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WILLIAM S. LIVENGOOD, JR., *Secretary*

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GEORGE H. ASHLEY, *State Geologist*

ANTHRACITE RESERVES

By GEO. H. ASHLEY

State Geologist

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INTRODUCTION

“Pennsylvania’s Mineral Heritage,” published by the Department of Internal Affairs in 1944, contains new estimates of Pennsylvania anthracite reserves by the writer. After publication a discrepancy was noted between the figures in a table on page 85 and a chart on page 87. The writer assumes full responsibility for the error. In seeking the source of the error it became evident that several factors were overlooked which materially modify the results. For example, the original study did not allow for the fact that coal derived from culm banks or dredged from rivers does not reduce the reserves.

The reserves were recalculated with more care than was possible in the short time allotted for completing the “Heritage” volume, and other factors have been considered in the revision. In two instances, when the production credited to counties exceeded the estimate of original coal, that estimate was boosted to cover the discrepancy. The present study has revealed that coal mined in one county has been credited to another county because the colliery was there, while the mine was in an adjoining county. For example, the U. S. Bureau of Mines gives the production of Wayne and Susquehanna counties in 1944 as 189,033 tons. The State Department of Mines’ figure for the same counties, taking strict account of where the coal is mined, is 57,119 tons, and for many years the difference is much greater. Again, the ratio of coal mined underground and stripped has changed materially in recent years. As stripping gets 90 to 100 percent of the coal while underground mining may get only 45 percent, the effect on exhaustion and reserves differs materially.

This paper lays the cards on the table so that anyone interested can study the data as developed and detect errors if made.

Such a study reveals a very large lack of information. The “Heritage” report stressed the county as the basic unit. Much anthracite data available for districts or fields are not available for counties. Even where production is given by counties, the U. S. Bureau of Mines follows the practice of combining county figures where there are less than three producers in a county; nor are the individual figures by counties available to those outside the statistical division of the Bureau. Some years Sullivan county is included with the Northern field, some years not. For some years figures for counties are entirely lacking, but they may be approximated by a canvass by mines of the State Mine Inspectors report. For the early years only shipment figures are given. For some years State and Federal figures differ materially. Thus, figures for coal dredged from Pennsylvania rivers: in 1923, State, 1,175,991 tons; Federal, 956,368; in 1940, State, 607,238; Federal, 1,097,000 tons. These facts are cited to show that too much reliance must not be put on the final results. In general, because of

their greater completeness the figures of the U. S. Bureau of Mines (earlier the U. S. Geological Survey) are followed. Where figures are lacking State figures have been sought.

ORIGINAL CONTENTS

The first careful estimate of the original contents of the Pennsylvania anthracite fields was made by A. D. W. Smith, and published in the Report of the Pennsylvania Coal Waste Commission in 1893. The summary tables were repeated in the Summary Final Report of the Second Geological Survey of Pennsylvania, volume 3, part 1, pages 2147-2152. The figures are given by fields. The Anthracite fields as mapped were covered by 59 "areas," each lying between two carefully drawn cross sections which show each of the coal beds in its proper thickness and structure. The coal content of each "area" was then calculated, assuming that each bed in any area had an average thickness and structure as between the two end sections. Allowance was made for specific gravity from area to area.

The original "areas" took no account of county lines, most of them were all in one county. Where an area included parts of two or more counties an estimate was made of the proportional area underlain by coal beds in each county and the coal contents of the area divided in the same ratio. Counties including parts of areas were: Wayne County, 50% of area 1, 5% of area 2; Susquehanna County, 50% of area 1, 10% of area 2; Lackawanna County, 85% of area 2, 33 $\frac{1}{3}$ % of area 8; Luzerne County, 66 $\frac{2}{3}$ % of area 8, 40% of area 24; Carbon County, 60% of area 4, 5% of area 26; Columbia County, 10% of area 29, 60% of area 30; Northumberland County, 20% of area 30; Schuylkill County, 90% of area 26, 20% of area 30, 90% of area 29, 66 $\frac{2}{3}$ % of area 55; Lebanon County, 80% of area 59; Dauphin County, 33 $\frac{1}{3}$ % of area 55, 10% of area 59. On this basis, the original contents in gross tons by counties and fields are summarized in Table 1.

TABLE 1

*ANTHRACITE: Original contents summarized (thousands of gross tons)—
1893*

Counties	North- ern	E. Middle	W. Middle	South- ern	Total
Carbon		98,682		443,334	542,016
Columbia		12,899	465,309		478,208
Dauphin				294,489	294,489
Lebanon				300,779	300,779
Lackawanna	1,886,937				1,886,937
Luzerne	3,755,277	455,951			4,211,228
Northumberland			2,015,352		2,015,352
Schuylkill		34,959	1,528,904	8,159,830	9,723,693
Sullivan	31,161				31,161
Susquehanna	14,418				14,418
Wayne	9,587				9,587
Totals	5,697,380	602,491	4,009,565	9,198,432	19,507,869

TABLE 2

ANTHRACITE: Original content by counties and fields, in millions of tons

Counties	1	2	3	4	5	6	7		8	9
	Gross Tons	Net Tons	-	Net Tons	Northern	E. Middle	FIELDS W. Middle		Southern	Totals
Carbon	542.0	607.1	-2.1	605		110			495 + 25	630
Columbia	478.2	535.6	-0.6	535		15	110	520 + 80	520	615
Dauphin	294.5	329.8	+0.2	330			15	600	330 - 150	180
Lebanon	300.8	336.9	-1.9	335					180	180
ω Lackawanna ..	1,886.9	2,113.4	-3.4	2,110	2,110 - 80				335 - 300	35
Luzerne	4,211.2	4,716.6	-1.6	4,715	4,210 - 200	505 + 10			35	2,030
Northumberland .	2,015.3	2,257.2	+2.8	2,260	4,010	515		2,260 + 340		4,525
Schuylkill	9,723.7	10,890.5	-0.5	10,890		45		2,600	9,145 + 1,000	2,600
Sullivan	31.2	34.9	+0.1	35	35		45	1,700 + 240	10,145	12,130
Susquehanna .	14.4	16.1	-1.1	15	15			1,940		35
Wayne	9.6	10.1	-0.7	10	10					15
										10
Totals	19,507.8	21,848.8		21,840	6,380	675	685	4,480	10,350	22,805
					6,100			5,140	10,880	

The net or short ton is today the legal unit in weighing anthracite as well as bituminous coal. In Table 2 the figures in gross tons are first converted to net tons, and these in turn changed to round numbers equivalent to the round numbers in gross tons suggested by Mr. Smith; that is, for the Northern field 5,700, Eastern Middle field 600, Western Middle field 4,000, Southern field 9,200 and for the whole, 19,500 million gross tons. See Table 2.

Anthracite reserves were recalculated in 1923 by Dever C. Ashmead as of January 1, 1922. His work was based on map measurements of exhausted areas and led to a considerable increase in the estimated original coal in all fields except the Northern, where he estimated a decrease of 250 million gross tons. Expressed in millions of net tons these changes were: Northern field -280, Eastern Middle +10, Western Middle +660, Southern +1,025. The present writer has reduced the estimate for Dauphin and Lebanon counties by 450 million net tons on the basis of mining reports. Table 2 shows these changes.

Column 1 gives in millions of gross tons, the totals in Table 1; column 2 the same figures converted to net tons; column 4 the same in round numbers totaling 21,840 million tons, equal to 19,500 million gross tons. The left hand figures under each field, columns 5, 6, 7, and 8 are the 1893 figures and those on the right hand side of these same columns are the result of changes as proposed by Ashmead and the writer. Column 9 gives the figures used in subsequent tables.

PRODUCTION

Figures for anthracite mined and shipped are available from 1820 on. Early figures for total coal mined included 10% added to the figures for "shipped" coal to cover "used for power" or "sold locally." Later, actual figures were collected for those items. Early figures were reported by commercial districts only, which do not agree with fields or counties. Production by fields was first reported for 1884-1887, 1889 (the last by the Second Geological Survey of Pennsylvania), and is lacking from 1890 to 1912, inclusive. The total production before 1884 (600 million net tons) was divided by the writer on the basis of the ratio of production by fields in that year. From 1890 to 1912 the division of fields was on a sliding ratio with the 1889 ratio at one end and the 1913 ratio at the other. The estimated production is reliable only as to the total figures; the field totals are not official. Note how the ratio of production changes with the years.

Next, as it is desired to know the reserves by counties, it is necessary first at least to estimate the total production by counties. Actual figures are available from 1884 by using State Department of Mines figures in places. The ratios by counties in the production for 1884

Ashmead, Dever C., *Anthracite Losses and Reserves in Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. 8, 1926.*

TABLE 3

ANTHRACITE: Production by fields, partly computed (millions of net tons)

Years	Fields	Totals	Northern % tons	E. Middle % tons	W. Middle % tons	Southern % tons
To 1883 based on 1884 ratio		600	50 300	16 96	24 144	10 60
1884-1887 actual		157	53 82	14 22	24 38	9 15
1888-1889 based on 1889 ratio		92	53 49	14.7 14	23.2 21	9.1 8
1890-1912 based on 1889-1913 ratio ...		1506	56 843	11 166	23 347	10 150
1913-1921 actual ...		856	56 465	9 75	20.5 168	14.5 118
Total to 1921 ..		3181	1739	373	718	351
1922-1944 actual		1445	772	140	310	223
Total to Jan. 1, 1945.		4626	2511	513	1028	574

were used to divide the total production up to 1884 in county sub-totals. The figures for 1916-1921 were interpolated between the figures for 1915 and 1922. Difficulty arises for the smaller producing counties in that whenever they contain less than three producers, their production is combined with that of some other county. As far as possible, estimated figures for each of the combined counties have been arrived at, checked by using the Mine Inspectors' reports and their lists of mines, with their production.

More serious is the custom of crediting a county with coal produced if the colliery is in that county, as illustrated by the Clinton colliery in Wayne County. This colliery produced a quarter- to a half-million tons of coal a year for many years, all credited to Wayne County, but the mine mouth was a quarter of a mile over the line in Lackawanna County and all the coal came out of Lackawanna County. Meanwhile, the Clifton Falls mine in Wayne County might be producing from 2,000 to 10,000 tons a year, all that should properly be credited to Wayne County. Furthermore, some large mines extend from one county to another. In such instances, it has been assumed that the coal mined out was proportional to the area of the mine in each of the counties.

Table 4 shows how total production, figured to 1921 by counties, was built up. The totals in every instance must agree with the totals for the several years and for the fields, as shown in Table 3. To insure that the field and county totals agree, the same table shows the distribution of county production by fields. In the Northern field, all of the counties except Luzerne are all in the field. Their total production is therefore subtracted from the total for the field to get the part of Luzerne County production in that field. The balance of Lu-

TABLE 4

ANTHRACITE: Production up to 1921 by counties and fields, in millions of net tons

	1884 M gross tons	%	Up to 1883 estimated	1884- 1921 actual	Total	North.	E. Mid.	W. Mid.	South.
Carbon	1,156	3.54	21	90	111		65		46
Columbia	746	2.28	14	40	54		*	54	
Dauphin	604	1.85	11	30	41				41
Lebanon	—	0.00	*	*	*				*
Lackawanna	7,093	21.73	127	660	787	787			
^o Luzerne	13,383	41.00	247	958	1205	931	274		
Northumberland	2,331	7.14	43	202	245			245	
Schuylkill	7,165	21.96	133	583	716		34	418	264
Sullivan	86	0.26	2	12	14	14			
Susquehanna	77	0.24	2	5	7	7			
Wayne	—	0.00				*			
River coal and other counties				1	1			1	
Totals	32,641	100.0	600	2,581	3,181	1,739	373	718	351

* Tonnage included with other counties or under one million tons up to 1883 based on percentage of production in 1884. Distribution by fields based on mine map study, 1889.

zerne County's production came from the Eastern Middle field. In the same way it is possible to determine the portion of the Schuylkill County production that came from the Western Middle field. To divide the production of Carbon and Schuylkill counties between Eastern Middle and Southern fields it was necessary to locate and study the production of the individual mines in those counties, using maps showing mine workings where possible. The figures by fields as well as counties are necessary in obtaining the losses and reserves by counties.

LOSSES AND RESERVES

Having copied or computed figures for original content of coal and production by fields and counties, and having Ashmead's estimates, based on field and mine-map studies for depletion in the several fields, it is possible to compute the losses and reserves as of January 1, 1922. This is shown in lines 1 to 5 of Table 5.

The figures for reserves differ from Ashmead's insofar as the figures for original contents were changed from his, aside from being in net tons as against his use of gross tons.

From 1922 on, total figures are available for coal recovered from culm, from river coal, and from stripping. For most years, figures are available for coal from culm and river coal by fields, and for a few years for stripped coal. Figures are available by counties only for total production. In addition the Heritage report carries incomplete figures for river coal by counties. The totals do not agree closely with those of the U. S. Bureau of Mines but the relative production was assumed to give a basis for the subdivision of their totals.

Starting with the Reserves as of January 1, 1922, line 6, Table 5, gives the U. S. Bureau of Mines' totals of production as a whole and by fields; the coal recovered from culm piles and rivers on line 7 and the coal obtained by stripping on line 8. Figures for line 8 are available for the fields for only a few years and not at all by counties. Using the available totals and ratios derived from the few figures available by fields, the totals by fields were estimated. Taking the totals for coal from waste and by stripping from total produced, left the coal obtained by underground mining, line 9. Applying the ratio of recovery in 1921 found by Ashmead, line 10, to the coal obtained by underground mining gives the depletion due to such mining. True, the ratio as computed by Ashmead included coal obtained by stripping, which recovers from 90 to 100 percent of the coal uncovered, but in 1921 only one ton in 40 was mined by stripping (figures by fields not available). The effect on the ratio of recovery was, therefore, so small it is assumed that improvements in recovery since that date have overcome any difference on that account. Adding the coal recovered by stripping, assuming 100 percent recovery, gives the total depletion for the period 1922-1944, inclusive, line 12. The reserves as of January 1, 1922, line 5, less the depletion, line 12, gives the reserves as of January 1, 1945, as a whole and by fields, line 16. Dividing the reserves, line 16, by the average annual depletion gives the life of the fields as a whole and of each field. This will be discussed beyond.

TABLE 5

ANTHRACITE: Reserves and life of fields as of January 1, 1945, in millions of net tons

	Total	Northern	E. Mid.	W. Mid.	Southern
1 Original content, table 2	22,805	6,100	685	5,140	10,880
2 Depletion to 1921 (Ashmead)	4,946	2,430	408	1,147	961
3 Production to 1921 inclusive, table 3	3,181	1,739	373	718	351
4 Losses to 1921 (line 2 - line 3)	1,765	691	35	429	610
5 Reserves as of January 1, 1922 (line 1 - line 2)	17,859	3,670	277	3,993	9,919
6 Production 1922-1944 incl., U. S. Bureau of Mines	1,445	772	140	310	223
7 Coal from waste 1922-1944, culm and river coal	97	18	6	38	35
8 Stripped coal	137	17	34	51	35
9 Coal from underground mining (6 - (7 + 8))	1,211	737	100	221	153
10 Ratio of recovery (Ashmead), percentage	61.1	67	69.4	58	49
11 Depletion by underground mining	1,937	1,100	144	381	312
12 Total depletion (11 + 8)	2,074	1,117	178	432	347
13 Losses 1922-1944 (12 - 6)	629	345	38	122	124
14 Total production to 1945 (3 + 6)	4,626	2,511	513	1,028	574
15 Total losses to 1945 (4 + 13)	2,394	1,036	73	551	734
16 Reserves as of January 1, 1945 (5 - 12)	15,785	2,553	99	3,561	9,572
17 Average annual depletion 1922-1944 (12 ÷ 23 years)	90	48	8	19	15
18 Life of fields if rate continues (16 ÷ 17), years	175	53	12	187	638

These figures should be substituted for those in the diagram, figure 7, page 87, of the Heritage report. Some of the figures are the same or nearly so, others differ materially for reasons already given.

Table 6 gives for each field: A, original content, B, production, C, depletion, and D, reserves. To get similar figures for the counties, the original content and production, as already given, are first set down by fields. Having no actual figure by counties for coal recovered from waste or by stripping, it was assumed that coal recovered from culm and by stripping was proportional to the production in each field, while coal from the rivers was proportional to amounts given in the Heritage volume, page 12. In every instance the totals by counties in each field must equal the field totals as in Table 5.

As the method of computing reserves up to 1921 differs from that used for the later figures, the earlier figures are given in Table 6.

At the bottom of the several columns headed: Northern, Eastern Middle, Western Middle, and Southern fields, are given from Table 5, the figures for each field for: A, original content; B, production; C, depletion; and D, reserves.

Opposite each county in the column for each field are four figures. The first two repeat the figures for original content and production already given, Tables 2 and 4. The third figure represents the depletion. It is derived by dividing the total depletion for the field at the bottom of the column in proportion to the production in the county. This figure deducted from the first figure gives the reserves. Obviously this method is based on an assumption that may or may not be true. The figures divided are right only so far as the assumption is true. However, they are probably not far wrong.

Because of the different method of computing the depletion and reserves by fields for the period 1922 to 1944, the ones for depletion and reserves by counties follow the same formula. Starting with the reserves as of January 1, 1922, as derived in Table 6, the figures of Table 5 by fields are divided by counties as shown in Table 7.

Here, column A gives the reserves as of January 1, 1922, for each county (see Table 6). Column B gives the production for the period 1922 to 1944, inclusive, as reported by the U. S. Bureau of Mines. Columns C to G are derived from figures in the columns for each of the fields. In those columns opposite each county name are six figures in two lines. In the first line appears the estimated production of the county in that field, then the estimated coal from waste and by stripping, arrived at by subdividing the corresponding figures for the field in proportion to production. In the second line are given figures for coal obtained by underground mining, the depletion due to such underground mining, and the total depletion obtained by adding the stripped coal. These six figures under the several fields are then totaled in order in columns B to G. Column H is derived by subtraction of column G from column A.

TABLE 6

ANTHRACITE: Original content, production, depletion and reserves by counties to 1921, inclusive (millions of net tons)

Counties	A	B	C	D	Northern		E. Middle		W. Middle		Southern	
	Original content Table 2	Produc- tion Table 4	Deple- tion	Reserves	A Original content, B Production, C Depletion, D Reserves							
Carbon	630	111	197	433			A110 B65 A15 *	C71 D39			A520 B46	C126 D394
Columbia	615	54	86	529			*	D15	A600 B54	C36 D514		
Dauphin	180	41	112	68							A180 B41	C112 D68
Lebanon	35		*	35							A35 *	D35
Lackawanna ...	2,030	787	1,100	930	A2030 B787 A4010	C1100 D930						
Luzerne	4,525	1,205	1,600	2,925	B931	D2710	A515 B274	C300 D215				
Northumberland .	2,600	245	392	2,208					A2600 B245	C392 D2208		
Schuylkill	12,130	716	1,429	10,701			A45 B34	C37 D8	A1940 B418	C669 D1271	A10145 B264	C723 D9422
Sullivan	35	14	20	15	A35 B14 A15	C30 D15						
Susquehanna ..	15	7	10	5	B7	D5						
Wayne	10			10	A10 *	D10						
Other counties .		1								B1		
TOTALS.	22,805	3,181	4,946	17,859	A6100 B1739	C2430 D3670	A685 B373	C408 D277	A5140 B718	C1147 D3993	A10880 B351	C961 D9919

* Production combined with other counties or less than one million tons.

TABLE 7
Anthracite reserves by counties and fields, in millions of net tons

Counties	A	B	C	D	E	F	G	H	Northern	1922-1944 inclusive			Southern							
										E. Middle	W. Middle									
Carbon	433	53	7	10	36	67	77	356			† 15 11	1 16	3 19				38 25	6 51	7 58	
Columbia	529	13	1	2	10	17	19	510						13 10	1 17	2 19				
Dauphin	68	20	8	4	8	16	20	48									20 8	8 16	4 20	
Lebanon	35	*						35												
Lackawanna	930	298	6	7	285	425	432	498	298 285 471	6 425 12	7 432 10		109 100	4 4	28 28					
Luzerne	2,925	580	16	38	526	781	819	2,106	449 449	670 670	680 680	77 77	111 111	139 139						
Northumberl'd	2,208	132	17	24	91	157	181	2,027								132 91	17 157	24 181		
Schuylkill	10,701	343	39	52	253	469	521	10,180				16 12	1 17	3 20	163 121	18 207	25 232	164 120	20 245	24 269
Sullivan	15	3			3	5	5	10	3 3	5 5	5 5									
Susquehanna	5	*						5												
Wayne	10	*						10												
Others		3	3													2 2			1 1	
Totals	17,859	1,445	97	137	1,212	1,937	2,074	15,785	772 727	18 1100	17 1117	140 100	6 144	34 178	310 222	38 381	51 432	223 153	35 312	35 347

A—Reserves as of Jan. 1, 1922, Table 6.

B—Production 1922-1944, inclusive.

C—Coal from waste.

D—Stripped coal.

* County figures combined with those of other counties or under 1,000,000 tons.

† Figures correspond to items as follows: B C D
E F G

E—Coal from underground mining.

F—Depletion from E.

G—Total depletion 1922-1944 (F + D).

H—Reserves as of Jan. 1, 1945 (A - G).

Table 8 summarizes Tables 6 and 7 and gives an estimate of the coal in each county, assuming that mining continued in each county at the same average rate as over the period 1922 to 1944. That mining will not continue at the same rate is obvious from the known facts.

Assuming that the percentage rate of recovery in each field would remain the same in the future, Ashmead (op. cit., p. 71) estimated the total recoverable coal by fields, in millions of gross tons, as follows:

Field	Total coal remaining	Percent recoverable	Recoverable coal remaining
Northern	3,277	67	2,195
Eastern Middle	249	69.4	173
Western Middle	3,573	58.1	2,076
Southern	9,256	49	4,535

“This recoverable tonnage may be separated into that portion recoverable within the next 40 years, designated as available, and the reserves, the mining of which will doubtless be deferred beyond 40 years.

Available recoverable tonnage (gross)	3,908 million tons
Reserves, recoverable tonnage (gross)	5,071 million tons

Total recoverable tonnage (gross) 8,979 million tons”

Of the 3,908 million gross tons (4,377 million net tons) 1,445 million of these net tons have been recovered, leaving 2,932 million net tons for recovery possibly within the next generation. But that is not the whole story. In 1921, anthracite was a luxury fuel. Then came fuel oil, by-product coke, and other sources of heat, and today anthracite is in a highly competitive position. Moreover, as anthracite mining continues, costs increase rapidly. The coal mined is deeper, the water handled has increased until today underground mining must raise twenty tons of water for every ton of coal. The thicker beds are being exhausted and mining must turn to thinner beds. These are some of the factors that have tended to slow down or throttle the anthracite industry.

It is now recognized that the time has come when serious thought must be given to the future of the anthracite industry and region. It is a highly seasonal industry owing to its serving mainly household heating in winter. Other seasonal industries whose demand is for summer use and suitable for mining labor would greatly help the situation.

Under these conditions it would be quite unsafe to plan on the assumption that anthracite mining in the several counties will continue at the recent rate for the years indicated in column 11 of Table 8. It is not the purpose of this paper to discuss the future outlook. The facts are given as they now appear.

TABLE 8

ANTHRACITE: Summary by counties, 1945, in millions of net tons

Counties	1	2	3	4	5	6	7	8	9	10	11
	Original content	Production			Depletion			Losses: columns 7 - 4	Reserves: columns 1 - 7	Average depletion 1922 to 1944 $7 \div 23$	Years life remaining at that rate
Tables	2	to 1921 4	1921 to 1944 7	Total	to 1921 Ashmead	1921 to 1944 7	Total				
Carbon	630	111	53	164	197	77	274	110	356	3.3	108
Columbia	615	54	13	67	86	19	105	38	510	.8	637
Dauphin	180	41	20	61	112	20	132	71	48	.8	60
Lackawanna .	2,030	787	298	1,085	1,100	432	1,532	447	498	18.8	27
Lebanon	35	*	*	*	*	*	*	*	35	*	*
Luzerne	4,525	1,205	508	1,785	1,600	819	2,419	634	2,106	35.6	60
Northumberland.	2,600	245	152	377	392	181	573	196	2,027	7.9	260
Schuylkill	12,130	716	343	1,059	1,429	521	1,950	891	10,180	22.7	450
Sullivan	35	14	3	17	20	5	25	8	10	.2	50
Susquehanna .	15	7	*	7	10		10	3	5		
Wayne	10	*	*	*					10		
Other counties		1	3	4				(-4)			
Totals ..	22,805	3,181	1,445	4,626	4,946	2,074	7,020	2,394	15,785	90.1	175

* Combined with other counties or under one million tons.