	<u>Depletion</u>	<u>1/1/79 DRB</u>
Total	201.73	11.72	190.01
UG	169.26	10.03	159.23
Strip	32.47	1.69	30.78

APPENDIX B

WESTERN STATES

- Alaska
- Arizona
- Arkansas
- Colorado
- Idaho
- Iowa
- Kansas
- Missouri
- Montana
- New Mexico
- North Dakota
- Oklahoma
- Oregon
- South Dakota
- Texas
- Utah
- Washington
- Wyoming

ALASKA

The original resources of Alaska coal, on which the 1979 DRB is based, were derived from Tables 4 and 5 in a report by F. F. Barnes entitled Coal Resources of Alaska.¹ Table 4 of the Barnes report presents original bituminous resource data by measured, indicated and inferred reliability categories, by coal field and district, by bed thickness (14"-28", 28"-42", >42"), and by overburden thickness (0-1000', 1000'-2000', 2000'-3000', and, when a finer breakdown cannot be made, 0-2000' and 0-3000'--these categories are mutually exclusive). Table 5 presents the same information for subbituminous and lignite coal combined (although the thickness categories are different: 2½'-5', 5'-10', and >10'). From these two tables, an original bituminous reserve figure of 710.05 million tons was derived, and an original combined subbituminous and lignite reserve figure of 5587.13 million tons was obtained. The original bituminous reserves of 710.05 million tons of coal consists of all coal in the measured and indicated resources categories, >28" thick, and under less than 1000 feet of cover. The subbituminous and lignite reserves of 5587.13 million tons consists of all coal greater than 5 feet thick in the same reliability and overburden depth categories. The only adjustments made to the resource estimates presented in Tables 4 and 5 to arrive at the 710.05 and 5587.13 million ton figures were to multiply all coal in the 0-2000' overburden depth category by 0.5 (on the assumption that half of this coal falls into the 0-1000' category), and to multiply all coal in the 0-3000' category by 0.33 (to obtain the coal in the 0-1000' category).

¹Barnes, F. F., Coal Resources of Alaska, U.S. Geological Survey Bulletin 1242-B, 1967.

To break the bituminous reserve estimate down into strippable reserves and underground reserves, EIA assigned 12 percent of the 710.05-million-ton original reserve estimate to the surface category, and the remainder to the underground category (i.e., 85.21 million tons surface, and 624.84 million tons underground). The 12 percent estimate was (according to the Alaska "Methodology") based on the methodology employed by the Bureau of Mines.² The Bureau, according to the Alaska Methodology, "assumed a maximum strippable overburden thickness of 120 feet; thus 12 percent of the coal determined to lie within 1000 feet of the surface was considered strippable."

The 5587.13 million tons of subbituminous and lignite original reserves was subdivided into 116.7 million tons of lignite and 5470.43 million tons of subbituminous. The breakdown by rank was obtained from Warfield of the BOM. The field office sent Warfield on Alaska reserves worksheet, and he sent the worksheet back to the field office with the rank of the coal in the various deposits noted.

As was the case with bituminous coal, 12 percent of the original subbituminous reserves of 5470.43 million tons was assumed to be strippable (i.e., 656.45 million tons strippable, and 4813.98 million tons underground). Likewise, 12 percent of the 116.7 million tons of lignite reserves was assigned to the strippable category (14.00 million tons), and the remainder was dropped from the DRB (since lignite is assumed to be uneconomical to mine by underground methods).

Production for the years 1880-1975 was derived from a table entitled "Alaska Coal Production", obtained from the Alaskan office of the BOM. This table presents the cumulative production for the years

²U.S. Bureau of Mines, Strippable Reserves of Bituminous Coal and Lignite in the United States, U.S. Bureau of Mines Information Circular 8531, 1971.

1880-1940, and then the annual production for the years 1941-1976,³ by mining method and by coal field. To obtain the desired production by rank, a rank was assigned to each field in the table. Production for the years 1976-1978 (which was taken as being subbituminous) was obtained from the EIA annual reports. After multiplying the strip production by 1.25 and the underground production by 2.00 to obtain depletion, the following results were obtained:

	Bituminous	Subbituminous
Surface	4.72	18.42
Underground	7.82	8.07

Thus:

Strip Bituminous:

85.21 million tons original reserves
-4.72 depletion
 80.49 million tons calculated 1979 DRB, as compared with
 80.49 published DRB

Underground Bituminous:

624.84 million tons original reserves
- 7.82 depletion
 617.02 million tons calculated 1979 DRB, as compared with
 617.02 published DRB

Strip Subbituminous:

656.45 million tons original reserves
-18.42 depletion
 638.03 million tons calculated 1979 DRB, as compared with
 638.02 published DRB

³The 1976 figure was identified in the Table as being preliminary, and hence was not used.

Underground Bituminous:

4813.98 million tons original reserves
-8.07 depletion
4805.93 million tons calculated 1979 DRB, as compared with
4805.93 published DRB

Lignite:

14.00 million tons original reserves
-0.00 depletion
14.00 million tons calculated 1979 DRB, as compared with
14.01 published DRB.

The 1979 DRB can be derived from the 1976 DRB estimate, but not from the 1971 DRB. From 1976 through 1978, the only depletion fell in the strip/subbituminous category. In the bituminous, lignite and underground/subbituminous categories, the 1979 published DRB estimates match the 1976 published DRB estimates. Depletion in the strip/subbituminous category was 2.68 million tons, hence

638.0 million tons 1979 DRB
+2.7
640.7 million tons calculated 1976 DRB, as compared with
640.7 published 1976 DRB.

From 1971 through 1975, strip subbituminous depletion was equal to 4.39 million tons, while strip bituminous depletion equaled 0.02 million tons (there was no lignite or underground production in these years). However, the 1971 DRB differed from the 1976 DRB as follows:

	<u>Underground</u>	
	<u>1971</u>	<u>1976</u>
Bituminous	-	617.0
Subbituminous	4246	4805.9

	<u>Surface</u>	
	<u>1971</u>	<u>1976</u>
Lignite	296	14.0

For Strip/Subbituminous:

640.7 million tons 1976 DRB
+4.4 depletion
 645.1 million tons calculated 1971 DRB, as compared with
 5902.0 published DRB

and for Strip/Bituminous:

80.5 million tons 1976 DRB
+0.0 depletion
 80.5 million tons calculated 1971 DRB, as compared with
 1201.0 published DRB.

ARIZONA

The original underground reserves,⁴ upon which the 1979 Arizona DRB is based, were derived solely from a reserve report written by Robinson and Robinson, Inc., for Peabody Coal Company.⁵ This report presented original reserve data for Peabody's Black Mesa coal dedicated to the Navajo Power Plant. The reserve data are presented in a 5-page long table (entitled "Deep Mine Reserves") and are broken down by seam and "area" (the different "areas" are outlined on maps included in the report). The reserves in each area and seam are broken down by average coal thickness, and both the individual seam thicknesses and the reserves are reduced by one foot of top coal. Only coal 7-15 feet in thickness, and 130' to 270' deep was included in the underground reserves.

The only adjustment made by EIA to the Robinson and Robinson reserve data was to increase the reserves by the amount reduced by leaving out the one foot of top coal. In the underground reserves table, Robinson and Robinson present the acres, along with the reserves, for each area/seam/coal height category. Thus, to calculate the reserves to be added to account for the top coal, the following formula was applied:

$$(1760 \text{ tons/acre-ft}) (1') (\# \text{ of acres}) = \text{tons}$$

⁴All of the underground (and all of the surface) Arizona reserves consist of bituminous coal.

⁵Robinson and Robinson, Inc., Report of Reserves and Quality of Coal in the Black Mesa Coal Field, Navajo County, Arizona, in Lands Leased by Peabody Coal Company on the Reservation of the Navajo Indians and the Joint Reservation of Navajo and Hopi Indians, to be used at the Navajo Power Plant, for the Navajo-Four Corners Power Plant Steering Committee and Fuel and Water Supply Task Force, May 1969, 1969.

As an example of the application of this formula, for the "ND-1, Brown Seam", 8.9' thick coal, Robinson and Robinson's estimate of the area extent was 120.14 acres. Thus:

$$(1760) (1) (120.14) = 211 \text{ thousand tons additional reserves}$$

The additional reserves were added to the reserves shown for each area/seam/thickness category, and then the total across all area/seam/-thickness categories was calculated. The result was 101.56 million tons. The figure represented the remaining reserves as of the date of the report (1969). The BOM Minerals Yearbooks and EIA production reports indicated that there was no underground production from 1969 to 1979. Thus depletion was taken as zero and the 101.56 million ton figure was published as the Arizona DRB.

The original surface reserves were obtained from the 1979 Keystone Coal Industry Manual.⁶ In the section entitled "Arizona," on page 454 of the Manual, the following statement is made:

"The only measured reserves are of strippable coal proved up by Peabody Coal Company - 387 million tons within 130 feet of the surface".⁷

The 387 million tons mentioned in this statement was taken as the original reserve base on which the 1979 DRB was based. The Robinson and Robinson report was used to calculate the reserves by coal bed and seam thickness category (4'-5', 5'-10', 10'-15', 15'-20') for that

⁶1979 Keystone Coal Industry Manual, "Arizona", New York, New York: McGraw-Hill, Inc., 1980.

⁷In the DOE field office files, a photocopy of the "Arizona" section was found, with this statement underlined.

portion of the 387 million-ton total that is dedicated to the Navajo Plant.⁸

Surface production was obtained from the BOM Minerals Yearbooks for the years 1970-1975, and from the EIA annual reports for 1976-1978 (prior to 1970 there was no surface production, according to the summary depletion calculation sheet found in the DOE field office files - it is assumed that the BOM Minerals Yearbooks were used to substantiate this). A total cumulative surface production, as of January 1, 1979, of 51.45 million tons was obtained. This total production was multiplied by 1.25 to obtain 64.31 million tons of depletion. Thus:

387.00 million tons original reserves
<u>-64.31 depletion</u>
322.69 million tons calculated 1979 DRB

The published 1979 surface DRB was 322.69 million tons, which matches the calculated DRB precisely.

Neither the 1976 nor the 1971 DRB can be traced from the 1979 DRB. In 1976 and 1971, no underground reserves were presented for Arizona. Surface production from 1976 through 1978 was 30.53 million

⁸The portion dedicated to the Navajo Plant was calculated by EIA to be equal to 304.485 million tons. An error was made, however, in calculating this value. For area J-24, Brown seam, the tons per acre, rather than the tons, were erroneously used in the calculation. This resulted in an increase in the 5'-10' reserve estimates from 812 thousand tons to 9.856 million tons, and an increase in the 10'-15' thick reserves from 4.388 million tons to 40.48 million tons. These errors, it should be remembered, did not affect the published state total DRB (based on the 387 million ton original reserve estimate from the Keystone). The error affected only the reserve estimate for the 5'-10' and 10'-15' Brown Seam coal.

tons, and from 1971 through 1978 was 51.32 million tons; these production figures, when multiplied by 1.25, yield depletions of 38.16 million tons and 64.15 million tons, respectively. Thus:

$$\begin{array}{r} 322.69 \text{ million tons (1979 published DRB)} \\ +38.16 \\ \hline 360.85 \text{ million tons calculated 1976 DRB} \end{array}$$
$$\begin{array}{r} 322.69 \text{ million tons (1979 published DRB)} \\ +64.15 \\ \hline 386.84 \text{ million tons calculated 1971 DRB.} \end{array}$$

But the 1976 published surface DRB was 325.5 million tons (35.3 million tons less than the DRB calculated on the basis of the '79 DRB), and the 1971 published surface DRB was 350 million⁹ tons (36.8 million tons less than the calculated DRB). The differences are not surprising, since the Arizona Methodology indicates that previous DRB estimates had been based on different source documents than the '79 estimates.

⁹It should be noted that in 1971, all of the Arizona DRB was considered to fall into the subbituminous rank, while in both 1976 and 1979, all of the Arizona DRB was considered to be bituminous in rank.

ARKANSAS

The 1979 DRB for Arkansas is based primarily on Haley (1960).¹⁰ Further information on lignite reserves was obtained from Woodward and Gilbreath (1976).¹¹

Haley estimated the anthracite and bituminous reserves of Arkansas as the original resource. He divided these resources into reliability, thickness, and depth categories. The summary of this work appears in Haley in Tables 1, 2 and 9 (pages 801-809, 825) for bituminous, anthracite, and lignite respectively. The original reserve base derived from Haley for use in the 1979 DRB can be summarized as follows:

	<u>Underground</u>	<u>Surface</u>	<u>Total</u>
Anthracite	88.60	7.80	96.40
Bituminous	<u>365.15</u>	<u>122.70</u>	<u>429.60</u>
	453.75	130.50	526.00

To arrive at these figures, several assumptions for the coals were made:

- Strippable anthracite is the total of all coal greater than 28" in the 0-60 foot depth range.
- The underground anthracite reserve is the sum of all coal between 60 and 1000 feet deep and greater than 28".

¹⁰Haley, B. R., Coal Resources of Arkansas, U.S.G.S. Bulletin 1072-P, 1954.

¹¹Woodward, M. B., and Gilbreath, L., Arkansas Lignite Characteristics, U.S. BOM Grant Number G0254007, Arkansas Geological Commission, 1976.

- Strippable bituminous coal is the sum of all coal greater than 14" thick and less than 60 feet deep.
- Underground bituminous coal is the sum of the coal greater than 28" lying between 60 and 1000 feet in depth .

The lignite reserves from Woodward and Gilbreath was simply the sum of the appropriate lignite estimates by region (Plate). Plates 2, 3, 4, 6, and 7 contained lignite coal averaging more than 5 feet. Adding these plates together yielded the 25.65 million ton lignite reserve estimate.

The production and subsequent depletion of Arkansas coal reserves was obtained from the Arkansas Geological Commission (AGC) for years 1840 through 1975. The total production and production breakdown is outlined by William V. Bush, geologist for the AGC as:

<u>Years</u>	<u>Total Production</u>	<u>Surface</u>	<u>Underground</u>
1840-1927	59,260,821	988,697	58,272,124
1928-1966	40,952,205	8,926,905	32,025,300
1967-1875 ^a	<u>2,977,000</u>	<u>2,711,000</u>	<u>268,000</u>
Total	103,190,026	12,626,602	90,565,424

^a1967-1975 production figures were rounded to the nearest 1,000 tons.

Arkansas production for 1976 through 1978 was obtained from information contained On EIA Form 7 reports. Depletion was derived by using the standard depletion factors of 2.00 for underground and 1.25 for surface mining. The total production and depletion can be summarized as:

<u>1840-1979</u>	<u>Underground</u>	<u>Surface</u>	<u>Total</u>
Production	90.62	14.184	104.80
Depletion	181.24	17.730	198.97

By subtracting all Arkansas depletion from the bituminous coal rank, the 1979 DRB published figures can be derived. The general methodology can be seen in the flow chart of Figure 1.

Figure 1

ARKANSAS DRB METHODOLOGY

COLORADO

The methodology followed during the development of the DRB in Colorado can best be compared with the assembly of a jigsaw puzzle. In all, 16 different information sources were used in the estimation of the State's total coal resource base and subsequent DRB (these sources are listed at the end of this discussion). The principal source of coal resource data was Landis and Cane, Coal Resources of Colorado Tabulated by Bed. This report provided detailed information by township and coal bed. This work covered all of Colorado except for the Trinidad coal field in Huerfano and Las Animas Counties, and those resources in the San Juan River and Raton Mesa regions. To complete the estimation of the original resources, USGS bulletins and investigation maps of the coal-bearing regions were obtained. The Landis numbers for each township were entered onto the maps. The supplemental information was then used to fill in any data gaps.

Huerfano County is an example. The Trinidad coal field of Colorado runs through a major portion of this county. Landis estimated coal resources for a majority, but not all of the Huerfano County townships. To supplement the Landis work, USGS Bulletin 1112-E, Coal Resources of the Trinidad Coal Field In Huerfano and Las Animas Counties, Colorado, was used. A comparison of the township resource estimates of both Landis and Bulletin 1112-E is provided below:

<u>Township</u>	<u>(Million Tons)</u>	
	<u>Landis</u>	<u>Bulletin 1112-E</u>
27 S, 66 W	1.60	1.60
27 S, 67 W	102.90	108.40
27 S, 68 W	9.60	14.60

(Million Tons)		
<u>Township</u>	<u>Landis</u>	<u>Bulletin 1112-E</u>
28 S, 66 W	85.90	88.30
28 S, 67 W	14.50	14.60
28 S, 68 W	0.00	1.40
28 S, 69 W	0.00	0.00
29 S, 65 W	39.00	0.00
29 S, 66 W	82.89	118.40
29 S, 69 W	22.20	24.60
30 S, 68 W	0.00	0.00
30 S, 69 W	0.00	13.60
31 S, 68 W	0.00	1.20
31 S, 69 W	0.00	15.04
Total	358.59	440.44

Although differences exist in the resource estimates for many of the townships, it appears that Bulletin 1112-E data were used only to fill in those townships not covered by Landis.

This basic procedure was followed for many of Colorado's coal bearing areas. Landis was used as the principal data source and where necessary additional information was gathered and added to the Landis estimates.

Once the total resource base was established, which was mostly on a township basis, U.S. BOM Information Circular 8531 was used to split the identified resource and reserve base into strip and underground categories. Information circular 8531 provided strippable resource/reserve data by county and by seam. To match the various data sets, some adjustments had to be made to the township-level resource estimates. While most townships lie within a single county, some cross county lines. In these cases, the fraction of in-place coal lying in

each county had to be estimated. These estimates were based on detailed reviews of USGS Coal Investigation Maps and in some cases engineering judgement. Once the resource/reserve base was adjusted to reflect county totals it was split between underground and surface mineable coal based on IC 8531.

In addition to using numerous data sources to establish the resource/reserve base, it was also necessary to rely on many sources to classify the coal according to rank. Landis provided good information on coal rank, but, as discussed above, he did not cover all coal-bearing areas. The supplemental sources used to identify additional coal resources did not, however, give a breakdown of deposits by rank. To divide fully the resource base, engineering judgement coupled with historical production and coal quality information had to be used to estimate coal rank in those areas not covered by Landis.

Lastly, the lignite resources of the Denver Basin were excluded from the work of Landis and others in their identification of Colorado coal deposits. Estimates of the lignite resources and subsequent demonstrated reserve base were taken directly from worksheets used to prepare an unpublished BOM report by Charles Rich and others, Lignite and High-Kaolin Clay in the Denver Basin Coal Region, Colorado. The published DRB lignite estimate represents total reserves meeting DRB criteria. The Rich estimates were not depleted since no lignite mining has occurred in Colorado since the reserve estimates were made.

Depletion of the resource/reserve base for Colorado followed standard DRB practice (50 percent average recovery for underground production, 80 percent recovery for surface). Production statistics through 1974 came from the Colorado Geological Survey and BOM Mineral Yearbooks, and EIA production reports were used for depletion through 1978.

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IDAHO

The 1979 DRB for Idaho is based solely on the work of Kiilsgaard, T.H. in a pamphlet called The Geology and Coal of the Horseshoe Creek District, Teton County, Idaho, #92, published in 1951. The reserves identified in this report were not included in the 1974 DRB, but were for 1976.

Basically, the document stands alone. The original reserves are estimated to be 4.62 million short tons. All the coal falls in the indicated category.¹²

Coal production for Idaho has not been recorded officially since 1951. However, pre-1951 records show 100,000 tons being produced. Quotes from Kiilsgaard indicate the Brown Bear and Progressive underground mines were the chief producers of Idaho coal. No surface production was reported and therefore depletion was calculated as 200,000 tons using the standard 50 percent recover factor.

For the 1979 DRB, no changes were made to the 1976 published reserve estimate of 4.42 million short tons.

¹²The Kiilsgaard report was not available for review during the course of our analysis and therefore further investigations could not be conducted.

IOWA

The demonstrated reserve base for Iowa is based on two sets of sources dividing underground and surface reserves.

The underground reserves are based on a report by E. R. Landis,¹³ while two BOM¹⁴ by Garvin and Van Eck supplied strippable figures.

The original reserve base for Iowa, as calculated from the Landis report, contained total reserves. It was not until the Garvin and Van Eck reports that strippable coal was broken out of the Iowa DRB. Landis reported a total of 3,500.72 million short tons of measured and indicated coal over 14" thick in Iowa. On Table 17, pages 95 through 141, Landis tabulated the reserves by county, township and range, and by coal seam. In this table, Landis identifies 618 million tons (page 141) of thin coal, which was eliminated from the original DRB. This left 2,882.7 million short tons as the original reserve base.

Production and depletion for Iowa were obtained from the Iowa Division of Mines and Minerals for 1840 through 1969. Production from January 1970 through 1978 was taken from Mineral Yearbooks and DOE/EIA

¹³Landis, E. R., Coal Resources of Ioda, Iowa Geological Society Technical Paper 4, 1965.

¹⁴Garvin, Paul L., and Orville J. Van Eck, Strippable Coal Reserve study in selected Iowa Counties, Bureau of Mines Grant Numbers G0254008 and G0264013, Iowa Geological Survey, Iowa City, Iowa, 1975 and 1976.

_____, Strippable Coal Reserve Study in Seven Iowa Counties, Iowa Geological Survey, U.S. Bureau of Mines Grant No. G0264013, 1976.

reports. The summary of this production and associated depletion, as shown on file notes, is as follows:

Surface Production 1840-1975	28.93 million tons
Underground Production 1840-1975	<u>328.64 million tons</u>
Total Production 1840-1975	357.57 million tons
Surface Depletion at 80 percent recovery	36.16 million tons
Underground Depletion at 50 percent recovery	<u>657.28 million tons</u>
Total Depletion 1840-1975	693.44 million tons
Depletion from January 1976 to January 1979	<u>2.48 million tons</u>
Total Depletion Through January 1975	695.92 million tons

Unfortunately, when one subtracts total depletion from the original Landis reserve estimate of 2,882.7 million tons, a remaining DRB (as of January 1979) of 2,186.8 million tons is derived - 12 million tons less than the published figure.

This discrepancy lies solely in the reserve estimate for underground mineable coal. The strippable reserves of Iowa were originally developed by Garvin and Van Eck (1975, 1976). Both reports show a total of 501.6 million tons of recoverable coal to a depth of 150 feet. Given that the total surface depletion through January 1979 was 37.3 million tons, the remaining surface mineable reserves should be 464.2 million tons, which matches exactly with the published figures. Following the same line of thought, if the Garvin and Van Eck strippable reserves are subtracted from the Landis total, a reserve estimate and underground mineable figure of 2,381.1 million tons is obtained. Subtracting the total underground depletion (658.8 million tons) from

this original in-place reserve estimate results in a figure of 1,722.5 million tons, or 12 million tons less than the published reserve estimate.

The discrepancy in the underground reserve estimates can be traced to the computer generated data, EIA identified some Iowa quadrangles where there was more strip coal than Landis showed for total coal; the computer program used to prepare the reserve estimate was designed to assign a zero tonnage for deep coal in such cases. By following this approach, SRC was able to distinguish some of the differences in a quadrangle/county level, but not by seam.

KANSAS

The 1979 DRB for Kansas can be derived from the original source data prepared by Brady and others (1976).¹⁵

The original source estimated reserves of strippable bituminous coal as of January 1976. The breakdown was by county and seam and included coal to a minimum mining height of 12 inches to reflect current mining practices. From Appendix I of Brady, pages 35-39, the state totals were as given:

<u>0-50 ft. Overburden</u>		<u>50-100 ft. Overburden</u>	
Measured	Indicated	Measured	Indicated
205.46	373.72	136.92	282.11

yielding a total DRB for 1976 of 998.21 million tons.

Production for 1976, 1977, and 1978 as reported by ETA was 2.7 million tons. Depletion was derived using a factor of 1.25. The total depletion to January 1979, therefore, was 3.39 million tons.

The January 1979 DRB was as follows:

998.21
<u>-3.39</u>
994.82

¹⁵Brady, L.L., Adams, D.B., and Livingston, N.D., An Evaluation of the Strippable Coal Reserves in Kansas, Geological Survey Mineral Resources Series 5, 1976.

MISSOURI

The 1979 Missouri DRB estimates the underground bituminous reserve base at 1479.14 million tons, and the surface reserve base at 4598.05 million tons. The DRB is based on two reports written by C. E. Robertson and D. C. Smith entitled A Detailed Evaluation of Missouri's Coal Reserves¹⁶ (written in 1976), and Evaluation of the Mineable Coal Reserves of the Northern Bevier, Mendota, and Novinger Coal Fields in North-Central Missouri¹⁷ (published in 1980). The 1976 report provides total remaining resource estimates¹⁸ by coal thickness category (8"-14", 14"-28", 28"-42", > 42"), by bed and county, and measured, indicated, and inferred categories of reliability. In addition, Table 5 of the report presents strippable resource estimates on the same basis. Strippable resources, in this table, include all coal under 150 feet or less of cover.

The 1980 report, in Tables 1a, 1b, and 1c, presents measured and indicated resources by the same thickness categories employed in the 1976 report, by bed and county, by overburden thickness categories (0'-60', 60'-90', 90'-120', 120'-150', > 150'), and by measured and indicated reliability categories. However, unlike the 1976 report, this report did not cover the entire state. The 1976 remaining reserves, on which the 1979 DRB is based, was derived by taking the state's

¹⁶Robertson, C. E. , A Detailed Evaluation of Missouri Coal Reserves, Missouri Department of Natural Resources, U. S. Bureau of Mines Grant No. G0254029, 1976 (unpublished).

¹⁷Robertson, C. E. and Smith, D. C., Evaluation of the Mineable Coal Reserves of the Northern Bevier, Mendota, and Novinger Coal Fields in North-Central Missouri, Missouri Department of Natural Resources Open File Report 79-2-ER, 1980.

¹⁸As of July 31, 1976.

total measured and indicated strippable resources (that portion of the coal under 150 feet or less of cover), 8 inches or more in thickness, from the 1976 report, and adding the > 8" measured and indicated resources under < 150 feet of cover from the 1980 report. It is important to note that EIA did not replace the 1976 resource data with the data presented in the 1980 report; rather the 1980 resources for the Northern Bevier, Mendota, and Novinger coal fields were added to the 1976 resources for the entire state. Since the resource estimates presented in the 1980 report represent remaining resources as of November 30, 1977, while the estimates presented in the 1976 report represent remaining resources as of July 31, 1976, the depletion between July 31, 1976 and November 30, 1977 was added back into the resource estimate,¹⁹ so that the sum of the resources from the 1980 report and the 1976 report represent the remaining resources as of July 31, 1976. The reserve base estimate derived using this methodology was 4,616.17 million tons.

The 1976 remaining underground reserve base estimate was derived solely from the 1976 report. It was calculated by subtracting the total measured and indicated strippable resources (< 150 feet) falling into the 28"-42" and > 42" thickness categories (obtained from Table 5 of the report) from the total measured and indicated resources greater than 28" under 1000 feet or less of cover (from Table 4 of the 1976 report). The result is the remaining measured and indicated reserves, as of July 31, 1976, falling in the 150'-1000' overburden thickness category, and the > 28" coal thickness category; this was found to be equal to 1,479.14 million tons.

¹⁹This depletion was derived by multiplying total production during this period (from the EIA annual reports) by 1.25.

Since the EIA's surface and underground estimates represent remaining reserves as of July 31, 1976, depletion was only required from this date to January 1, 1979. The production data used to calculate depletion were obtained from the EIA annual production reports; a typed version of the calculation sheet used to derive depletion is presented in Exhibit 1. As the sheet indicates, the surface-mineable reserves were depleted by 18.15 million tons (total production was multiplied by 1.25 to obtain depletion). There was no underground production between 1976 and 1979. Thus:

for surface:	4,616.17 million tons remaining reserves (7/31/76)
	- 18.15 depletion
	<u>4,598.02</u> million tons calculated 1979 DRB, as compared with
	4,598.05 published DRB

for underground:	1,478.99 million tons remaining reserves (7/31/76)
	- 0.00
	<u>1,479.14</u> million tons calculated 1979 DRB, as compared with
	1,479.14 published DRB.

Since a 1980 report was used to derive the 1979 DRB, one would not expect to be able to derive the 1979 published DRB simply by depleting the 1976 DRB. In fact, the 1976 DRB estimates are lower than the 1979 estimates for both the surface and underground categories. Specifically, the 1976 underground estimate was 1,418.0 million tons, 61.1 million tons less than the 1979 DRB, and the 1976 surface estimate was 3,596 million tons, 1,002 million tons less than the 1979 DRB. Likewise, the 1979 DRB cannot be derived by depletion of the 1971 DRB; the 1971 underground estimate exceeds the 1979 estimate by over 4 billion tons, and the 1971 surface estimate is over 1 billion tons less than the 1979 estimate.

Exhibit 1

Bituminous Strip Production
(1000)

1976	2,490	August-December
1977	6,366	
1978	<u>5,665</u>	
	14,521	

@ 80%

Depletion to January 1979:

18.15 million tons

MONTANA

The original surface (both subbituminous and lignite) reserves estimates on which the 1979 DRB is based, was derived from information contained in a handout for the 1977 Rocky Mountain Coal Symposium,²⁰ along with information included in a report by R. E. Matson and J. W. Blumer.²¹ The symposium handout consists of a table that provides reserve estimates on a coal field/coal bed basis, along with a map of the Montana coal fields. The Matson and Blumer report also provides coal field/coal bed reserves (in Tables 2, 3, 16, 22, 25, 28, 33, 36, 39, 42, 45, 47, 51, 54, 57, 64, 67, 70, 75, 76, 77, 80, 83, 86, and 89) for most, but not all, of the Montana coal fields. Unlike the handout, which provides only a lump sum reserve estimate for each coal field/coal bed combination, the Matson and Blumer report breaks reserves down into two reliability categories (indicated and inferred), and into five overburden thickness categories (0-50', 50'-100', 100'-150', 150'-200', and 200'-250'). The indicated reliability category was taken by EIA as covering both measured and indicated reserves. Since the handout covers all of Montana, while the Matson and Blumer report covers only a portion of the State, the handout was used as the main basis for deriving the original surface reserves.²² However, it was

²⁰ _____, Strippable Subbituminous and Lignite Coal Fields, Montana, Handout at 1977 Rocky Mountain Coal Symposium, Golden, Colorado, May 9 and 10, 1977.

²¹ Matson, R. E., and Blumer, J. W., Quality and Reserves of Strippable Coal in Southern Montana, Montana Bureau of Mines and Geology Bulletin 91, 1973.

²² The reserve estimates of the handout were matched against those in the Matson and Blumer report, and for all the coal field/coal bed combinations covered by both reports the reserve estimates matched.

first crosschecked against the Matson and Blumer report in order to identify inferred reserves included in its lump-sum reserve estimates. In some cases, inferred reserves had been included, while in other cases they had not. As a result of this crosscheck, 85.18 million tons of inferred reserves were found to have been subtracted out of the Deer Creek coal field, (Anderson-Dietz) 1 and 2 beds, and 215.83 million tons of inferred coal in the Little Pumpkin Creek Field, Sawyer A and C, D, X, and E beds. This was the only inferred coal included in the handout's estimates.

After subtraction of the inferred reserves, the next step was to break the lump-sum reserve estimates presented in the handout down into subbituminous and lignite reserves. The breakdown by rank was accomplished with the aid of the map of Montana's coal fields included in the handout. This map indicated the position of each of the coal fields included in the table in the handout. In addition, the map was divided into two sections by a north-south line; to the east of this line (according to the notation on the map) lie the lignite fields, and to the west lie the subbituminous fields. Thus the map could be (and was) used to identify which fields are lignite and which are subbituminous. The Pumpkin Creek coal field (which contains the Sawyer bed) straddles the cutoff line; 45 percent of the 2426.5 million tons in this field was assigned to the lignite reserves, and the remainder was assigned to the subbituminous fields. All other fields were assigned either to lignite or subbituminous according to their position with respect to the cutoff line, with one exception--the Sand Creek field (containing the Knobloch bed) is shown on the map as lying in the lignite area, but this field was assigned to the subbituminous category. After the assignments to rank were completed, the coal field/coal bed estimates were summed across the state to yield 15,773.43 million tons of original surface lignite reserves, and 33,966.49 million tons of subbituminous reserves.

The handout does not make any statements regarding the thickness, depth or reliability categories of the coal included as reserves. However, it is clear that, at least for the coal fields covered by both documents, the estimates presented in the handout are based on the same criteria as the estimates presented in the Matson and Blumer report (since the estimates match). The Matson and Blumer report, as already mentioned, does define overburden depth categories and break the reserve estimates down according to these categories. In the text of the report, the statement is made that reserves classified as indicated consist of reserves "calculated on a basis of specific measurements and partly by projection of visible data for a reasonable distance, such as 2 or 3 miles for coal beds of known continuity". Finally, with regard to coal thickness, the text states that coal more than 40 feet thick was included in the estimates up to an overburden depth of 250', coal 25 to 40 feet thick was included up to a depth of 200', coal 10 to 25 feet thick was included up to a depth of 150', and coal less than 10 feet thick was included up to a depth of 100'.

The Matson and Blumer report did not state what the minimum thickness of coal included as reserves was, but EIA, using the tons/acre estimate supplied with the reserve estimate for each coal field/depth/bed combination, calculated an average coal thickness (using 1770 tons/acre-foot) for each combination. The lowest thickness calculated in this way was 6 feet, and thus (apparently) EIA did not subtract any reserves for being below its minimum thickness.

Exhibit 1 presents a flowchart of the methodology discussed above, for illustrative purposes.

Production from the late 19th century to 1949 was obtained from a report written by J. X. Combo, D. M. Brown, H. F. Pulver and D. A.

EXHIBIT 1

ORIGINAL SURFACE RESERVES METHODOLOGY

Taylor.²³ This report, however, provided only one lump sum total production of 175 million tons; no breakdown by rank or mining method was given. To obtain the breakdown and also to obtain production for the years 1949-1974, a number of steps had to be taken. First, the county annual production for the years 1905 and 1923-1974 were obtained. The sources of these data were as follows:

- 1905 - Montana Coal and Lignite Deposits²⁴
- 1923-45, 1948-71 - reports of the state Board of Equalization.
- 1946-47 - Combo, Brown, Pulver and Taylor report
- 1972-74 - BOM Minerals Yearbooks.

The annual county production data from these sources were summed to obtain the pre-1949 and 1949-1974 total county production values. The results, are presented in the second and fourth columns of Exhibit 2. The 1946-1947 production data were inadvertently left out of the pre-1949 county totals. The pre-1949 and 1949-1974 county totals presented in Exhibit 2 and used by EIA were not confirmed by SRC.

The pre-1949 and 1949-1974 county production data presented in Exhibit 2 were subdivided by rank by assigning a coal rank to each county. Then the state total pre-1949 production of bituminous, sub-bituminous and lignite was calculated, along with the total pre-1949 coal production. From these figures the percentages of the total pre-1949 coal production which were bituminous, lignite and subbitu-

²³Combo, J. X., Brown, D. M., Pulver, H. F., and Taylor, D. A., Coal Reserves of Montana, U.S. Geological Survey Circular 53, 1949.

²⁴This report is not listed as a reference in the Montana "Methodology", and it could not be found in the DOE field office files. However, it is listed as the source of the 1905 production data on a calculation sheet found in the field office files.

Exhibit 2

MONTANA PRODUCTION

<u>County</u>	<u>1905 and 1923-1974</u>	<u>1949 - 1974</u>	<u>Assumed Rank</u>	<u>Pre- 1949</u>
Beaverhead	1,095	0	L	1,095
Big Horn	9,168,448	9,161,856	Subbit	6,592
Blaine	206,450	16,795	Subbit	189,655
Broadwater	500	0	Bit	500
Carbon	16,599,539	1,572,130	Bit	15,027,509
Carter	3,416	0	Lig	3,416
Cascade	10,398,741	1,036,132	Bit	9,362,609
Chouteau	77,752	3,726	Subbit	74,026
Custer	138,167	40,365	L	97,802
Daniels	73,348	0	Lig	73,348
Dawson	187,237	66,316	Lig	120,921
Fallon	5,987	267	Lig	5,720
Fergus	126,137	2,717	B	123,420
Flathead	500	0	Subbit	500
Gallatin	174,368	0	B	174,368
Garfield	7,461	1,476	Subbit	5,985
Golden Valley	32,697	0	SB	32,697
Granite	500	0	Lig	500
Hill	12,854	0	Subbit	12,854
Judith Basin	55,023	0	Bit	55,023
Lewis and Clark	500	0	B	500
Madison	150	0	L	150
Missoula	973	0	Lig	973
McCone	25,631	11,367	Lig	14,264
Meager	150	0	Bit	150
Musselshell	27,688,896	6,406,188	Subbit	21,282,708
Park	207,197	0	B	207,197
Phillips	5,468	0	Subbit	5,468

Exhibit 2

(Continued)

<u>County</u>	<u>1905 and 1923-1974</u>	<u>1949 - 1974</u>	<u>Assumed Rank</u>	<u>Pre- 1949</u>
Pondera	48,916	0	Bit	48,916
Powder River	102,184	57,117	L	45,067
Prairie	17,423	8,267	Lig	9,156
Ravalli	500	0	L	500
Richland	5,406,665	4,877,401	Lig	529,264
Roosevelt	82,705	4,780	Lig	77,925
Rosebud	67,490,063	38,460,430	SB	29,029,633
Sheridan	540,230	107,484	Lig	432,746
Stillwater	6,843	0	Bit	6,843
Teton	1,887	0	B	1,887
Toole	16,300	0	B	16,300
Valley	42,893	1,474	Lig	41,419
Wibaux	113,338	0	Lig	113,338
Yellowstone	50	0	Subbit	50
Deerlodge	0	0	-	0
<hr/> Total				77,232,994

Bit 25,025,222 32.4%
 Subbit 50,640,168 65.6%
 Lig 1,567,604 2.0%

minous were calculated (32.4 percent bituminous, 65.6 percent subbituminous, and 2.0 percent lignite (see second page of Exhibit 2), and these percentages were applied to the total 175-million-ton pre-1949 production figure obtained from the Combo, Brown, Pulver and Taylor report. To the resulting pre-1949 rank production figures was added the 1949-74 production by rank from Exhibit 2 (obtained using the county rank assignments, and summing across county), and the 1975 production by rank (from the 1975 BOM Minerals Yearbook). Then, the amount of strip production by county for the periods 1923-45, 1946-47, and 1948-74 and 1975 was obtained (see Exhibit 3, a typed version of the field office summary of these data). According to EIA these data were obtained from old Keystone Coal Industry Manuals and various magazine articles.

In any event, after the strip production was obtained (by county and hence by rank) it was subtracted from the total production to yield the underground production by rank. Then the 1976-78 annual EIA reports were used to update the production information to January 1979. Thus, production was now subdivided both by rank and method of mining. Exhibit 4 is a flowchart presenting the methodology discussed above, and Exhibit 5 is a copy of the production summary sheet found in the DOE field office files. Underground production was multiplied by 2, and surface production by 1.25, to obtain depletion (see Exhibit 4). Applying the surface depletion to the original surface reserves, we obtain

For lignite:

15,773.43	million tons original reserves
<u>-7.78</u>	depletion
15,765.65	million tons calculated 1979 DRB, as compared with
15,765.65	published DRB

For subbituminous:

33,966.49	million tons original reserves
<u>-222.02</u>	depletion
33,744.47	million tons calculated 1979 DRB, as compared with
33,744.46	published DRB.

Exhibit 3

MONTANA - STRIP PRODUCTION

	<u>1923-1945</u> <u>1948-1974</u>	<u>1946-1947</u>	<u>1975</u>	<u>Total</u>
SB Big Horn	9,161,856	-	13,222,716	22,384,572
SB Musselshell	115,000	-	18,951	133,951
L Powder R.	102,184	-	1,862	104,046
L Richland	4,871,848	-	300,054	5,171,902
SB Rosebud	63,054,625	4,434,938	8,510,417	<u>75,999,980</u>
				103,794,451
			Subbit	98,518,503
			Lig	5,275,948

MONTANA DEPLETION

Exhibit 5

DEPLETION SUMMARY SHEET

Cum. Total Prod. to 1-1-79

	<u>Total</u>	<u>Strip</u>	<u>UG</u>
Bit.	60.36	-	60.36
Subbit.	268.65	177.62	91.03
Lig.	9.93	6.22	3.71
Total	338.94	183.84	155.10

ASSUME: 80% Strip
50% UG

Cum. Depletion to 1-1-79

	<u>Total</u>	<u>Strip</u>	<u>UG</u>
Bit.	120.72	-	120.72
Subbit.	404.08	222.02	182.06
Lig.	15.20	7.78	7.42
Total	540.00	229.80	310.20

Montana's original underground reserves, on which the 1979 DRB is based, were derived from the Combo, Brown, Pulver, and Taylor report (which covers the entire state), along with the following reports (which cover portions of the state):

Prichard, George E., and Landis, Edwin R., Coal Resources and Cenozoic Geology of the Girard Coal, Richland County, Montana, U.S. Geological Survey Bulletin 1310, 1975.

Baker, A. A., The Northward Extension of the Sheridan Coal Field, Big Horn and Rosebud Counties, Montana, U.S. Geological Survey Bulletin 806-B, 1929.

Bass, N. W., The Ashland Coal Field, Rosebud, Powder River and Custer Counties, Montana, U.S. Geological Survey Bulletin 831-B, 1932.

Bryson, R. P., and Bass, N. W., Geology of Moorehead Coal Field, Powder River, Big Horn, and Rosebud Counties, Montana, U.S. Geological Survey Bulletin 1338, 1973.

Dobbin, C. E., The Forsyth Coal Field, Rosebud, Treasure and Big Horn Counties, Montana, U.S. Geological Survey Bulletin 812-A, 1929.

Pierce, W. G., The Rosebud Coal Field, Rosebud and Custer Counties, Montana, U.S. Geological Survey Bulletin 847-B, 1936.

Roberts, A. E., Geology and Coal Resources of the Livingston Coal Field, Gallatin and Park Counties, Montana, U.S. Geological Survey Professional Paper 526-A, 1966.

Rogers, G. S., and Lee, W., Geology of Tullock Creek Coal Field, Rosebud and Big Horn Counties, Montana, U.S. Geological Survey Bulletin 749, 1923.

Warren, W. C., Reconnaissance Geology of the Birney-Broadus Coal Field, Rosebud and Powder River Counties, Montana, U.S. Geological Survey Bulletin 1072-J, 1959.

The references listed above provide reserve estimates on a township basis, while the Combo, Brown, Pulver, and Taylor report provides estimates for each county. To determine the original reserves, reserves across all townships, for each county covered in the reports listed above, were summed. Because of the enormous number of townships

involved, it was not possible to verify the underground original reserves (and hence it was not possible to verify the published underground DRB estimates). Instead, three counties were selected for investigation. The results of these county investigations will be presented later. First, we will present our inferences on how the state total original reserves were derived. Although the following inferences could not be confirmed by statewide calculations (due to lack of time), they were confirmed for the three counties investigated, and we believe they are an accurate representation of the methodology employed to develop the original underground reserve estimates.

The township reserve estimates presented in the listed references were, we believe, summed for each county (sometimes more than one reference was required to complete the total). The calculated county total was then compared with the county totals presented in the Combo, Brown, Pulver, and Taylor report (Table 1 of the report presents the county totals for bituminous coal, and Table 2 presents the totals for subbituminous coal). If the calculated total exceeded the total presented in the report, then the calculated total was used in the calculation of the original reserve estimate. On the other hand, if the county estimate presented in the report exceeded the calculated estimate, then the calculated estimate was increased to make it equal to the estimate in the report.

Tables 1 and 2 of the Combo, Brown, Pulver, and Taylor report, in addition to breaking reserves down by county, subdivided reserves into three categories: measured and indicated, inferred, and unclassified as to thickness. The table also broke reserves down by seam thickness category, as follows:

Bituminous (Table 1):

14"-24"
24"-36"
> 36"

Subbituminous (Table 2):

2.5'-5'
5'-10'
>10'

Reserves included in both tables are 2000 feet deep or less.

In developing the original reserve estimates, all the coal in the "unclassified as to thickness" category²⁵ was assigned to the measured and indicated reliability category, and the 5'-10' or > 10' thickness categories. Assignment of the unclassified coal to the measured and indicated category and the thicker categories was based on a comment in the Combo, Brown, Pulver, and Taylor report: "When final reserve figures for Montana are prepared, it is anticipated that most of this (unclassified) tonnage will be transferred to the 'measured and indicated' class and that much of it will be added to the totals in the thicker bed". This comment was substantiated by Paul Averitt in the Northern Great Plains Resources Program report,²⁶ and by personal contact with Averitt. It should be noted that the "unclassified as to thickness" coal was reassigned prior to the comparison between the Combo, Brown, Pulver and Taylor reserve estimates and the calculated estimates; thus the "unclassified as to thickness" coal is included in the DRB.

As already noted, the listed references present reserve estimates on a township basis. It is not always clear what criteria (in terms of seam thickness, overburden depth, and reliability) were used in

²⁵No bituminous coal was included in the "unclassified as to thickness" category, but 57,356.13 million tons of subbituminous coal was included in this category.

²⁶Mineral Resources Work Group Report, Northern Great Plains Resources Program, Denver, Colorado and Washington, D.C. 1974.

developing these estimates. In one of the reports (The Rosebud Coal Field, Rosebud, Treasure, and Big Horn Counties, Montana), coal to a minimum thickness of 3 feet was included in the estimates, but this is not necessarily the standard for all the reports. It is possible that each reference does, at some point, set forth the criteria used in developing the estimates, but because the DOE field office files contained only xeroxed copies of portions of the report, this could not be confirmed.

Exhibit 6 presents a flowchart of the inferred methodology discussed above. This methodology is based on investigations of three Montana counties: Big Horn, Gallatin, and Park Counties. In the following paragraphs the results of these county investigations are presented.

The township level reserve data for both Gallatin and Park Counties were obtained from a single source - the report entitled Geology and Coal Resources of the Livingston Coal Field, Gallatin and Park Counties, Montana. This report provided reserve estimates by coal bed, overburden depth (0-1000', 1000'-2000', and 2000'-3000'), measured and indicated, and inferred reliability categories, and seam thickness categories (14"-28", 28"-42", > 42"). The reserves in township 2S-7E were assigned to Gallatin County, while the reserves in 2S-8E, 3S-8E, and 4S-8E were assigned to Park County. The reserves of township 3S-7E were split - 60 percent was assigned to Gallatin County and 40 percent to Park County. The two pages of Exhibit 7 are typed versions of the DOE field office worksheets for Gallatin and Park Counties, which indicate the breakdown of the reserves by county. On the worksheets, all coal from 0-3000' in depth was included in the township totals, although a note at the top of the second worksheet indicates that in coding the reserve data the coal was split into categories of 0-1000', 1000'-2000', and 2000'-3000' of depth (this was confirmed by referring to the printout of the coded data). Coal in the 14"-28" thickness range, along with inferred coal, was included in

EXHIBIT 6

INFERRED METHODOLOGY FOR THE DEVELOPMENT
OF UNDERGROUND RESERVE ESTIMATES

the worksheets (see Exhibit 7), but this coal was kept separate from the measured and indicated coal in the 28"-42" and > 42" range. It is assumed that only measured and indicated, > 28" coal was included in the original reserve estimate, but this cannot be confirmed from the Exhibit 7 worksheets or the printout of the coded information (which includes all data coded, both data used in developing the DRB and other data not meeting the DRB criteria).

In Tables 1 and 2 of the Combo, Brown, Pulver, and Taylor report no reserves are presented for Gallatin County. Thus, the reserves calculated for Gallatin County on the basis of the township level reserve data from the Livingstone Coal Field report were used in the calculation of Montana's original underground reserves. A note at the bottom of the second Gallatin-Park County worksheet (see Exhibit 7) confirms this by stating "Delete Circ. 53 Bit" (USGS Circular 53 is the Combo, Brown, Pulver, and Taylor report). For Park County, the Combo, Brown, Pulver, and Taylor report indicates 440,000 tons of measured and indicated subbituminous coal (in the 2.5'-5' thickness range), and no bituminous coal. Since the subbituminous reserves do not meet the thickness criteria for the DRB, it is assumed they were not included in the DRB. The original bituminous reserves for Park County, like the reserves for Gallatin County, were taken from the Livingstone Coal Field report.

Township level reserve data from the reports by Baker, Bryson, Dobbin and Roger and Lee (see reference list) were used to calculate the original reserves for Big Horn County. All Big Horn County townships in each of these reports were identified, and the reserves listed for these townships were totaled. Exhibit 8, a typed version of one of the DOE field office's worksheets for Big Horn County, shows that when the measured and indicated 5'-10' and >10' thick reserves in the Tullock Creek, Forsyth, North Sheridan, and Moorhead coal fields were totaled, the result was 2690.41 million tons in the 5'-10' range, and 31,380.93 million tons in the >10' range, yielding a total of

Exhibit 7

PARK AND GALLATIN COUNTIES

	Measured and Indicated			Inferred		
	14-28	28-42	> 42	14-28	28-42	> 42
<u>Gallatin Co.</u>						
2S, 7E	4.607	11.950	59.149	2.580	7.153	-
3S, 7E	.021	-	.028	-	-	-
	<u>4.09</u>	<u>11.95</u>	<u>59.18</u>	<u>2.58</u>	<u>7.15</u>	<u>-</u>
<u>Park Co.</u>						
2S, 8E	.263	26.422	40.375	6.819	9.193	8.294
2S, 9E	-	-	25.920	-	13.893	-
3S, 8E	.161	.291	65.272	-	-	2.880
4S, 8E	4.526	38.757	201.806	9.399	30.239	16.058
3S, 7E	.014	-	.018	-	-	-
	<u>4.96</u>	<u>65.47</u>	<u>333.39</u>	<u>16.22</u>	<u>53.33</u>	<u>27.23</u>
2S, 7E	4.07	11.95	59.15	2.58	7.15	-
3S, 7E	.02	-	.03	-	-	-
	<u>4.09</u>	<u>11.95</u>	<u>59.18</u>	<u>2.58</u>	<u>7.15</u>	<u>-</u>
2S, 8E	.26	26.42	40.38	6.82	9.19	8.29
2S, 9E	-	-	25.92	-	13.89	-
3S, 7E	.02	-	.02	-	-	-
3S, 8E	.16	.29	65.27	-	-	2.88
4S, 8E	4.53	38.76	201.81	9.40	30.24	16.06
	<u>4.97</u>	<u>65.47</u>	<u>333.40</u>	<u>16.22</u>	<u>53.32</u>	<u>27.23</u>

County Proportion Factor in 3S, 7E: 60% Gallatin County
40% Park County

Exhibit 8

BIG HORN COUNTY

	<u>2 1/2-5</u>	<u>5-10</u>	<u>10</u>	<u>2 1/2-5</u>	<u>5-10</u>	<u>10</u>	<u>Total</u>	<u>5</u>
Circ. 53	420.46	13,033.92	25,350.96	322.02	1,717.75	2,685.54	32,500.65	38,354.88
Tullock Co.	.10	33.40	1,291.40	-	-	-	1,381.40	1,324.80
Forsyth	-	326.46	627.60	-	488.78	-	1,442.84	954.06
N. Sheridan	-	2,293.95	28,106.05	-	-	-	30,400.00	30,400.00
Moorhead	121.20	36.60	1,355.88	102.75	659.40	1,627.62	3,927.06	1,392.48
Total	121.30	2,690.41	31,380.93	102.75	1,148.18	1,627.62	37,151.30	34,071.34
Difference		(4,283.54)						

"4" Card Coding

Code Tullock Cr, Forsyth, U Shendon, & Moorhead

Code Circ. 53 subbit: 0-1,000, M&I, 5'-10'
4,283.54 Unc.

34,071.34 million tons of > 5' thick coal. After reassigning the unclassified reserves in the Combo, Brown, Pulver, and Taylor report, the measured and indicated reserves in the 5'-10' thickness categories were calculated as being 13,003.92 million tons, while the total measured and indicated reserves in the > 10' thick category was found to equal 25,350.96. This is a total of 38,354.88 million tons in the > 5' category, which is 4283.54 million tons greater than the value calculated on the basis of the township level data. Thus, as the note at the bottom of Exhibit 8 indicates, the additional 4283.54 million tons of subbituminous reserves from Circular 53 (the Combo, Brown, Pulver, and Taylor report) were coded as uncorrelated, along with the 34,071.34 million tons of coal from the Baker, Bryson, Dobbin, and Reger and Lee reports.

Both Exhibits 7 and 8 are dated 1977, indicating that these worksheets were used to develop the 1976 underground DRB, which was simply depleted to obtain the 1979 DRB. In fact, that the 1979 DRB can be derived by depleting the 1976 DRB. There was no underground production from 1976 through 1978, and the 1979 underground DRB estimates of 1,385.4 million tons of bituminous coal and 69,573.3 million tons of subbituminous coal match the estimates published for 1976. (There was, in fact, a slight discrepancy in the subbituminous category - the 1976 underground DRB estimates subbituminous reserves at 69,573.5 million tons, 200,000 tons greater than the 1979 DRB estimate).

For surface mineable coal:

Subbituminous:	33,744.5 million tons 1979 DRB
	+ 98.9 depletion
	33,843.4 million tons calculated 1976 DRB, as
	compared with
	33,843.2 published DRB

Lignite:	15,765.6 million tons 1979 DRB
	+ 1.2 depletion
	15,766.8 million tons calculated 1976 DRB, as compared
	with
	15,766.8 published DRB.

The 1979 DRB cannot be derived by depleting the 1971 DRB. The 1971 underground bituminous estimate was 1,384 million tons, which is 1.4 million tons less than the 1979 estimate (depletion during the period was 0.1 million tons). This discrepancy is small enough to have been caused, perhaps, by rounding. But the 1971 underground subbituminous estimate was 63,781 million tons, 5,792 million tons less than the 1979 estimate. The 1971 surface lignite estimate is also much less than the 1979 estimate -- 7,131 million tons in 1971 versus 15,766.8 million tons in 1979.

For surface mineable subbituminous coal:

35,431 million tons 1971 DRB
- 76 depletion
35,355 million tons calculated 1979 DRB, as compared with
33,843 published DRB.

NEW MEXICO

The demonstrated reserve base for New Mexico was developed from two primary sources: Read, et. al.,²⁷ and Shoemaker, et. al.²⁸ The first source defined the total resource for New Mexico on a coal region and county level by splitting the estimates into appropriate measured, indicated, and inferred categories. The second source defined the strippable reserves for the major coal fields of New Mexico by coal field, township, and ranges in reliability categories of measured and inferred.

The original source for the majority of New Mexico's reserve base comes from a 1950 USGS Information Circular, No. 89, entitled Coal Resources of New Mexico, by Read, Duffner, Wood and Zapp. The original resource base was obtained from text discussions by adding all appropriate measured, indicated and inferred resources for each particular coalfield and county. Read, however, estimated resources for subbituminous coal greater than 30", and bituminous and anthracite greater than 14" thick.

The original resource, from Reed, can be summarized as the following:

²⁷These original coal resources were identified for underground mining only.

²⁸Shoemaker, J. W., Beaumont, E. C., and Kottlowski, F. E., compilers and editors, Strippable Low-Sulfur Coal Resources of the San Juan Basin in New Mexico and Colorado, New Mexico Institute of Mining and Technology, Bureau of Mines and Mineral Resources Memoir 25, 1971.

Exhibit 1

TOTAL ORIGINAL COAL RESERVES OF NEW MEXICO

(In Millions of Short Tons)

(p. 20 of USGS Information Circular, No. 89, 1950)

Region or field and county	Subbituminous coal (Beds more than 30 inches thick)										
	Fruitland formation					Mesaverde formation					Total Subbituminous coal
	Calculated on coal bed basis			Additional inferred on coal zone basis (Table 13)	Total Fruitland formation	Calculated on coal bed basis			Additional inferred on coal zone basis (Table 13)	Total Mesaverde formation	
	Measured (Table 6)	Indicated (Table 7)	Inferred (Table 8)			Measured (Table 6)	Indicated (Table 7)	Inferred (Table 8)			
<u>San Juan River Basin</u>											
Bernalillo County	...	...	...	...	...	1.0	...	...	...	1.0	1.0
McKinley County	4.3	59.2	84.6	18.1	166.2	229.5	180.2	21.4	12,597.4	13,028.5	13,194.7
Rio Arriba County	0.9	0.8	...	2,135.7	2,137.4	5.0	30.6	...	470.7	506.3	2,643.7
Sandoval County	0.2	0.5	...	1,609.6	1,610.3	67.3	320.9	547.9	2,399.1	3,335.2	4,945.5
San Juan County	514.1	1,171.2	4,747.0	9,319.8	15,752.1	1.3	4.2	...	12,657.2	12,662.7	28,414.8
Valencia County	...	...	...	...	...	2.9	...	...	278.4	281.3	281.3
<u>Raton Field</u>											
Colfax County	...	...	...	...	...	...	...	...	...	...	...
<u>Miscellaneous small fields:</u>											
<u>Carrizozo and Jornada del Muerto fields</u>											
Socorro County	...	...	...	...	...	...	...	...	...	...	...
<u>Gerrillos Field</u>											
Santa Fe County	...	...	...	...	...	...	...	...	...	...	...
<u>Patil Mountain Field</u>											
Catron County	...	...	...	...	...	...	...	...	267.4	267.4	267.4
Socorro County	...	...	...	...	...	...	...	...	109.9	109.9	109.9
Valencia County	...	...	...	...	...	...	...	...	942.9	942.9	942.9
<u>Sierra Blanca Field</u>											
Lincoln County	...	...	...	...	...	...	...	...	...	...	...
Otero County	...	...	...	...	...	...	...	...	...	...	...
<u>Tierras Field</u>											
Bernalillo County	...	...	...	...	...	...	...	...	...	...	...
<u>Una del Cato Field</u>											
Sandoval County	...	...	...	...	...	...	...	...	...	...	...
Total original reserves	519.5	1,231.7	4,831.6	13,083.2	19,666.0	307.0	535.9	569.3	29,723.0	31,135.2	50,801.2

Exhibit 1

(Continued)

Region or field and county	Bituminous coal (Beds more than 14 inches thick)					Anthracite (Beds more than 14 inches thick)			Total, all ranks				
	Mesaverde, Raton, and Vermejo formations					Mesaverde formation							
	Calculated on coal bed basis			Additional inferred on coal some basis (Table 13)	Total Bituminous coal	Calculated on coal bed basis		Total anthracite	Calculated on coal bed basis			Additional inferred on coal some basis	Total
	Measured (Table 9)	Indicated (Table 10)	Inferred (Table 11)			Measured (Table 12)	Indicated (Table 12)		Measured	Indicated	Inferred		
San Juan River Basin													
Bernalillo County	...	...	...	...	...	...	...	...	1.0	...	...	...	1.0
McKinley County	...	...	...	...	...	...	...	...	233.8	239.4	106.0	12,615.5	13,194.7
Rio Arriba County	7.0	6.6	...	390.3	403.9	...	...	...	12.9	38.0	...	2,996.7	3,047.6
Sandoval County	...	...	...	...	...	...	...	...	67.5	321.4	547.9	4,008.7	4,945.5
San Juan County	49.1	66.8	12.4	3,957.4	4,085.7	...	...	...	564.5	1,242.2	4,759.4	25,934.4	32,500.5
Valencia County	...	...	...	...	...	...	...	...	2.9	...	...	278.4	281.3
Raton Field													
Colfax County	567.9	1,296.4	2,844.5	...	4,709.0	...	...	...	567.9	1,296.6	2,844.5	...	4,709.0
Miscellaneous small fields													
Carabage and Jornado del Muerto Fields													
Socorro County	19.7	14.3	4.7	...	38.7	...	...	...	19.7	14.3	4.7	...	38.7
Gerrillos Field													
Santa Fe County	6.6	14.6	26.3	...	47.5	2.8	2.9	5.7	9.4	17.5	26.3	...	53.2
Devil Mountain Field													
Catron County	...	...	...	...	...	...	...	...	...	...	...	267.4	267.4
Socorro County	...	...	...	...	...	...	...	...	...	...	...	109.9	109.9
Valencia County	...	...	...	...	...	...	...	...	...	...	...	942.9	942.9
Sierra Blanca Field													
Lincoln County	3.3	8.0	...	1,405.3	1,416.6	...	...	...	3.3	8.0	...	1,405.3	1,416.6
Otero County	...	...	...	227.4	227.4	...	...	...	...	...	...	227.4	227.4
Tularas Field													
Bernalillo County	0.4	1.2	...	...	1.6	...	...	...	0.4	1.2	...	...	1.6
Rio del Gato Field													
Sandoval County	0.6	15.9	0.8	...	17.3	...	...	...	0.6	15.9	0.8	...	17.3
Total original reserves	654.6	1,424.0	2,884.7	5,980.4	10,947.7	2.8	2.8	5.7	1,483.9	3,194.5	4,289.6	44,786.6	61,754.6

<u>COUNTY</u>	<u>ORIGINAL RESOURCE (IN MILLION SHORT TONS)</u>
Bernallio	2.60
Catron	267.40
Colfax	4,709.00
Lincoln	1,416.60
McKinley	13,194.70
Otero	227.40
Rio Arriba	3,047.60
Sandoval	4,962.80
San Juan	32,500.50
Santa Fe	47.50
Socorro	148.60
Valencia	1,224.20
	<u>61,748.90</u>

The reserve estimates were derived from Read by following the standard DRB criteria for subbituminous (> 5' thickness), bituminous (> 28"), and anthracite (> 28" thickness). It was necessary to sum the reserves from the text discussions of the coalfields which identified the seam thicknesses and reliability according to DRB criteria.

The original reserve base figures for New Mexico were summed by coal rank to yield the following state reserve estimate:

<u>Rank</u>	<u>Reserve (In Million Short Tons)</u>
Anthracite	2.30
Bituminous	1,527.20
Subbituminous	889.00
	<u>2,418.30</u>

The strippable resource for New Mexico was obtained from Shoemaker, Beaumont and Kottowski, Strippable Low-Sulfur Coal Resources of the San Juan Basin in New Mexico and Colorado, Memoir 25, published in 1971. This source identified strippable resources in "measured and indicated" and "inferred" categories up to 250 feet in depth. Shoemaker

broke his estimates into township and range resources for each coalfield. Each township, range and coalfield was identified on a county basis by EIA personnel to correspond with the resource estimates of Read and DRB criteria. Table 1 shows the coalfields identified from Shoemaker with a summary of original strippable resources broken into reliability and depth categories.

In looking at this table, one notices no delineation between reliability in the Gallup or Navajo coalfields. To get a "measured" portion from these coalfield estimate totals, a review of the township descriptions contained in the report was necessary. Here, the measured reserves were estimated from the descriptions and from confidential bureau data. From maps contained in Shoemaker, each coalfield and coalfield reserve estimate was apportioned into a county report.

The strippable reserve comes from Shoemaker from the text discussions of each township of the appropriate coalfield and from Table 13 on page 125, as shown in Table 1. The summarized breakout of DRB reserves is as follows:

<u>Rank</u>	<u>Original Strippable Reserve</u>
Anthracite	-
Bituminous	558.00
Subbituminous	<u>1,934.30</u>
	2,522.30

The strippable bituminous reserve is the summing of coal reserves in the Gallup and Fruitland fields as estimated by Shoemaker. These reserves are estimated to a depth of 250 feet. The breakdown is as follows:

Table 1

ORIGINAL STRIPPABLE RESOURCES

(Millions of Short Tons)

<u>Coalfield or Area</u>	<u>Overburden Less Than 150 Feet</u>		<u>Overburden 150 Feet to 250 Feet</u>	
	<u>Measured</u>	<u>Inferred</u>	<u>Measured</u>	<u>Inferred</u>
Cortez	13.1	115.2	-	29.5
Gallup		270.0		88.0
Durango & Mesa Verde	-	-	-	-
Barker Creek	-	-	-	-
Hogback	-	-	-	-
Toadlena	-	-	-	-
Newcomb	-	78.5	-	6.3
Chaco Canyon	-	31.0	-	-
Chacra Mesa	-	-	-	-
San Mateo	-	21.2	-	-
Standing Rock		63.5	-	75.0
Zuni		6.2	-	-
Crownpoint		15.0	-	-
South Mount Taylor	-	1.4	-	-
East Mount Taylor	-	-	-	-
Rio Puerco	-	-	-	-
La Ventana	-	15.0	-	-
Tierra Amarilla	-	-	-	-
Monero	-	-	-	-
Pagosa Springs	-	-	-	-
Durango	-	-	-	-
Red Mesa	-	22.0	-	18.0
Fruitland	93.0	-	65.0	-
Navajo	1,024.7		1,352.8	
Bisti	-	958.0	-	912.0
Star Lake	-	365.0	-	270.0
Totals	<u>3,092.8</u>		<u>2,816.6</u>	
Grand Total			5,909.4	

	Depth	
	(in Million Tons)	
	0-150'	150'-250'
Gallup Field (page 43)	250.0	180.0
Fruitland Field (page 107)	93.0	65.0
	343.0	245.0

Total 588-0 million short tons

The subbituminous reserve of 1,934.30 million short tons cannot be lifted directly from Table 13 (Table 1) in the Shoemaker report. It is the estimated amount of strippable coal greater than 5 feet thick according to DOE criteria. These figures were developed entirely from confidential BOM file data. The New Mexico files did not contain the confidential worksheet where this calculation was made.

From the total reserves contained in Read, and the strippable reserves broken out of Shoemaker, the 1979 demonstrated reserve base was derived.

In deriving the 1979 numbers, several key assumptions were made. First, for the 1976 DRB and later 1979 DRB numbers, underground and surface coal production was split by coal rank. It was assumed that all underground mining was of bituminous coal and all surface mining was subbituminous. Secondly, production figures from 1882 to 1948 reported in Read and others was assumed to be all underground mining. Lastly, that depletion from mining would be calculated with the standard factors of 2.0 for underground mining and 1.25 for surface mining.

In addition to these assumptions, an error was discovered in the reserve estimates taken from Shoemaker. The Cortez field reported to contain 13.1 million tons of measures reserves was found to lie in

Colorado. This amount was correctly subtracted from the strippable reserves when discovered.

Production and depletion data were obtained from several sources. Production through 1947 came from Read and others. Production from 1948 to 1979 was obtained from BOM and EIA annual production reports. Again, depletion factors of 2.00 and 1.25 for underground and surface mining losses respectively were used. The depletion of New Mexico coal reserves can be summarized by the following table:

<u>Depletion (In Million Short Tons)</u>			
<u>Rank</u>	<u>1881-1971</u>	<u>1971-1979</u>	<u>Total</u>
Anthracite	-	-	-
Bituminous	260.35	12.28	272.63
Subbituminous	37.97	88.72	126.69

This leads to the next table, which outlines the reserve calculation for 1979.

<u>Rank</u>	<u>Original Reserve</u>	<u>Depletion to 1/1/79</u>	<u>DRB</u>
Anthracite	2.30	-	2.30
Bituminous	2,115.20	272.63	1,842.57
Subbituminous	2,823.30	126.69	2,696.61
	<u>4,940.80</u>	<u>399.32</u>	<u>4,541.48</u>

Rearranging these data to reflect underground and surface reserves produces the following table:

<u>Rank</u>	<u>Underground</u>	<u>Surface</u>	<u>Total</u>
Original Reserve (Read, Shoemaker)	2,418.50	2,522.30	4,940.8
Depletion	<u>272.63</u>	<u>126.69</u>	<u>399.32</u>
1979 DRB	<u>2,145.87</u>	<u>2,395.61</u>	<u>4,541.5</u>

The figures shown above can be documented from a memo in the New Mexico file shown in Figure 1. By tracing these numbers, the 1979 DRB can be derived from the source documents.

Figure 1

FILE MEMO OF NEW MEXICO DEPLETION

New Mexico

Using as a basis:

- 80% - Strip
- 50% - Underground

		<u>Production</u>	<u>Depletion</u>	
	<u>Depletion to</u>	<u>1-1-76 to 1-1-79</u>		<u>Depletion</u>
	<u>1/1/76</u>			<u>to 1-1-79</u>
Bituminous (UG)	268.38	2.126	4.25	272.63
Subbituminous (S)	87.54	31.323	39.15	126.69
	<u>355.92</u>	<u>33.449</u>	<u>43.40</u>	<u>399.32</u>

Source: New Mexico files.

NORTH DAKOTA

The published 1979 DRB for North Dakota is 9971.22 million tons; all of this coal is lignite amenable to surface mining. The original reserve on which this is based, which is equal to 10,206.64 million tons, was derived by adjusting county-level reserve data obtained from R.A. Brant's Lignite Resources of North Dakota²⁹ to estimate the strip-pable reserves. Table 1 of the Brant report, which provides estimates of measured and indicated reserves broken down by county and thickness category (5'-10', >10'), was the basis for the 10,206.64 million ton figure. Two adjustments were made to the estimates presented in the table: first, each county was multiplied first by 0.7 (Brant estimated that 70 percent of the reserves presented in Table 1 lie within 500 feet of the surface); second, the results were multiplied by 0.4 (to estimate the amount of reserves lying within 200 feet of the surface, i.e., the strippable reserves). The results were summed across all counties to obtain the 10,206.64 million ton original reserves. A typed version of the calculation sheet used by EIA to develop this estimate is presented in Exhibit 1; the data presented in the first four columns of this sheet were taken directly from the Brant report.

Depletion was calculated on the basis of state-level production data contained in the Brant report for the years 1884-1950. Brant obtained the production data from State mine inspectors; according to the North Dakota Methodology, their records indicate that in 1927 40% of the State's production was by surface mining and that by 1950 the figure had risen to 86 percent.³⁰ Thus, EIA interpolated the pre-1950

²⁹Brant, R.A., Lignite Resources of North Dakota, U.S. Geological Survey Circular 226, 1953.

³⁰prior to 1927 production was predominantly by underground mining but a breakdown for this period is lacking.

Exhibit 1

CALCULATION OF STRIPPABLE COAL IN NORTH DAKOTA

County	<u>Measured^a</u>		<u>Indicated^a</u>		Demonstrated Reserve Base	0-500' (70%)	0-200' (40%)
	5-10'	10'	5-10'	10'			
Adams	28.56	38.20	115.64	83.13	265.53	185.87	74.35
Billings	251.54	213.45	1,066.26	1,344.40	2,835.65	1,984.96	793.98
Bowman	52.94	166.39	472.52	444.30	1,136.45	795.31	318.12
Burke	148.78	11.05	329.70	80.56	539.09	371.06	148.43
Burleigh	5.66	36.20	89.86	76.07	207.79	145.45	58.18
Divide	63.41	53.85	374.48	300.08	791.82	554.27	221.71
Dunn	303.78	194.93	1,574.52	918.96	2,992.19	2,094.53	837.81
Golden Valley	205.77	27.62	979.46	76.73	1,289.58	902.71	361.08
Grant	180.45	21.50	457.43	10.59	669.97	468.98	187.59
Hettinger	47.56	49.02	508.56	241.74	847.28	593.10	237.24
McHenry	3.91	9.93	21.44	4.24	39.52	27.66	11.07
McKenzie	761.04	25.56	2,116.00	308.71	3,211.31	2,247.92	899.17
McLean	305.87	31.75	1,206.48	379.21	1,923.31	1,346.32	538.53
Mercer	425.94	649.61	2,056.17	1,621.89	4,753.61	3,327.53	1,331.01
Morton	338.64	41.82	1,301.75	286.21	1,968.42	1,377.89	551.16
Mountrail	67.97	79.52	368.05	233.57	749.11	524.38	209.75
Oliver	206.25	52.21	1,257.16	407.32	1,922.94	1,346.06	538.42
Renville	5.29	18.57	35.01	-	58.87	41.21	16.48
Sheridan	-	-	-	-	-	-	-
Slope	169.68	356.08	1,827.30	2,600.45	4,993.51	3,495.46	1,398.18
Stark	150.94	136.44	836.39	1,092.72	2,216.49	1,551.54	620.62
Ward	37.43	145.55	381.36	340.93	905.27	633.69	253.48
Williams	241.91	63.87	1,251.64	556.42	2,143.84	1,500.69	600.29
State Total	3,963.72	2,463.12	18,627.18	11,398.23	36,452.25	25,516.58	10,246.64

^aData from USGS Circular 226 - Table 1.

production split to be 65 percent underground mining and 35 percent surface mining. Recovery factors (which, according to the North Dakota Methodology, were based on information contained in Brant and staff professional judgement) of 70 percent for surface mining and 40 percent for underground mining were used to determine the pre-1950 depletion.

Depletion for the years 1951-1978 was based on production data obtained from production records of the BOM (through 1975) and EIA annual reports (1976-1978). Underground production was insignificant during this period, and a recovery factor of 80 percent was employed to determine the surface depletion. The total depletion from surface mining for the period 1884-1978 was then determined, and the original reserve figure of 10,206.64 million tons was reduced by this amount to obtain the 1979 DRB:

10,206.64 million tons original reserves
- 235.39 depletion (surface only)
9,971.25 million tons calculated 1979 DRB, as compared with
9,971.22 published DRB

Both the '76 and '79 DRB are based on the same original reserve estimate. In '79 the total depletion by strip mining from 1884 on was used to derive the DRB. This strip depletion was 735.39 million tons. In '76, the total depletion by underground mining, from 1884 on, was used to derive the DRB. This underground depletion was 61.32 million tons. Thus,

10,206.64 million tons original reserves
- 61.32 depletion
10,145.30 million tons calculated 1976 DRB, as compared with
10,145.30 published 1976 DRB.

Although the 1976 and 1979 DRB estimates are based on the same original reserve estimate, the 1971 DRB is not. The 1971 DRB estimate is 16,003 million tons of surface mineable lignite; this is nearly 6 billion tons greater than the 1976 estimate. Depletion between 1971 and 1976 was only 55.6 million tons.

OKLAHOMA

The Oklahoma 1979 DRB is based on resource information from S. A. Friedman's Investigation of the Coal Reserves in the Ozarks Section of Oklahoma and Their Potential Uses.³¹ Specifically, the remaining reserve estimates as of January 1, 1974 were derived directly from resource data presented in Tables 40 through 58 in the Appendix to Friedman's report; the 1979 DRB was then calculated simply by depleting the 1974 remaining reserves to 1979. Tables 40 through 58 in the Friedman report present resource estimates broken down by county, seam, overburden depth range (0'-100'; 101'-1000'; 1001'-2000'; 2001'-3000'; +3000') bed thickness range (12"-14", or, for some counties, 10"-14"; 15"-28"; 29"-42"; +42"), and measured, indicated, and inferred reliability categories. The 1974 remaining strippable reserves determined from Tables 40 through 58 include all coal under 100 feet or less of cover, falling in the measured and indicated reserve categories. Coal with a thickness equal to or greater than 12 inches is included in the strippable reserves (and for some counties, coal with a 10"-12" thickness is also included in the reserves, depending on whether or not this coal was included in Friedman's tables for the county). The total remaining surface reserves calculated from Friedman's tables equals 431.58 million tons.

The 1974 remaining underground reserves consists of all coal in the 101' - 1000' overburden depth categories, with a thickness greater than 28 inches, falling in the measured and indicated resource categories in Friedman's tables. Our calculation of underground reserves yielded a value of 1238.45 million tons.

³¹Friedman, S. A., Investigation of the Coal Reserves in the Ozarks Section of Oklahoma and Their Potential Uses, Final Report to the Ozarks Regional Commission, July 10, 1974, Fourth Printing, 1977.

The 1974 remaining reserves were depleted on the basis of production data obtained from the BOM Minerals Yearbooks (for the years 1974 and 1975), and the EIA annual production reports (for the years 1976-78). Exhibit 1 is a typed version of the calculation sheet used to determine the state-level depletion values. As the sheet indicates, the surface depletion³² between 1974 and 1978 was 26.14 million tons, while the underground depletion was insignificant. Thus:

For Surface:

431.58 million tons remaining reserves (1/1/74)
- 26.14 depletion
405.44 million tons calculated 1979 DRB, as compared with
405.57 published DRB

For Underground:

1238.45 million tons remaining reserves (1/1/74)
- 0.00 depletion
1238.45 million tons calculated 1979 DRB, as compared with
1238.44 published DRB

The 1979 surface DRB estimate can be derived simply by depleting the 1976 estimate, as follows:

425.2 million tons 1976 published DRB
- 19.6 depletion
405.6 million tons calculated 1979 DRB, as compared with
405.6 published 1979 DRB.

The 1979 underground DRB estimate, on the other hand, cannot be derived by depleting the 1976 estimate. the 1976 estimate is actually less than the 1978 estimate (by 45.5 million tons).³³

³²The surface depletion was obtained by multiplying the surface production by the standard depletion factor of 1.25.

³³The 1979 underground DRB was increased by EIA's computer program after the program was improved.

Exhibit 1

OKLAHOMA DEPLETION

	<u>1974</u>	<u>1975</u>	
UG	ø	-	
Strip	2,191	2,872	
Auger	165	-	
Total	2,356	2,872	5,228 @ 80% = <u>Depletion</u> 6,535,000

5-19-80

	<u>Strip</u> <u>(1,000 Tons)</u>		<u>UG</u> <u>(1,000 Tons)</u>	
	<u>Production</u>	<u>80%</u>	<u>Production</u>	<u>50%</u>
1976	3.635		0	
1977	5,978		0	
1978	6,068		2	
	<u>15,681</u>	19,601.25	<u>2</u>	4

To 1-1-79

19.60 MM
+6.54
26.14

0.00 MM
+0.00
0.00

The 1971 underground DRB estimate is 860 million tons, which is 378 million tons less than the 1979 estimate. For surface mineable coal:

434 million tons 1971 DRB

-15 depletion

419 million tons calculated 1979 DRB, as compared with

406 published 1979 DRB.

Thus, neither the surface nor underground 1979 DRB estimates can be derived by depleting the 1971 estimates.

OREGON

The 1979 Oregon DRB is based on data presented in D. C. Duncan's Geology and Coal Deposits in Part of the Coos Bay Coal Field, Oregon,³⁴ and Ralph S. Mason's and M. I. Erwin's Coal Resources of Oregon.³⁵ The underground reserve estimate was based solely on Table 2 in the Mason and Erwin report. This table provides remaining (as of July 1, 1945) reserve data on portions of the Coos Bay Coal Field, broken down by bed, "reserve area" (keyed to a map--Figure 20--in the report), thickness range, overburden depth category and measured, indicated and inferred reliability categories. Only coal in the measured and indicated categories was included in the DRB. Also, although all reserves in some reserve areas, with overburden depth categories of 0-1200', were included in the DRB, none of the coal in other reserve areas with overburden depths of 0-1500' was included in the DRB. Three of the 17 reserve areas were included in the underground DRB estimate. All of the coal in Areas 3 (9.993 million tons at a depth of 0-1200', with a thickness of 4.8'-6.1'), 5 (1.032 million tons at a depth of 0-300', with an average thickness of 5.3'), and 6 (3.555 million tons at a depth of 0-1200', with a thickness ranging from 3.9' to 7.5') was included in the DRB. The other reserve areas were completely excluded, some (apparently) because of the overburden depth (0-1500'), and some because of the average coal thickness (5'). The total July 1945 remaining underground reserves included in the DRB were:

³⁴Duncan, D. C., Geology and Coal Deposits in Part of the Coos Bay Coal Field, Oregon, U.S. Geological Survey Bulletin 982-B, 1953.

³⁵Mason, Ralph S., and Erwin, M. I., Coal Resources of Oregon, U.S. Geological Survey Circular 362, 1955.

9.993 million tons
1.032 million tons
3.555 million tons
14.580 million tons

The reserves of Reserve Area 1 (from Table 2 of the Mason and Erwin report) with an overburden depth of 0-200' and a coal thickness range of 3.6' to 5.2' (a total of 2.556 million tons) were included in the surface DRB estimate. None of the coal in the other 16 reserve areas was added to the Area 1 coal. However, strippable reserves in other parts of the Coos Bay Field, from Table 1 in the Duncan report, was added to the 2.556 million tons.³⁶ A total of 369,000 tons of coal, classified as strippable in Table 1,³⁷ in the Englewood and Riverton areas of the Coos Bay Field, were added to the 2.556 million tons from the Mason and Erwin report to yield a total of 2.93 million tons.

Production data, according to the Oregon Methodology, were obtained from the files of the BOM, Western Field Operations Center. The source data could not be found in the field office files, but a handwritten calculation sheet (a typed version of which is presented as Exhibit 1) presenting production data from 1945 to present (May 1977) was found. As the exhibit indicates, 34,563 tons were produced during

³⁶To ensure that coal in areas already covered by the Mason and Erwin report was not double-counted, reference was made to maps (Figure 20 in the Mason and Erwin report and Figure 1 in the Duncan report). Double counting did not occur.

³⁷The definition of strippable coal could not be found in the Duncan report, so it is not known how thick or deep the 369,000 tons are. However, since reserves in Table 1 are presented by reliability category (measured, indicated and inferred), it could be determined that this coal is measured and indicated coal.

this period. The EIA annual reports indicate that there was no production from 1976 through 1978; thus 34,563 was taken as the total production from 1945 through 1978. All production was assumed to be by underground mining (see Exhibit 1), and thus the cumulative production was multiplied by 2 to yield 0.07 million tons of depletion.

Thus:

For surface:

2.93 million tons remaining reserves
0.00 depletion
2.93 million tons calculated 1979 DRB, as compared with
2.94 million tons published DRB

For underground:

14.58 million tons remaining reserves
-0.07 depletion
14.51 million tons calculated 1979 DRB, as compared with
14.51 million tons published DRB

All reserves were assigned to the subbituminous category.

Exhibit 1 indicates that there was no production after 1953. Thus, the 1976 and 1971 DRBs should match the 1979 DRB. The 1976 estimates do match the 1979 estimates, but the 1971 estimates do not. In 1971, underground subbituminous reserves were estimated at 1.03 million tons (13.48 million tons less than the 1979 estimate), and surface subbituminous reserves were estimated at 0.37 million tons (2.57 million tons less than the 1979 estimate). Also, in 1971 it was estimated that there were 0.46 million tons of strippable bituminous coal in Oregon, while in 1979 it was estimated that there was no bituminous reserves (either surface or underground) in the State.

Exhibit 1

OREGON PRODUCTION/DEPLETION

	<u>Tons</u>	
1945	6,000	
1946	18,000	
1947	2,000	
1948	2,000	
1949	4,000	All production from Coos County
1950	1,384	
1951	None Recorded	
1952	7,179	Subbituminous
1953 to Present	<u>None Recorded</u>	
	34,563 x 2 = 69,126	

Assume all Underground
Depletion (1945 to Present)

0.07 million tons

SOUTH DAKOTA

The South Dakota Methodology presented in the 1979 DRB publication indicates that for all counties, other than Harding County, data estimated by Paul Averitt, from D. M. Brown's Lignite Resources of South Dakota³⁸ and information from the South Dakota Geological Survey, were used in developing the DRB. These data were summarized, the Methodology states, in the Northern Great Plains Resources Program's Mineral Resources Work Group Report.³⁹ For Harding County, the Methodology states that the DRB is based on J. A. Redden's Lignite Reserves, Harding County, South Dakota,⁴⁰ published in 1978. Further investigation indicates that it was the back-up data to the Redden report, rather than the data presented in the report itself, that were used to develop the Harding County DRB estimate. The back-up data present reserve estimates by section. Due to errors made when totaling the section estimates, the Harding County estimate presented in the Redden report does not equal the total of the section estimates.

The 1971 South Dakota DRB estimate is 428 million tons, and the 1979 estimate is 366.1 million tons.⁴¹ The BOM and EIA annual production publications indicate that there was no production between 1971 and 1979. Furthermore, the 1971 DRB estimate matches the total in-place reserves for the state presented in Table 9 of the Northern Great

³⁸Brown, D. M., Lignite Resources of South Dakota, U.S. Geological Survey Circular 159, 1952.

³⁹Northern Great Plains Resources Program, Mineral Resources Work Group Report, 1974.

⁴⁰Redden, J. A., Lignite Reserves, Harding County, South Dakota, U.S. Bureau of Mines Grant Number GO 264015, 1978; later administered under U.S. Department of Energy Contract Number ET-76-G-01-90779.

⁴¹All of the reserves are lignite, amenable to surface mining.

Plains Resources Program's (NGPRP) report (see Exhibit 1). Thus, it is believed that the county-level reserve data presented in Table 9 of the NGPRP report from the basis of the 1979 DRB (since the only difference between the 1971 and 1979 DRB should be the use of the 1978 Redden report), with the Harding County estimate of 227⁴² million tons (see Exhibit 1) replaced with the total of the Redden section data.

It should be noted that a derivation of the 1979 DRB from the 1976 DRB is not possible - the 1976 DRB is 426.1 million tons, which equals the 1971 DRB of 428 million tons, minus 1.9 million tons of depletion from the 19th century to present.⁴³ Thus, the 1976 and 1971 DRBs are based on the same original reserve estimate, and since the 1979 DRB cannot be derived from the 1971 DRB, it clearly cannot be derived from the 1976 DRB.

⁴²Unfortunately, this could not be confirmed, due to the large number of sections in Harding County, and the lack of time needed to make the summation.

⁴³There may be a small error due to rounding of production estimates.

Exhibit 1

METHOD OF RECOVERY OF LIGNITE RESERVES OF SOUTH DAKOTA, JANUARY 1, 1972

(In Millions of Short Tons)

County	Original reserves in the ground, 0-1,000 ft overburden ^a	Method of recovery				
		Surface mining ^b			Underground mining	
		Reserves in the ground ^c	Potentially recoverable ^d	Economically recoverable ^e	Reserves in the ground ^c	Potentially recoverable ^f
	(1)	(2)	(3)	(4)	(5)	(6)
Corson	40	30	24		10	5
Dewey	200	130	104		70	35
Harding	700	227	182		473	237
Meade	---	---	---		---	---
Perkins	80	40	32		40	20
Ziebach	1	1	1		0	0
Total	1 021	428	343	206	593	297

- a From col. 1, table 8. Cumulative production and losses to Jan. 1, 1972 is small. Use of figures for original reserves introduces no appreciable error.
- b M. J. Tipton, South Dakota Geological Survey, written communication, 1973.
- c Col. 2 plus col. 5 equals col. 1.
- d 80% of figures in col. 2.
- e 60% of total in col. 3; not classified by county.
- f 50% of figures in col. 5.

TEXAS

The 1979 Texas DRB was developed from resource data presented in Lignite Resources in Texas.⁴⁴ The estimates, included in Table 3 of this report, are broken down into measured, indicated and inferred categories, but EIA made the judgement that the measured category includes coal in both the measured and indicated categories (as defined by EIA), and the indicated category includes coal in both EIA's indicated and inferred categories. Thus, EIA decided to include only measured resources from Table 3 of the report. This Table presents resource estimates of lignite under 200 feet or less of cover, 3 feet or more thick, by geologic groups and formations, and by region. The total measured strippable lignite resources presented in Table 3 equals 12,916 million tons; this value was depleted to obtain the 1979 DRB of 12,693.54 million tons.⁴⁵

A typed version of the calculation sheet used to determine the total depletion to be applied to the 12,916 million ton resource estimate is presented in Exhibit 1. The production data for the pre-1974 period were obtained from page 29 of Kaiser's Texas Lignite: Near-Surface and Deep Basin Resources.⁴⁶ (It should be noted that Kaiser states in this report that the pre-1974 production figures represent

⁴⁴Kaiser, W. R., Ayers, W. B., Jr., and La Brie, L. W., Lignite Resources in Texas, Bureau of Economic Geology Report of Investigations 104, 1980.

⁴⁵The 1979 Texas DRB includes only lignite amenable to surface mining.

⁴⁶Kaiser, W. R., Texas Lignite: Near-Surface and Deep-Basin Resources, Texas Bureau of Economic geology Report of Investigations 79, 1974.

estimates.) For the pre-1950 period, EIA assumed a recovery factor of 50 percent (during this period, the Texas Methodology states, most production resulted from shallow underground mining). Between 1950 and 1974, a 75 percent recovery factor was assumed.

Production data for the years 1974 and 1975 were obtained from the BOM Minerals Yearbooks, and data for the years 1976-1978 were obtained from EIA annual production reports. The standard surface recovery factor of 80 percent was used to determine depletion for this period. The total depletion, as Exhibit 1 indicates, and as confirmed by reviewing the source documents, is 222.46 million tons. This depletion, when subtracted from the 12,916 million ton resource estimate from the Lignite Resources in Texas report, yields 12,693.54 million tons of strippable lignite, which is precisely equal to the 1979 DRB.

Because the 1979 DRB is based on data (contained in the Lignite Resources in Texas report) that were not available in 1971, the 1979 DRB cannot be derived simply by depleting the 1971 DRB. The new data presented in the 1980 report resulted in a substantial increase in the Texas DRB, from 3,272 million tons of strippable lignite in 1971, to 12,916.54 million tons in 1979. The 1976 DRB estimate is even lower than the 1971 estimate--3,181.9 million tons.

Exhibit 1

TEXAS - PRODUCTION

Source: Tex Bu Econ Geol RI 79

Cum. to 1950	35,000,000 tons	(assume shallow UG) @ 50%
1950 to 1-1-74	50,000,000 tons	(assume strip) @ 75%
USBM 1974	7,684,000 tons	(Assume strip) @ 80%
1975	11,002,000 tons	
Cum. to 1-1-76	103,686,000 tons	

<u>Depletion</u>	70,000,000	(50% and 75% given)
	66,667,000	(80% assumed)
	<u>23,357,500</u>	
	160,024,500	

Prior to 1950 - mostly shallow room and pillar (avg. 50%)
 Since 1950 - almost all strip (avg. 75%, locally to 90%)

USBM/DOE (1,000) Lignite

1976	14,063
1977	15,865
<u>1978</u>	<u>20,020</u>
Total	49,948

Depletion @ 80%	= 62.435
Cum. to 1-1-76	<u>160.025</u>
Cum. to 1-1-79	222.460

UTAH

The Utah DRB is taken directly from the Monograph series Numbers 1, 2 and 3, by Doelling and Doelling and Graham published in 1972.⁴⁷ These reports estimated Class I, Class II and Class III coal resources up to 3000' in depth.

The procedure used for establishing the original Utah reserve base centered on interpreting the geologic maps and accompanying discussion of each coal field quadrangle contained in the monographs. Quadrangle estimates were then proportioned between the member counties making up the quadrangle. Figure 1 outlines Utah DRB methodology used to prepare 1979 DRB.

The difficulty in obtaining reserves meeting DRB criteria lies in the flexible nature of the monograph series. The resources are based on class estimates of reliability, which correspond, but do not match exactly, to the following DRB criteria:

- Class I - measured
- Class II - indicated
- Class III - inferred
- Class IV - (potential) no DRB criteria.

⁴⁷Doelling, H. H., Central Utah Coal Fields, Utah Geological and Mineralogical Survey Monograph Series 3, 1972.

Doelling, H. H., and Graham, R. L., Southwestern Utah Coal Fields, Utah Geological and Mineralogical Survey Monograph Series 1, 1972.

_____, Eastern and Northern Utah Coal Fields, Utah Geological and Mineralogical Survey Monograph Series 2, 1972.

Figure 1

UTAH DRB

Also, Doelling estimated resources for all coal seams with a 4-foot mineable limit. According to Doelling, "In most cases, the reserves under 4 feet has been eliminated as well as coal at a depth greater than 3,000 feet."

Because of the Doelling treatment with the 48" cutoff of mineable coal, it became necessary to review the compiled tables of resources, but derive the coal reserves from the quadrangle discussions which included production reports, mining descriptions and detailed seam descriptions of all coal horizons in the quadrangle. These descriptions identified reserves lying within 1,000 feet at a specified average thickness.

For example, the Alton quadrangle of the Alton coal fields is discussed in the Series 1 report. On page 29 of the report, Doelling describes the coal reserves for the Alton quadrangle, and sums the information in Table 10 which estimates the coal reserves for all seams greater than 42".

The reserves are estimated, according to Doelling, based on work done by earlier geologists. Because the Alton reserves discussed in the report are all 42" or more in thickness, Table 10 corresponds with the total quadrangle estimate. Table 1, below, shows the Alton quadrangle reserve figures as estimated by Doelling.

Table 1

COAL RESERVES IN THE ALTON QUADRANGLESEAMS MORE THAN 42 INCHES THICK

(In Short Tons)

<u>Smirl Coal Zone (Ft)</u>	<u>Class II</u>	<u>Class III</u>	<u>Total</u>
0-1000	181,920,000	31,630,000	213,550,000
1000-2000	17,510,000	37,310,000	54,820,000
2000-3000	25,730,000	48,240,000	73,970,000
Total	225,160,000	117,180,000	342,340,000
<u>Bald Knoll Coal Zone (Ft)</u>			
0-1000	75,450,000	46,760,000	122,210,000
1000-2000	400,000	28,220,000	28,620,000
2000-3000	2,100,000	32,810,000	34,910,000
Total	77,950,000	107,970,000	185,740,000
<u>All Coal (Ft)</u>			
0-1000	257,370,000	78,390,000	335,760,000
2000-3000	17,910,000	65,530,000	83,440,000
2000-3000	27,830,000	81,050,000	108,880,000
Total	303,110,000	224,970,000	528,080,000

For the Alton quadrangle, EIA accepted the Class II 0-1000 foot category figure of 257.37 million tons as the underground reserve. Because strippable coal was not mentioned in the discussions, no reserves were estimated for this quadrangle.

The other coal fields of Utah were developed along similar lines as the Alton field. Interpretation of the discussions on the coal seams, in many cases, was the only reference point available to build the reserve base. Strippable coal was identified where mentioned; however, these strippable estimates were given as tons recoverable. It was necessary for EIA personnel to identify recoverable percentage factors for that seam, and to calculate back to the in-place tonnage. The total original underground and surface reserves matching DRB

criteria were the sum of the quadrangle estimates for all three monographs. These reserves can be summarized by the following table:

<u>Rank</u>	<u>(In Million Tons)</u>	
	<u>Underground Original</u>	<u>Surface Original</u>
Bituminous	6,720.56	267.89
Subbituminous	1.10	-

Production and subsequent depletion of the original Utah reserves were based on quadrangle discussions (1870 to 1970) in Doelling, the BOM production reports and Yearbooks (1971-1975), and EIA annual reports (1976, 1977, 1978). A major split in depletion factors occurred between depletion from the period 1870-1976 and 1976-1979.

Production and depletion from the original reserves to January 1976 is assumed to have been done on a coal field basis from information in Doelling, and Bureau production data.⁴⁸ Let us return to the Alton coal field example.

The production from the Alton field to January 1970 came from Doelling discussions of the Alton field. From 1970 to 1979, BOM and DOE/EIA annual reports were used. According to Doelling on page 29:

"Total production estimates for the Alton coal field ranged from 35,000 to 50,000 tons, with at least 95 percent coming from the Alton quadrangle".

⁴⁸Few records exist of the pre-1976 methodology; however, file notes show 1970 to 1976 data developed in this manner. Therefore, pre-1970 production is assumed to be developed on a coal field basis.

Therefore, EIA assumed 95 percent of 50,000 tons was the production from the Alton quadrangle, which amounted to 47.5 thousand tons. The Doelling report for the Alton field also noted that mining was stopped in the Alton quadrangle in 1969.

To arrive at the depletion figure for the Alton quadrangle from Doelling required more than a straightforward 2.0 depletion factor. Here, a Doelling reference to Grose, Hileman and Ward (1967, pages 42-43) indicates the typical recovery of the Alton mines:

"....A section measured by Cashion (1961) consists of 18 feet of coal with no impurities.....The upper 9 feet of coal is serving adequately as a self supporting roof.

On the basis of these reports, EIA used a 25 percent depletion factor, (0.50 x 0.50) or 4.00 for the Alton quadrangle depletion. Total depletion, therefore, amounted to 0.19 million tons (0.0475 x 4).

Each coal field was likewise depleted using actual depletion factors derived from local production. Underground production and depletion for each coal field to January 1976 can be summarized by the following table:

<u>Coal Field</u>	<u>Production (Millions)</u>	<u>Depletion (Millions)</u>	<u>Coal Field Depletion Factor</u>
Alton	0.0475	0.19	4.00
Kaiparowits	0.0430	0.14	3.25
Kolob	0.6080	1.45	2.38
Vernal	0.2710	0.46	1.70
Henry Mountains	0.0080	0.02	2.50
Ligo	2.6570	6.63	2.50
Coalville	4.0000	8.00	2.00
Salina Canyon	0.4300	1.05	2.44
Sterling	0.0600	0.00	0.00

<u>Coal Field</u>	<u>Production (Millions)</u>	<u>Depletion (Millions)</u>	<u>Coal Field Depletion Factor</u>
Wales	0.1750	0.00	0.00
Wasatch Plateau	116.1710	74.55	0.64
Book Cliffs	225.5797	337.49	1.50
Emery	<u>2.6764</u>	<u>6.69</u>	<u>2.50</u>
	352.7271	436.67	1.24

Surface production and subsequent depletion for Utah was considered small and generally localized by Doelling. Operating on this information, EIA did not deplete any surface reserve estimates.

The production data for years 1976, 1977 and 1978 were obtained on a state level from DOE/EIA annual reports. The production was then depleted by a standard factor of 2.00 to yield a 1976-1978 depletion of 52.38 million short tons. This is verified on a file calculation sheet of July 1980. The total depletion, then, for Utah is:

Depletion to 1/1/76	436.67 (calculation sheet of 5/23/77)
Depletion	<u>51.38</u> (calculation sheet of 7/8/80)
	488.05

This represents a depletion of underground bituminous reserves. By subtracting this depletion from the original reserve base of 6,720.56 million tons, the 1979 reserve base of 6,232.51 million tons as reported in the DRB can be documented.

WASHINGTON

The 1979 DRB for Washington is based mainly on Beikman and others (1961). Beikman estimated the reserves as of 1/1/60, so depletion from 1960 was necessary. Figure 1 outlines the basic methodology used to estimate Washington's coal reserves.

Beikman gave the coal reserve estimates by bed and township within given counties. This source derived the reserves for "measured", "indicated", and "inferred" reliability categories for 0-1000, 1000-2000 and 2000-3000 foot depths. Thickness categories included 14-28", 28-42" and greater than 42" for bituminous reserves, and 2.5-5.0', 5.0-10.0', and greater than 10 feet for subbituminous and lignite reserves.

The total reserves for bituminous, subbituminous, and lignite coals in Washington are the sum of the remaining reserves for every coal field in Washington that meet the criteria of being in a:

- "Measured and Indicated" reliability category greater than 28" for bituminous (5' - subbituminous, lignite) lying between 0-1000 feet deep (0-60' - lignite).

A total close to 1,450.0 million tons was obtained by EIA from Beikman as the January 1960 reserve.

Two studies added more reserves to the Washington reserve base after the January 1960 reserve estimate. Moen (1969) and Vonheeder (1977) both estimated more underground reserves for a remote township of Whatcom County. Moen estimated an additional 9.03 million tons and Vonheeder added 2.16 million tons for a combined total of 11.19 million tons, which was added to the underground bituminous reserve estimates.

Figure 1

WASHINGTON DRB METHODOLOGY FLOW CHART

The Washington strippable reserves were derived from the U.S. Bureau of Mines Information circular Number 8531 (1971) and Beikman (1960). The subbituminous reserves are obtained from Table A-80, page 116 of IC 8531, under the column "Remaining strippable resource." These strippable reserves are calculated to a depth of 250 feet, and totaled 500 million tons. The strippable lignite reserve was obtained from Table 35, page 106 of Beikman (1960) and totaled 8.06 million tons. The total strippable, therefore, is the sum of the depleted (1971-1979) 500 and 8.06 million. Since no production of 19.84 million yielded a depletion of 18.55, the 1979 DRB estimate is simply the summed estimate of 489.51 (481.45 8.06).

Production and subsequent depletion to 1979 was done in two stages, 1960 to 1976 and 1976 to 1979. Both periods used the standard depletion factors of 1.25 and 2.00.

Production from 1960 to 1976 was obtained from a letter by the western Field Office of the Bureau of Mines in Spokane, Washington, for years 1960 through 1974, and from EIA data for years 1975 and 1976. Total production and depletion for 1960-1974 is shown in the following table:

Table 2
(In Million Tons)

County	Type	Rank	1960-1975 Production	1960-1975 Depletion
King	Strip	Bituminous	0.013	0.076
	UG	Bituminous	0.622	1.244
Kittitas	Strip	Bituminous	0.010	0.013
	UG	Bituminous	0.564	1.128
Lewis	Strip	Subbituminous	13.183	16.479
Thurston	Strip	Subbituminous	1.648	2.060
Total ^a			16.040	20.940

^aMay not correspond directly because of rounding.

As an interesting note, depleting the original reserve to 1976 will yield the 1979 demonstrated reserve base.

Depleting from 1976 to 1979 resulted in an addition error that understated the production for that period by over 13 million tons. This error was transferred into the 1979 reserve base estimates is explained as follows:

- The production between 1976 and 1979 amounted to 13,874 million short tons. However, when this amount was added to the previous production (i.e., from 1960-1975), it was taken as 13.874 thousand tons. Hence the indication of no depletion between the 1976 and 1979 published figures. The error can be traced to a file worksheet where the 1979 DRB was depleted from 1976. This worksheet is shown in Exhibit 1.

The true total production for Washington through 1978 comes to the following:

Table 3			
(In Million Tons)			
	<u>Underground</u>	<u>Surface</u>	<u>Total</u>
Bituminous	1.204	0.071	1.275
Subbituminous	-	28.652	28.652
			<u>29.927</u>

This translates into a true depletion of 38.312 million tons, instead of the 20.99 million tons used to deplete the January 1960 reserve base to January 1979. However, the 1979 published figures can be derived from the original source documents by using the addition error in production.

By using this addition error for the total production, the 1979 DRB can be derived from the original source documents.

Exhibit 1

WASHINGTON - PRODUCTION AND DEPLETION

See letter
from W. Field Op. Co. (150M)

County	Type	Assessed rank	1950-1974	1975	1976	1977	1978	
King	Strip	3.4	(avg)	12,464	16,613 ⁽¹⁾	17	14	48
	UG	.	1,621,926	13,000	5,268 ⁽²⁾	-	-	5
Grimes	Strip	3.4	9,953	-	-	-	-	-
	UG	-	563,991	-	-	-	-	-
Lewis	Strip	Subbit	9,464,967	3,717,810	4,086,736 ⁽³⁾	5,040	2,347	13,821
Thurston	Strip	Subbit	1,142,175	-	16,309,512 ⁽⁴⁾	2,347	2,347	-
			12,309,512	3,743,674	(S) 4,104	5,057	4,708	13,869
			16,052,486		(UG) 5	-	-	.005
					(Total) 4,109	5,057	4,708	13,874

	Strip	UG	Total
Bit	22,617	1,198,917	1,221,534
Subbit	14,730,952	-	14,730,952
Total	14,753,569	1,198,917	16,052,486

Depletion

	Strip	UG	Total
Bit	.03	2.40	2.43
Subbit	18.54	-	18.54
Total	18.57	2.40	20.97

	Strip	UG	Total
Bit	22,665	1,198,922	1,221,587
Subbit	14,844,773	-	14,844,773
Total	14,867,438	1,198,922	16,066,360

Depletion to 1-1-79

	Strip	UG	Total
Bit	.03	2.40	2.43
Subbit	18.56	-	18.56
Total	18.59	2.40	20.99

WYOMING

The bituminous DRB estimates were based primarily on Tables 4 and 5 in Berryhill, Brown, Brown, and Taylor Coal Resources of Wyoming.⁴⁸ Table 4 presents measured original reserve estimates by township, overburden thickness category (0-1000', 1000'-2000', 2000'-3000'), and coal thickness category (14"-28", 28"-42", >42"). Table 5 presents the same information for indicated original reserves. The original reserves, on which the DRB is based, were derived by summing the township-level reserve estimates in the 0-1000' overburden category, and the 28"-42" and >42" thickness categories, across both tables to yield a state total estimate. The result was 4,524.03 million tons of bituminous coal. To this total was added 475.23 million tons of bituminous reserves from the Hanna Coal Field which, according to Gary Glass,⁴⁹ had been ranked as subbituminous coal by Berryhill, Brown, Brown, and Taylor. The 475.23 million ton figure had been obtained by taking the 648.29 million tons⁵⁰ of strippable reserves in the Hanna

⁴⁸Berryhill, H. L., Jr., Brown, D. M., Brown, A., and Taylor, D. A., Coal Resources of Wyoming, U.S. Geological Survey Circular 81, 1950.

⁴⁹Glass, G. B., The Geological Survey of Wyoming, Private Communication, February 20, 1981 (telephone).

Glass, G. B., The Geological Survey of Wyoming, Private Communication, February 18, 1981 (letter).

Glass, G. B., and Roberts, J. T., Coals and Coal-Bearing Rocks of the Hanna Coal Field, Wyoming, The Geological Survey of Wyoming Report of Investigations Number 22, 1980.

⁵⁰This figure was obtained from Table 6 of the Glass and Roberts report. This table provides remaining (as of 1978) strippable reserve estimates for the Hanna Field by mining district, measured, indicated and inferred reliability categories, and overburden thickness categories (0-100', 100'-200', and 200'-300'). Also, average coal thickness categories are given for each mining district; the lowest figure given is 5.9' for the Corral Creek District. The 648.29 million ton figure was derived by summing the total reserves under 200' (or less) of cover in the measured and indicated categories, across all mining districts.

Field, and subtracting 173.06 million tons of Ferris Formation coal. The Ferris Formation coal was subtracted because, according to the Glass and Roberts report (page 24), this coal is subbituminous in rank. To determine the quantity of coal contained in the Ferris Formation, it was first noted (from the Glass and Roberts report) that the Ferris Formation occurs in the Seminoe Mining District. Then, by referring to Figure 15 in the Glass and Roberts report (a stratigraphic section of the coal beds and formations in the Seminoe Mining District) and Table 4 in another Glass and Roberts report entitled Remaining Strippable Coal Resources and Strippable Reserve Base of the Hanna Coal Field in Southcentral Wyoming,⁵¹ the quantity of coal in the Ferris Formation was derived. Table 4 provides estimates of original reserves by mining district, coal bed, township, measured, indicated and inferred categories, coal thickness categories and overburden thickness (0-100', 100'-200', and 0-200') categories. All of the measured and indicated reserves under 200' or less of cover, in the Seminoe District, except those reserves shown (in Figure 15 of Glass and Roberts Coals and Coal-Bearing Rocks of the Hanna Coal Field, Wyoming) as being located in beds not correlated with the Ferris Formation, were added together to obtain the 173.06-million-ton estimate. It should be noted that all the beds included in the 173.06 million ton estimate are shown (in Figure 15) as being correlated with the Ferris Formation, except for the Brooks Bed, which is shown as being correlated with the Hanna Formation.⁵²

⁵¹Glass, G. B., and Roberts, J. T., Remaining Strippable Coal Resources and Strippable Reserve Base of the Hanna Coal Field in South central Wyoming, Geological Survey of Wyoming Report of Investigations Number 17, 1979.

⁵²The Brooks Bed contains 4.31 million tons.

The estimated 475.23 million tons of strippable bituminous when added to the 4,524.03 million tons from the Berryhill, Brown, Brown and Taylor report, yields a total bituminous reserve estimate of 4,999.26 million tons. This figure was subdivided into strippable and underground reserves by noting that the 475.23 million tons of bituminous coal in the Hanna Field lies under <200' of cover (and hence meets the criteria for strippable coal). To the 475.23 million tons was added 50 million tons of strippable bituminous coal in the Northern Little Snake River deposit and 60 million tons of strippable bituminous in the Salt Wells deposit. Both the Northern Little Snake River and Salt Wells reserves were identified as being strippable, bituminous reserves by Gary Glass during the February 20, 1981 telephone call referenced earlier.⁵³ By adding the 110 million tons to the 475.23 million tons, a total remaining (as of January 1978)⁵⁴ strippable bituminous reserve of 585.23 million tons is obtained. This total was then subtracted from the 4,999.26 million tons of total original reserves to yield an underground reserve estimate of 4,414.03 million tons.⁵⁵

⁵³Notes found in the margins of a copy of Table 9 from the "Wyoming" chapter of the 1980 Keystone Coal Industry Manual (_____, "Wyoming" in 1980 Keystone Coal Industry Manual, New York, New York: Mc Graw-Hill, Inc., 1980) confirm that the telephone call was the source of this information - see Exhibit 1. The 110 million tons of strippable coal identified by Glass represents remaining reserves as of January 1979.

⁵⁴Except for the 110 million tons, which is remaining as of January 1979.

⁵⁵It is not clear whether the 110 million tons of Northern Little Snake River and Salt Wells reserves were included in Tables 4 and 5 of the Berryhill, Brown, Brown, and Taylor report. The footnote to Table 9 of the Keystone Coal Industry Manual suggests that at least some of this coal represents new reserves "derived from government publications, and/or company reports" - see Exhibit 1.

Exhibit 1

REMAINING STRIPPABLE COAL RESERVE BASE OF WYOMING

TO JANUARY 1, 1979

(Modified from Smith, et. al., 1972)

Coal-Bearing Region	Strippable Deposit	Coal Bed(s) (Average thick- ness in feet)	Acres Estimate	Original Estimated Reserves to Jan. 1, 1979	Production and Mining Losses Since Jan. 1, 1969	Remaining Strip- pable Reserves to Jan. 1, 1979
Powder River Coal Basin	Alamo-Kleenburn*	Monarch and Dietz No. 3 (23')	2,029.0	39,300,000	15,400,000	23,900,000
	Clear Creek	Canyon (11.2')	9,337.6	184,900,000	—	184,900,000
	Dave Johnston	School (38')	2,418.0	126,200,000	30,900,000	104,800,000
	Dry Cheyenne	Badger (16')	190.0	9,500,000	—	179,500,000
	Lake DeSmet	F(7.6')	13,260.8	179,500,000	—	1,000,000,000
	Spotted Horse	Healy (163')	3,572.0	1,000,000,000	—	480,700,000
		Felix (12.5')		480,700,000	—	178,000,000
		Smith (10.0')		178,000,000	—	58,500,000
		Local (10.0')	36,736.0	58,500,000	—	—
	Sunset	Wasatch Fm. coal (11.8')	651.0	13,600,000	—	13,600,000
	Wyarno- Verona*	PK (11')		200,000,000	—	200,000,000
		Ulm 2 (20')		990,000,000	—	990,000,000
		Ulm 1 (30')		543,000,000	—	543,000,000
	Wyodak	Other Wasatch coals (10'+) Wyodak-Anderson (71'); Anderson (D) and Canyon (E)	115,282.0	67,000,000 19,000,000,000	— 80,100,000	67,000,000 18,919,900,000
Subtotal			223,624.4+	23,070,000,000	126,400,000	22,943,600,000
Green River Coal Region	Black Buttes	Almond, Lance, Ft. Union, and Wasatch Fm. coals (12')	3,389.0	82,600,000	—	82,600,000
	Creston- Cherokee*	Upper Cherokee (B) (11')			—	
		Lower Cherokee (C) (25')	4,204.0+	360,000,000	—	360,000,000
		Other Ft. Union Fm. Coals			—	
	Jim Bridger Lancette Hills*	Deadman (30')	4,708.0	250,000,000	20,100,000	229,900,000
		Ft. Union Fm. coals		168,000,000	—	168,000,000
	Northern Little Snake River	Ft. Union Fm. Coals (15'); Lance Fm. coals (8'); Mesa- verde Fm. coals (6')	15,901.0+	269,600,000	—	269,600,000
	Red Desert	Battle 2 & 3 (7')	2,938.0	38,100,000	—	38,100,000
		Sourdough, Monument, and Tierney (6.8')	27,469.0	458,900,000	—	458,900,000
		Hadsell 2 (7.7')	2,874.0	39,800,000	—	39,800,000
		Creston 2 & 3 (14')	3,846.0	125,600,000	—	125,600,000
		Latham 3 & 4 (5.7')	6,893.0	70,700,000	—	70,700,000
	Salt Wells*	Mesa-verde Group coals		60,000,000	—	60,000,000
Subtotal			72,722.0+	1,923,300,000	20,100,000	1,903,200,000
Hams Fork Coal Region	Adaville	Adaville Fm. coals (44')	12,800.0	1,000,000,000	34,900,000	965,100,000
	South Haystack*	Adaville Fm. coals (40')	1,544.0	64,800,000	—	64,800,000
	Subtotal		14,344.0	1,064,800,000	34,900,000	1,029,900,000
Hanna Coal Field	Carbon Basin*	Finch (10')	2,725.0+	118,860,000	—	118,860,000
		Johnson (10')			—	
		Other Hanna Fm. coals			—	
	Hanna Basin	Hanna, Ferris & Medicine Bow Fm. coals (21')	8,400.0	529,700,000	80,220,000	449,480,000
Subtotal			11,125.0	648,560,000	80,220,000	568,340,000
Bighorn Coal Basin	Grass Creek	Mayfield (25')	420.34	18,600,000	—	18,600,000
	Subtotal		420.34	18,600,000	—	18,600,000
GRAND TOTAL			322,235.7+	26,725,260,000	261,620,000	26,463,640,000

* Includes new reserve base derived from company reports and/or government publications.

Exhibit 2 is a flow sheet presenting graphically the methodology used to develop the 585.23-million-ton surface and 4,414.03 million ton underground estimates. In the following paragraphs the methodology employed to develop depletion estimates is discussed.

Depletion (of both bituminous and subbituminous reserves) was based on a number of sources. County-level strip production from 1968 to 1975 was obtained from the annual BOM Minerals Yearbooks, and the EIA annual reports were employed to obtain this information for the 1976-1978 period. The county-level production figures were summed across the state to yield a total of 225.01 million tons. From this the Carbon County 1968-1978 total production of 68.55 million tons was subtracted to yield 156.46 million tons, all of which was assumed to be subbituminous in rank. Carbon County contains the Hanna Field, and while the strippable subbituminous reserves had (apparently) been calculated as of January 1968, the Hanna reserves (from the two Glass and Roberts Tables - 6 and 4 - discussed earlier) had been determined as of January 1978. To bring the subbituminous strip reserves to January 1979, the Carbon County 1978 strip production of 12.06 million tons (from the 1978 EIA report) was split into 6.3 million tons of bituminous production and 5.76 million tons of subbituminous production,⁵⁶ and then the 5.76 million tons was added to the 156.46 million tons of 1968-1978 subbituminous production to yield a total of 162.2 million tons of subbituminous production. This total was multiplied by 1.25, the surface depletion factor, to yield 202.77 million tons of subbituminous surface depletion for the State of Wyoming.

Tables 7 and 8 in the "Wyoming" section of the 1980 Keystone Coal Industry Manual was used to make further depletion estimates. Table 7 presents cumulative production by county to January 1979, while Table 8

⁵⁶The basis for this split is not clear.

EXHIBIT 2

METHODOLOGY FOR ORIGINAL BITUMINOUS RESERVE

(All figures are in million of tons)

* Glass, G.B., and Roberts, J.T., Coals and Coal-Bearing Rocks of the Hanna Coal Field, Wyoming, The Geological Survey of Wyoming Report of Investigations No. 22, 1980.

** Glass, G.B., and Roberts, J.T., Remaining Strippable Coal Resources and Strippable Reserve Base of the Hanna Coal Field in Southcentral Wyoming, Geological Survey of Wyoming Report of Investigations No. 17, 1979.

*

presents a breakdown of the total state production by underground and surface mining. From Table 8, an estimate of 268.09 million tons of total cumulative surface production, to January 1979, was obtained. From the previous paragraph, the total surface production from January 1968 to January 1979 was 225.01 million tons, so $268.09 - 225.01 = 43.08$ million tons of surface production prior to 1968. This production was assumed (from a calculation sheet found in the field office files) to be distributed as follows:

Campbell County - 30% (12.92 million tons)
Carson County - 10% (4.32 million tons)
Lincoln County - 30% (12.92 million tons)
Sheridan County - 30% (12.92 million tons)

These pre-1968 county estimates were added to the 1968-1978 county strip production figures (obtained earlier - see previous paragraph) to yield the cumulative county strip production figures to January 1979.⁵⁷

Having obtained the cumulative county-level surface production estimates to January 1979, these estimates were subtracted from the county-level total production estimates from Table 7 of the "Wyoming"

⁵⁷Prior to adding the pre-1968 production figures to the post-1968 figures, some adjustments were made to the pre-1968 county production distribution as presented in the text, and as found in one of the calculation sheets in the field office files. Specifically, 2.71 million tons was subtracted from the 12.92 million ton Campbell County estimate, while 0.9 million tons was added to the 4.32 million ton Carbon County estimate, 0.9 million tons was added to the 12.92 million ton Lincoln County estimate, and 0.91 million tons was added to the 12.92 million ton Sheridan County estimate. This was done to lower the Campbell County cumulative strip production to equal its cumulative total recorded production. Finally, an arithmetic mistake was made in adding the pre- and post-1968 strip production figures together for Carbon County - namely, the 4.32 million tons pre-1968 strip production was never added, and the result was the post-1968 strip production plus the 0.9 million ton adjustment.

section of the 1980 Keystone Coal Industry Manual, to yield the cumulative county-level underground production estimates to January 1979. These underground estimates were then broken down by rank (bituminous and subbituminous) by assuming a rank for county. Then the estimates were summed across counties to yield 254.68 million tons of underground bituminous production and 149.59 million tons of underground subbituminous production. Both of these estimates were then multiplied by 2.00 (the underground depletion factor) to yield 509.36 million tons and 299.18 million tons of bituminous and subbituminous underground depletion, respectively. Since surface production had all been assumed to be subbituminous, the only bituminous surface production was the 6.3 million tons of Carbon County 1978 surface production estimated earlier. This was multiplied by 1.25 to obtain 7.88 million tons of surface bituminous depletion for the state. To summarize:

Surface, bituminous depletion	=	7.88 million tons
Underground, bituminous depletion	=	509.36 million tons
Surface, subbituminous depletion	=	202.77 million tons
Underground, subbituminous depletion	=	299.18 million tons.

The methodology employed to determine depletion is presented in a flow-chart in Exhibit 3.

The bituminous DRB estimates can, at this point, be derived as follows:

Surface:

585.23 million tons remaining reserves (1/1/78)
- 7.88 depletion
577.35 million tons calculated 1979 DRB, as compared with
577.37 published DRB

EXHIBIT 3

WYOMING DEPLETION

(All figures are in millions of tons)

Underground:

4,414.03 million tons original reserves
509.36 depletion
3,904.67 million tons calculated 1979 DRB, as compared with
3,904.67 published DRB.

The basis of the strippable subbituminous DRB estimate is the resource data presented in Table 7 of Gary Glass, Review of Wyoming Coalfields, 1975. This table presents remaining (as of January 1968) strippable, subbituminous resources by region, deposit, and coal bed(s). The data in this table were updated on the basis of Table 9 of the 1980 Keystone, which also presents remaining (as of January 1969) strippable reserves by region, deposit, and coal bed(s). Prior to updating, it was necessary to determine which of the deposits listed in Table 9 contained bituminous reserves. As discussed earlier, Gary Glass of the Wyoming Geological Survey was contacted, and he identified 50 million tons of bituminous coal included in the reserve estimate for the Northern Little Snake River deposit, and 60 million bituminous tons included in the Salt Wells deposit. This 110 million tons of strippable bituminous coal was included in the strippable bituminous DRB estimate. However, in developing the surface subbituminous DRB estimate, although the 60 million tons of Salt Wells coal was excluded from the total, the 50 million tons of Northern Little Snake River and was included in the total.

Both Table 7 from the Glass report and Table 9 from the 1980 Keystone included reserves for the Hanna coal field (313 million tons in Table 7 and 648.56 million tons in Table 9). Much of the coal in the Hanna field is bituminous, and thus the Table 7 and Table 9 Hanna field reserve estimates were not included in the surface subbituminous DRB estimate. However, it should be noted that the 173.06 million tons of Ferris Formation, Hanna field strippable coal, identified as subbituminous in rank were also not included in the surface subbituminous DRB total.

After subtracting the 60 million tons of bituminous Salt Wells coal the 648.56 million tons of Hanna field coal from the reserves presented in Table 9, Table 7 could be updated with the Table 9 data. For most the region/deposit/bed combinations, the Table 9 estimates matched precisely the Table 7 estimates. In those cases where there were differences, the Table 7 estimate was replaced with the Table 9 estimate.⁵⁸ Then, additional data sources, listed as follows, were employed to update the region/deposit/bed estimates:

Culbertson, W. C., "Preliminary Geologic Map and Coal Sections of the Wyarno Quadrangle, Sheridan County, Wyoming". U.S. Geological Survey, Miscellaneous Field Studies Map MF-723, 1975.

Culbertson, W. C., and M. C. Klett, "Preliminary Geologic Map and Coal Sections of the Jones Draw Quadrangle, Sheridan County, Wyoming". U.S. Geological Survey, Miscellaneous Field Studies Map MF-726, 1975.

Culbertson, W. C., and M. C. Klett, "Preliminary Geologic Map and Coal sections of the SR Springs Quadrangle, Sheridan County, Wyoming". U.S. Geological Survey, Miscellaneous Field Studies Map MF-727, 1975.

Grazis, S. L., "Geologic Map and Coal Resources of The Pleanantdale Quadrangle, Campbell County, Wyoming". U.S. Geological Survey Coal Investigations Map C-76, 1977.

Grazis, S. L., "Geologic Map and Coal Resources of the Scaper Reservoir Quadrangle, Campbell County, Wyoming". U.S. Geological survey Coal Invesgitations Map C-77, 1977.

Grazis, S. L., "Geologic Map and Coal Resources of the Gap SW Quadrangle, Campbell County, Wyoming". U.S. Geological Survey Coal Investigations Map C-78, 1977.

⁵⁸Although neither Table 7 nor Table 9 indicate the overburden depth of the reserves, each table presents the average seam thickness for each region/deposit/bed combination. None of the reserves were excluded from the DRB for being too thin, since the thinnest bed had an average thickness of 5.7.

Grazis, S. L., "Geologic Map and Coal Resources of the Saddle Horse Butte Quadrangle, Campbell County, Wyoming". U.S. Geological Survey Coal Investigations Map C-79, 1977.

Haddock, D. R., B. H. Kent, and B. F. Bohor, "Geologic Map and Coal Sections of the Croton Quadrangle, Campbell County, Wyoming". U.S. Geological Survey, Miscellaneous Field studies Map MF-826, 1976.

Kent, B. H., D. R. Haddock, and B. F. Bohor, "Geologic Map and Coal Sections of the Truman Draw Quadrangle, Campbell County, Wyoming". U.S. Geological Survey, Miscellaneous Field studies Map MF-917, 1977.

Mapel, W. J., "Geological Map and Coal Sections of the Bar W Draw Quadrangle, Wyoming and Montana". U.S. Geological Survey, Miscellaneous Field Studies Map MF-763, 1976.

Mapel, W. J., and B. W. Dean, "Preliminary Geologic Map and Coal Sections, Ulm Quadrangle, Sheridan County, Wyoming". U.S. Geological Survey, Miscellaneous Field Studies Map MF-731, 1976.

Mapel, W. J. and B. W. Dean, "Geologic Map and Coal Sections of the Verona Quadrangle, Sheridan County, Wyoming". U.S. Geological Survey, Miscellaneous Field Studies Map MF-762, 1976.

Mapel, W. J., and M. D. Malahy, "Geologic Map and Coal Sections of the Buffalo Run Creek Quadrangle, Sheridan County, Wyoming". U.S. Geological Survey, Miscellaneous Field Studies Map MF-792, 1976.

These USGS maps include tables of reserves, by various reliability, thickness, and depth categories, and by township and bed. Some of the tables are identified as "strippable" tables.⁵⁹ It should be noted that the tables sometimes provide original reserve estimates, and sometimes provide remaining reserve estimates (as of various dates).

⁵⁹Not all of the USGS maps listed include strippable reserves in their reserve estimates, but although those that do not were not employed to update the Table 7-Table 9 data, they were employed in the development of the underground subbituminous estimate, as will be discussed later.

Although the USGS maps do not always indicate the overburden depth of the reserves, they at least identify those reserves amenable to strip mining, and those strippable reserves were included in the surface subbituminous DRB estimate.⁶⁰ Also, the USGS reserve estimates were not always categorized as to reliability category, but when they were only measured and indicated coal was included in the DRB. And finally, when the reserves were classified as to seam thickness, the following categories were employed:

- 0'-10', > 10' or
- 2.5'-5', > 5'.

All coal in all of these categories was included in the DRB estimate (including all coal in the 0'-10' and 2.5'-5' thick categories).

After summing all of the reserves meeting the DRB criteria from the USGS maps, the reserves of those Table 7 and 9 regional/deposit/bed combinations already covered by the USGS maps were subtracted from the sum of the modified Table 7 estimates. All of the reserves (1,800 million tons) presented in Table 9 for Powder River Basin/Wyarno-Verona deposit were subtracted from the total because this deposit was covered by the USGS map. Also, 600 million of the 19,000 million tons of Table 7 Powder River Basin/Wyodak deposit coal was subtracted from the total, along with 336.49 million tons of the 480.7 million tons of Table 7 Powder River Basin/spotted horse deposit/Felix bed coal. Only portions of the Wyodak and spotted horse deposit reserves were subtracted from the modified Table 7 reserve estimates, because only portions of these deposits were covered by the USGS maps. To determine the amount

⁶⁰When overburden depth of the reserves was provided, all coal under 200' of overburden was included in the surface DRB.

of reserves to be subtracted from the Table 7 Wyodak total maps, indicating the outline of the Wyodak deposit, were obtained from BOM Information Circular 538 and planimetered after the outline of the USGS quadrangles had been overlain on the maps. Because good structural contour maps of the spotted horse deposit were lacking, planimetry could not be done, so the portion of this deposit covered by the USGS maps was estimated by "eyeball" (according to Tom Matson, former Director of the Western Field Office).

After adding the total reserve estimate from the USGS maps to the modified Table 7 total reserve estimate, and subtracting 1,800 million tons for the Powder River Basin/Wyarno-Verona deposit, 600 million tons for the Powder River Basin/Wyodak deposit, and 336.49 million tons for the Powder River Basin/spotted horse deposit/Felix bed, or total surface subbituminous reserve estimate of 27,070.99 million tons was obtained. From this was subtracted the 202.77 million ton surface, subbituminous depletion estimate (see page _____), to yield:

27,070.99 million tons
- 202.77 depletion
26,868.22 million tons 1979 calculated DRB, as compared with
26,868.03 published DRB

The underground subbituminous estimate is believed to be based on Tables 7 and 8 of the Berryhill, Brown, Brown, and Taylor report, which present measured and indicated reserve estimates in the same format as Tables 4 and 5 for bituminous coal (except that the thickness categories for Tables 7 and 8 are 2.5'-5', 5'-10', and > 10'). The data presented in these tables are also believed to have been adjusted using the data presented on the previously listed USGS maps, along with the following publications:

Masursky, H., Uranium-Bearing Coal in the Eastern Part of the Red Desert Area, Wyoming, U.S. Geological Survey Bulletin 1979-B, 1962.

Olive, W. W., The Spotted Horse Coalfield, Sheridan and Campbell Counties, Wyoming, U.S. Geological Survey Bulletin, No. 1050, 1957.

Pipiringos, G. N., Uranium-Bearing Coal in the Central Part of the Great Divide Basin, U.S. Geological Survey Bulletin No. 1099-A, 1961.

Because some of the USGS maps do not summarize the township-level data on a county or other more aggregated basis, time did not permit an attempt to derive the underground subbituminous DRB estimate.

Given that a number of the publications used to derive the 1979 DRB were published after both 1971 and 1976, it is not surprising that the 1979 DRB cannot be derived by depleting the previous DRB estimates. The 1976 DRB estimates underground subbituminous reserves at 27,644.8 million tons, surface subbituminous reserves at 23,724.7 million tons, and surface bituminous reserves at zero; these estimates are 11,019.14 million tons, 3,143.53 million tons, and 577.37 million tons less than their 1979 counterparts, respectively. The underground bituminous estimate also could not be derived from the 1976 estimate:

4,002.5 million tons 1976 DRB
- 3.8 maximum depletion⁶¹
3,998.7 million tons calculated 1979 DRB, as compared with
3,904.7 published 1979 DRB

The 1971 underground subbituminous, surface subbituminous and surface bituminous estimates are 15,633.94 million tons, 3,194.03

⁶¹Depletion was calculated by determining the total production between 1976 and 1978 from the EIA annual reports and multiplying by 2. Since the EIA reports do not distinguish bituminous from subbituminous production, the total production was used.

million tons, and 577.37 million tons less than their 1979 counterparts, respectively. For underground bituminous:

4,524 million tons 1971 DRB

- 8 maximum depletion

4,516 million tons calculated 1979 DRB, as compared with

3,905 published 1979 DRB.